24th ESA Symposium on European
ROCKET & BALLOON
programmes and related research

16-20 June 2019 · Essen · Germany

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24TH ESA SYMPOSIUM ON EUROPEAN ROCKET AND BALLOON PROGRAMMES AND RELATED RESEARCH

16-20 June 2019

Essen - Germany

European Space Agency

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Editor's Note

The complete Proceedings will be published in a digital form only, shortly after the symposium. Papers not handed in at the symposium should be sent in pdf to:

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Submission deadline: 21 August 2019

Symposium Overview – Session by Session

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MONDAY 17 JUNE, MORNING SESSION

ROOM 1

CHAIR: F-J. LÜBKEN

[A-007]

SOUNDING ROCKET AND BALLOON RESEARCH ACTIVITIES WITHIN THE GERMAN SPACE PROGRAMME 2017-2019

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Sounding (suborbital) rockets and stratospheric balloons currently play a major role in the following research disciplines of the German space programme: Atmospheric Research, Space Science, Life and Physical Sciences under Microgravity, Space Technology development and Education. In its role as space administration, DLR manages these activities and promotes the related experiments by grants and contracts. Involved research entities are mainly German universities, the Max-Planck Society, the Helmholtz Association, the Fraunhofer Association, and the Leibniz Community.

In its role as a research establishment DLR also executes flight projects. The DLR Mobile Rocket Base (MORABA) provides launch services for rockets and balloons. The DLR Institute of Materials Physics in Space develops and conducts own microgravity experiments in the frame of the MAPHEUS research rocket missions. Further DLR institutes participate in flights with rocket technology experiments or support the STERN programme.

The National Report highlights the German research activities in the timeframe 2017 – 2019. In the Space Science discipline the research focus was the middle atmosphere of the Earth using stratospheric balloons, lidars, and DLR FALCON flights. Further, in-situ measurements of atmospheric parameters up to 140 km are conducted by sounding rocket campaigns (e.g. PMWE in April 2018) from the Andøya launch site in Norway. The scientific coordination of these missions is performed by the Leibniz-Institute of Atmospheric Physics at the University of Rostock (IAP) in Kuehlungsborn. 3-dimensional measurements are targeted for the future by releasing three daughter payloads from a single rocket. Biological, physical, and chemical phenomena under microgravity conditions were studied by German scientists using the national TEXUS and MAPHEUS missions as well as new flight opportunities like Blue Origin’s New Shepard carrier on parabolic trajectories.

Within the German-Swedish REXUS/BEXUS student programme more sounding rocket and balloon missions have been performed systematically. A wide range of scientific and technological experiments such as satellite communication and test of space equipment was addressed by the selected student teams.

[A-008]

FRENCH BALLOON ACTIVITIES 2017 - 2020

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The French Centre National d'Etudes Spatiales (CNES) goes on supporting a significant balloon program and infrastructure, for scientific and technological purposes.

Designed to be mobile, the CNES balloon systems and operation means can be deployed and operated worldwide, at several latitudes. The extended range of vehicles and payload gondola support provided by CNES allow addressing several kinds of missions such as astronomy, atmospheric physics and chemistry, stratospheric and tropospheric meteorology.

The main undertaking of the past decade was to deeply renovate the CNES balloons command and control systems and flight operation processes to comply with more stringent Safety constraints and with growing performance and reliability requirements. This is done for large zero pressure balloons (ZPB), and in progress for the other lines of products.

Since 2014, 23 successful scientific flights of heavy ZPBs have been carried out from Timmins (Canada), Kiruna (Sweden) and Alice Spring (Australia).

In the field of long duration balloons, CNES decided, in june 2016, the development of the STRATEOLE 2 project, for the study of the low stratosphere in equatorial regions (UTLS). Based on the use of fleets of small super pressure balloons (SPB) flying up to 3 months each, carrying payloads of 25 kg at 20 km in altitude. The related infrastructure will be available by the end of 2019, paving the way to a new capacity for long duration flights in general.

The presentation will give a synthesis of the launch campaigns of the past two years: Regarding ZPB flights, a focus will be made on the results of the STRATOSCIENCE 2018 flights from Timmins, Canada; 5 successful flights were performed in 16 days; A feedback will also be given about the FIREBALL UV telescope launch campaign of September 2018 in the USA.

A status on the development and qualification of the new SPB system for STRATEOLE 2 will be given, as well as the perspectives for new services, developments and promising collaborations, such as the CNES participation to the European HEMERA H2020 Infraia project on balloon services, accepted by EU in August 2017.

[A-020]

NORWEGIAN NATIONAL REPORT – ARCTIC SPACE RESEARCH

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Norway has long traditions as a space nation, much due to our northern latitude. The main scientific activities are within Solar-terrestrial physics, planetology and cosmology.

The first field has been a priority since before the space age and is still the major priority. The usage of the ground infrastructure in Northern Norway and on Svalbard is essential in studying the middle and upper atmosphere and the interaction with the Sun. This includes the utilization of sounding rockets, both small and large, and ground based installations like radars, lidars and other optical instrumentation.

A new sounding rocket program called Grand Challenge Initiative (GCI) has been established. GCI is an historic cooperation between Norway, Japan and the USA relating to the use of rockets to investigate the upper part of the Earth's atmosphere which is hit by the solar Wind.

The new EISCAT_3D facility in Norway is in construction phase with a goal to be operational in 2022. The SuperDarn radar at Svalbard is also operating to study space weather. This will provide a significant improvement of polar and ionospheric research infrastructure in Northern Norway and Svalbard .

The solar physics community is also heavily involved in the HINODE and IRIS missions and Norway is supporting downlink of data via the Svalbard Station for these missions. Norway also participating in the ESA Solar Orbiter mission.

The Norwegian Mapping Authority (NMA) operates a real time space weather monitoring service and also opened its new Geodetic observatory in Ny Ålesund at Svalbard June 2018

Norway is also participating in ESA´s Space Situational Awareness program with a strong focus on the space weather elements. In particular to utilize, and further develop the arctic space infrastructure. A national space weather center has been established in Tromsø to serve the user needs in Norway.

A small satellite with a space weather instrument onboard was launched into a polar orbit in 2017. And as a nation operating several other small satellites, space weather forecast will be important for our operators.

SWEDISH SPACE ACTIVITIES – GENERAL OVERVIEW WITH A FOCUS ON BALLOONS AND ROCKETS

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Swedish space research involves many fields of space science, such as astronomy, space physics, astrobiology, atmospheric research, life and physical sciences in microgravity and Earth observation. A major part of Swedish space research activities is supported by the Swedish National Space Agency (SNSA), within its national programmes for space research and Earth observation. Most projects utilise flights offered by ESA programmes and/or data provided by ESA satellites and other space missions. Several national projects deal with the utilisation of balloons and rockets, launched from the Esrange Space Center in Northern Sweden. SNSA has also established a new national initiative dealing with small innovative satellites, aiming at launching a new science satellite on regular basis. The first satellite, MATS, is scheduled for launch in late 2019, and a study of the next mission SIW is ongoing.

Esrange Space Center and its utilisation is emphasised in the new strategy of SNSA as one of the focus areas. Esrange provides unique opportunities for scientists and engineers from Universities and private entities to carry out technology tests for e.g. future space exploration missions and to undertake basic and applied science. Is also allows combining basic science with instrument and platform development and close cooperation between universities and industrial partners. In order to meet the needs of the Swedish space community and to promote scientific utilisation of Esrange, SNSA is carrying out a dedicated national programme for rocket and balloon experiments with regular calls for proposals.

During recent years, several successful balloon and rocket launches have been performed within the national balloon and rocket programme. Currently a new rocket project SPIDER-2 is under development and will carry several free-flying units to study the turbulence in the auroral electrojet.

Two balloon projects are ongoing within the national programme, In-situ IWC for investigation of ice clouds and collection of ice particles, and mini-Booster that will carry sensors for infrasound studies.

Sweden is one of the partners in the student rocket and balloon programme REXUS/BEXUS. The programme is a joint undertaking of the German Aerospace Center DLR and SNSA, in cooperation with ESA, and a call for proposals is being issued every year, offering an opportunity to carry out student experiments on real rockets and balloons. Two REXUS rockets and two BEXUS balloons are being launched from Esrange every year and more than 1200 European students have participated in the programme since its start in 2007.

Besides national activities, Sweden contributes to many ESA programmes. The E3P programme involve considerable Swedish participation, and Swedish activities are mainly focused on MASER sounding rockets for microgravity research as well as drop tests from high altitude balloons.

[A-196]

SOUNDING ROCKET AND BALLOON ACTIVITIES AND RELATED RESEARCH IN SWITZERLAND 2017–2019

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The research interest in processes of the upper atmosphere that can be investigated only by applying sounding rocket, balloons or by using high-altitude research platforms is popular in Switzerland. Most of the related studies in microgravity, astrophysics, astronomy and atmospheric science are taking place at the two research stations Jungfraujoch and Gornergrat, which are located in the heart of the Swiss alps. They are easily accessible and allow for even long-term observations ranging from of months to years. This is particularly important to unveil slow processes that are related to the global warming for example. Nitrous oxide (N_2O) and methane (CH_4) are trace gases with global warming potential that are 10 to 100 times stronger than CO_2. Their readings are just one of the many monitoring activities that are taking place at the high-altitude research stations. In contrast, the stations are also used to determine medical implications to high altitude exposure like finding potential correlation between certain blood gas compositions and symptoms of acute mountain sickness.
The use of sounding rockets to gain deeper knowledge in rocketry as well as to address scientific questions has awaken the interest of students in the past few years in Switzerland. An initiative named ARIS (Akademische Raumfahrt Initiative Schweiz) was launched by students who share the passion for space technologies. The ultimate goal of ARIS is to bring together research, education and industry in the field of aerospace technology and promote Swiss engineering excellence on a global stage. Under the ARIS initiative, several sounding rockets have been launched so far. Next step is to design, test and manufacture a sounding rocket for the 2019 Spaceport America Cup competition in New Mexico, USA.
The national report highlights just a few Swiss projects applying sounding rocket, balloon or related research platforms. It is beyond the scope of this report to introduce all the related activities performed between 2017 and 2019.

RUSSIAN STRATOSPHERIC BALLOON ACTIVITIES – GENERAL OVERVIEW AND PROJECTS OF MOST ACTIVE GROUPS

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In Russia, interest in balloon stratospheric projects is growing again. Over the past 7 years, the launch operator "Stratonautica.ru" has carried out more than 100 stratospheric launches.

Among the main scientific tasks of the experiments that have already been carried out are the researches in atmospheric physics, astronomy, meteorology, materials science, and biology. For example, in 2018, noctilucent clouds were successfully observed from the stratosphere for the Swedish Institute of Space Physics and the Institute of Atmospheric Physics of the Russian Academy of Sciences. 8 launches of composite material samples were carried out during the period 2013 - 2018 with the results of confirmation the possibility of polymerization of some types of composits under close to space conditions that were ordered by the Perm Institute of Continuous Media. Several launches were carried out with instruments for atmospheric measurments for the Central Aerological Observatory of Roshydromet, solar radiation sensors for the Physicotechnical Institute of the Russian Academy of Sciences, samples of biological materials for the Institute of Space Medicine and many others.

In Russia, under the active assistance of our laboratory, several educational stratospheric balloon projects are being developed for schoolchildren and students. The launches of equipment developed by students with various scientific and educational tasks were carried out. One example is the RosCanSat project launches.

We have developed a number of technical solutions to ensure ongoing and planned research during the flight of low-volume balloons:

- On-board computer that manages the processes during the flight and collects data for more than 30 different flight parameters

- Radio link connection receiving telemetry and sending commands

- Video broadcast from flight unit to ground control

- Camera stabilization and control system

Our equipment was launched from the territory of 5 countries (Russia, Sweden, Norway, Australia, USA), made a round-the-world flight in the southern polar circle.

A separate area of the development is participation in the provision of manned stratospheric flights. Our laboratory took part in the development of the equipment for the record round-the-world flight on the aerostat already carried out by Fedor Konyukhov. Our laboratory participates in researches dealing with technical equipment for the manned flight planned for 2019 to the altitude of 25 km.

The laboratory is developing its own manned flight support system at altitudes up to 40 km. The spacesuit with a dummy was lifted to the 25 km altitude for testing system components in 2018.

[A-197]

JAPANESE SOUNDING ROCKET ACTIVITY IN 2017-2018

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The Institute of Space and Astronautical Science (ISAS) of Japan Aerospace Exploration Agency (JAXA) is now operating three kinds of sounding rockets, S-310, S-520, and SS-520, to achieve various objectives such as thermospheric, ionospheric and magnetospheric physics, microgravity experiment, demonstration of various instrument and technique, and advanced engineering experiments. These rockets are launched not only inside Japan but also in foreign launch sites. In this talk, we will present recent activities of Japanese sounding rocket and balloon programs and related research.

At 14:03 (Japan Standard Time) on February 3, 2018, SS-520-5 rocket was launched from Uchinoura Space Center which locates in the south part of Japan. SS-520-5 is a three-stage rocket that is a modification of SS-520 two-stage sounding rocket. Through this launch, JAXA tried to conduct a demonstration of research and development of launch vehicles and satellites. The launch was followed by successful orbital insertion of its payload, “Tasuki” (TRICOM-1R), which is its onboard nanosat that weighs about 3 kilograms. The launch was part of Japanese government's program for development of launch vehicles and satellites in public-private partnerships.

In December 2017, we were supposed to launch SS-520-3 sounding rocket from the SvalRak launch facility at Ny-Ålesund in Svalbard, Norway. However, we had to postpone the launch in the later years because of malfunction of onboard timer system, which was identified during the final integration test in September 2017. The main purpose of this rocket experiment is to elucidate the plasma acceleration/heating mechanism responsible for the ion upflow in the ionospheric cusp region using a combination of the high time resolution in-situ rocket measurements and the ground-based optical and radar observations. Among science instruments onboard, Wave Particle Interaction Analyzer (WPIA) was newly developed for directly detecting the wave particle interaction and will certainly bring an important clue to understand the ion energization mechanism in the cusp.

As the near-future sounding rocket experiments, we will launch S-310 in 2019 and S-520 rocket in 2020. The former is intended for a demonstration of an inertia platform and a small probe bus technique while the later experiment is used to develop a new system of rocket engine. We will continue to the same level of activity in the coming years.

[A-083]

NASA SOUNDING ROCKET PROGRAM OVERVIEW

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An overview of the NASA Sounding Rocket Program will be presented. Highlights will include recent and upcoming launch campaigns in support of world class science investigations. Also, a summary of significant capability enhancements, recent and currently in development, will be discussed.

Recent launch campaigns were conducted from extraordinary points on the globe.

In April 2018, two astrophysics telescopes, CHESS and WRX-R, were launched from the island of Roi Namur in the Kwajalein Atoll (Marshall Islands - Pacific Ocean). CHESS studied the interstellar medium in the ultraviolet part of the spectrum. The Principal Investigator was Dr. Kevin France from the University of Colorado. WRX-R studied studied the Vela Supernova Remnant using X-ray spectroscopy. Both missions were successful in meeting their scientific objectives. Programmatically, these missions represent a significant step forward as the first evacuated telescope payloads recovered from the ocean.

In December 2018 and January 2019, six geo-space science missions were launched from Andoya Space Center in Norway. Two missions, VISIONS-2, were launched from the remote island of Ny Alesund at 79-degrees north latitude. The remaining missions were launched from Andenes on the mainland of Norway: TRICE-2 (two rockets), CAPER-2, and G-Chaser. All missions studied the unique interactions of the Solar Wind and the Cusp region of the Earth's magnetic field. G-Chaser was the first international undergraduate student mission for the NASA Sounding Rocket Program.

Upcoming launch campaigns will feature various Heliophysics and Astrophysics investigations from around the world, as well. First, the Program will launch two rockets from Andoya Space Center in Norway (both from Andenes), AZURE, releasing multiple chemical tracers to study dynamics in the upper atmosphere. Then, returning to Kwajalein for two additional rockets, TooWINDY will also release chemical tracers to study dynamics in the equatorial ionosphere. Late Fall 2019 will feature two rockets from Andoya Space Center, again. This time, one will launch from Ny Alesund (CHI) and one from Andenes (CREX-2). Both will further study the unique interactions of the Solar Wind and the Cusp region of the Earth's magnetic field. Winter 2019 will feature one rocket from Poker Flat, Alaska (LAMP) to study microbursts in a pulsating aurora. The Program will then turn its attention to The Land Down Under, launching four Astrophysics missions from Australia. WRX-2, XQC, SISTINE, and DEUCE will capture data from targets in the celestial southern hemisphere. This will represent an extraordinary undertaking for the Program since most of the infrastructure needed to conduct these launches will be shipped from the U.S. and erected temporarily just for these missions. Interspersed among the campaigns mentioned above will be several Astrophysics and Heliophysics missions from White Sands, New Mexico and Wallops Island, Virginia

The Program continuously develops capability enhancements in order to enable the next generation of scientific discovery.

Recent technology demonstration missions featured very valuable developments to this end. Small sub-payload ejection and event initiation have enabled multi-point chemical tracer or multi-point in-situ measurements using a single main payload carrier. The chemical tracer ampules mentioned above for the AZURE campaign are a perfect example of this. Furthermore, water recovery of evacuated telescope payloads was recently developed and then successfully demonstrated on the two missions from Kwajalein mentioned above. Logistical and budgetary challenges associated with this type of water recovery require further refinement, but the capability represents a significant set of opportunities for our science partners to launch from many places around the globe.

Capability enhancements currently in development include high data rate telemetry in the 400 mega-bit-per-second range to enable high resolution measurements during short-lived sounding rocket flights. Also, the Program is developing swarm communication in which multiple small sub-payloads will transmit data to the main payload for a single telemetry stream to be transmitted to the ground from.

The NASA Sounding Rocket Program has a proud history of serving the science community with low-cost, rapid access to space. The recent and upcoming launch manifest, coupled with the extensive efforts to develop new capabilities are evidence that this legacy continues and remains strong.

Astrophysics, Astronomy & Cosmology 1

Monday 17 June, Afternoon session – part 1

Room 1

Chair: P. Guigue

Plenary Invited Lecture

[A-188]

CONTRIBUTION OF BALLOON-BORNE EXPERIMENTS TO PRESENT ISSUES IN ASTROPHYSICS

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Astronomy uses balloon-borne experiments to observe the sky from above most of the earth atmosphere which otherwise prevents sensitive observations in some spectral windows, such as gamma-rays, X-rays, Infra-red and Far-infrared, or to collect high energy particles or even space materials.

I will summarize the status of current and future astronomy balloon experiments being carried for astrophysics, as well as to test hardware for future astronomy space missions. In particular, I will emphasize the recent scientific results of some of these experiments aiming at measuring the magnetic field structure of the interstellar medium through dust polarization, such as those from the Blastpol (USA) and PILOT (France) experiments, as well as the prospects of the latest high energy and cosmology experiments EUSO and OLIMPO. I will also discuss the emergence of new experiments and the possibility to use them to test hardware for the upcoming SPICA and Litebird space missions.

[A-116]

FIRST RESULTS FROM THE POGO+ BALLOON-BORNE X-RAY POLARIMETER

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PoGO+ is a balloon-borne telescope for measuring astronomical polarization in the hard X-ray band. The instrument comprises 61 plastic scintillators in a honeycomb structure, surrounded by a segmented side anticoincidence shield made of BGO and a passive polyethylene neutron shield. A custom attitude control system is used to orientate the two-tonne gondola and acquire sources to a precision of ~0.1°.

A successful one-week flight from the SSC Esrange Space Center, Sweden, to Victoria Island, Canada, was conducted in 2016, with altitudes exceeding 40 km. The Crab system (pulsar/nebula) and Cygnus X-1 (black-hole binary system) were observed for the first time with a dedicated polarimeter in the ~20–180 keV energy range, achieving a minimum detectable polarization (MDP) of about 10% and 8%, respectively. For the Crab system, a polarization fraction of (20.9 ± 5.0)% was measured, at a polarization angle which is compatible with the pulsar jet axis. For Cygnus X-1, the observations yielded a polarization fraction upper limit of 8.6% (90% confidence).

Here, we present an overview and interpretation of the scientific results, which have shed new light on the Crab emission and the periodic signals of its pulsar, as well as constrained the emission geometry of the Cygnus X 1 system and provided an upper flux limit for its synchrotron jet flux.

[A-193]

PILOT FIRST SCIENCE RESULTS: GEOMETRY OF THE MAGNETIC FIELD IN THE CENTRAL MOLECULAR ZONE OF OUR GALAXY

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I will present the first scientific results from the PILOT balloon-borne experiment regarding the geometry of the magnetic field in the central regions of our Galaxy, which were recently submitted to A&A (Mangilli et al. 2019, arXiv:1901.06196v1). The data was obtained during the 2nd flight of the PILOT experiment, within flight campaign from Alice-Spring, Australia, in April 2017 operated by CNES. The map of the polarization of the dust emission is the only one in the Far-Infrared covering the whole central molecular zone, where dense molecular material orbits the central back hole. The data allows to infer the sky-orientation of the magnetic field in the central molecular zone. The results show that the magnetic field orientation is unexpectedly homogeneous, with a well defined pitch angle of about 22° clockwise with respect to the Galactic plane. Little deviations of this orientation are observed, even towards very massive clouds with large velocities, indicating a possibly very strong magnetic field, with intensities exceeding a few mG. The overall low polarization fraction of the dust emission in that region also indicates that the magnetic field in 3D could be mostly oriented towards (or away from) us. I will also show maps of other sky regions obtained during this flight and discuss the prospect of a 3rd flight of the instrument, to take place in September from Timmins, Canada.

[A-126]

FIRST RESULTS FROM THE ANTARCTIC BALLOON FLIGHT OF THE HARD X-RAY POLARIMETER X-CALIBUR

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X-ray polarimetry promises geometrical information about compact astrophysical objects such as accreting black holes and neutron stars that are too small to be imaged at any wavelength. While some information about the source geometry can be derived from spectral and timing measurements of the high-energy emission, results are often model dependent. X-ray polarimetry can break these degeneracies by providing two new observables, namely the Stokes parameters Q and U.

X-Calibur is a balloon-borne hard X-ray polarimeter covering the 20-40keV energy range. It consists of an 8m long optical bench carrying the InFOCμS hard X-ray mirror, and a scattering polarimeter at its focal point. The optical bench is pointed with arc-second precision by the Wallops Arc-Second Pointer (WASP). The polarimeter consists of a Beryllium scattering element at the focal point of the mirror surrounded by CZT detectors on 4 sides to measure azimuthal scattering angle and energy of the scattered photons.

X-Calibur was flown on a 2 1/2 day long stratospheric balloon flight from McMurdo (Antarctica) from Dec. 29, 2018 to Jan. 1, 2019. The observations caught the accreting X-ray pulsar GX 301-2 close to the apastron at elevated flux levels. We report here on the first X-Calibur results including the 15-60 keV light curve, the hard X-ray energy spectrum, and the first constraints on the polarization of the hard X-ray emission. We furthermore show results from simultaneous observations with the Neil Gehrels Swift and NICER X-ray telescopes. We conclude with an outlook of the physical constraints that can be derived based on future, deeper X-ray spectropolarimetric observations of X-ray pulsars (see also Pearce et al., this conference).

[A-101]

FIREBALL-2 (2018) IN-FLIGHT POINTING PERFORMANCES

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FIREBALL (the Faint Intergalactic Redshifted Emission Balloon, funded by CNES-NASA, PI C.Martin, Caltech) is a balloon-borne 1m telescope coupled to an ultraviolet Multi Object Spectrometer (MOS), designed to study the faint and diffuse emission of the circumgalactic medium. The third flight of the gondola and the first flight of the second version of the instrument took place on the 22nd of September 2018 from Fort Sumner (NM, USA). The 5-metres high and 1800 kg gondola and its pointing system have been designed to obtain an absolute pointing accuracy of less than 1'' (1σ) over long integration time (hours). The goal of this paper is, after having restated the main features of the pointing system design, to present an overview of the different events that occurred and tasks that were carried out during the flight (which was unfortunately cut short because of a balloon flaw) and to uncover the good pointing performances that were obtained for the different science targets over nearly 4 hours of dark time (?σ ~ 0.6''), despite a challenging flight trajectory characterized by its high level of disturbances arising from the drop in altitude the balloon suffered (from 39 to 26 km). The spectral analysis of the residual line of sight errors reveals a good correlation with the perturbations encountered by the gondola. The in-flight gondola behavior shows very good agreement with the theoretical model in terms of pitch, roll and yaw main frequency modes. Furthermore, the low frequency response of gondola pitch and roll is impressively correlated with the acceleration of the balloon. To conclude with, the thorough investigation based upon the collected data of this first flight shows the way for further slight improvements that will be performed in order to strengthen the pointing performance for the next flight planned in 2020.

Range Facilities 1

Monday 17 June, Afternoon session – part 1

Room 2

Chair: K.Boen

[A-117]

ESRANGE SPACE CENTER – LATEST HIGHLIGHTS AND FUTURE PLANS

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After the last ESA-PAC meeting in Visby 2017, Esrange has been the host for 7 balloon and 3 rocket campaigns up to end of 2018, with 4 rocket and 2 balloon campaigns planned in the first half of 2019.

2017 ended with 3 balloon flights from Esrange, In October the student campaign BEXUS 24/25 with 8 student experiment from Germany, Sweden, UK, Spain and Italy onboard was performed. It was followed in December by a flight of a small balloon by Luleå University, looking at ice and snow in the atmosphere.

2018 started off with a flight within the German MAPHEUS rocket programme, number 7.

A parachute test for future Mars missions, LADT, was performed for ESA in February, followed by another balloon from Luleå University.

REXUS 23/24, a campaign with two rockets in the Swedish/German student programme, was performed in March. Due to problems during the first launch, the second rocket has been postponed and will be launched in 2019 instead. The rocket launches of 2018 were wrapped up with the German national microgravity rockets TEXUS 54 and TEXUS 55 in April.

In May NASA returned to Esrange for the first time since 2013 with large stratospheric balloons, and 3 transatlantic flights from Esrange to Canada were performed during the summer. In parallel with this, SSC also launched a large balloon for the Italian space agency from Svalbard. The mission, OLIMPO, flew for 5 days before landing in Canada after which it was recovered. It was the first launch from Svalbard for SSC, and a proof-of-concept of the capability in mobility when it comes to ballooning.

In August, there was launch of a balloon for the drop-test of a parachute system performed at Esrange for ESA, connected to the EXO-MARS project.

The last flights in 2018 were the student campaign BEXUS 26/27 with 7 student experiment from Poland, Germany, Sweden and Belgium.

For 2019, the plan for Esrange is to launch three Swedish/German student rockets, REXUS 23, 25 and 26, and one French student rocket, SERA-4, in the first half of the year. Some small balloons for Luleå University are also planned.

The parachute test for EXO-MARS will return in the beginning of summer, and during the same period two microgravity rockets, MAPHEUS 8 and MASER 14 are also planned to be launched.

Apart from the launch campaigns performed, there has been static motor tests of more than 20 rockets performed in 2018. The development of test capacity for all types of rockets, i.e. solid, hybrid and liquid, are ongoing, as is the capacity to launch satellites from Esrange.

All in all, Esrange has seen many interesting campigns since last ESA-PAC symposium, and are preparing for more forthcoming.

[A-123]

MOVING TOWARDS REMOTE OPERATION ON THE ALOMAR OBSERVATORY

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The Arctic Lidar Observatory for Middle Atmosphere Research (ALOMAR) at Andøya Space Center is a manned observatory situated in the Arctic, hosting a number of active and passive remote sensing instruments. The majority of the manned operations centre around maintenance of infrastructure and operation of several LiDAR-systems. The biggest lidar-system at ALOMAR is the RMR lidar owned by the Leibniz Institute of Atmospheric Physics (IAP). ALOMAR and IAP have participated in the ARISE2 project with an effort to increase automation of the RMR lidar and the ALOMAR observatory.

The automation of remote sensing of the middle atmosphere at high latitudes requires adaptation to the harsh environmental conditions in winter but also to the 24-hour solar heating on the instruments in summer. The ALOMAR RMR lidar is unique as there exists no other Doppler wind and temperature lidar system that measures winds and temperature in the mesosphere during daytime. IAP have, with implementation support from ALOMAR, developed a control system (ALOHA) that allows unattended operation of multiple lidar systems, their supervision and control throughout the observatory building. Benefits from such an initiative include greater flexibility and availability of lidar measurements, which will result in longer and more frequent measurement series.

We have examined possible challenges and solutions to implement unattended or remotely manned lidar operations at the ALOMAR observatory, such as communication with Air Traffic Control in the close vicinity of a military air base, rapidly shifting weather condition in a remote location, and safety and security issues at the location. Solutions to several of the challenges have been found, while others require further effort.

[A-005]

STATIC ROCKET MOTOR TEST FACILITY AT ESRANGE SPACE CENTER

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Esrange Space Center inaugurated the static rocket motor test facility and did 21 static motor tests during 2018. Procedures and infrastructure was developed for safe and efficient use. During one campaign 19 Taurus motors were tested in 9 days. The facility is designed for motors with thrust up to 500 kN.

Future plans include adding container twistlocks to the floor so a 20-foot container easily can be placed inside the test facility. Customers who want to prepare a test rig in advance can do that and quickly install the container in the test facility and make tests for solid, hybrid and liquid rocket engines.

[A-137]

THE NAMMO NUCLEUS LAUNCH: A SHOWCASE FOR HYBRID SOUNDING ROCKETS

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On Thursday 27 September Nammo successfully completed the first launch of Nucleus, a new sounding rocket powered by its new hybrid rocket motor. Nucleus launched at 14:16 local time from Andøya Space Center (ASC) in Northern Norway, and reached an altitude of 107.4 km. That made it not only the first rocket powered by a Norwegian motor design to cross the Karman line, the commonly recognized border to space, but also the first European hybrid rocket motor to do so in more than 50 years.

Nucleus is a Norwegian sounding rocket, designed to lift scientific instruments into the upper layers of the atmosphere. It is 9 meters long and has a total weight of around 800kg, including 70kg of payload. The hybrid rocket motor powering Nucleus has been developed by Nammo at Raufoss in Norway, as part of ESA Future Launchers preparatory Programme (FLPP). It uses liquid high concentration hydrogen peroxide and a rubber-type solid fuel as propellants, generating a thrust of 30 KN (3 tons) for 40 seconds duration.

The Nucleus launch was a complete success both in terms of the four technical experiments on board and of the vehicle final trajectory. Furthermore, all flight on-board data was successfully acquired through telemetry signals. But the success concerned as well the ground support equipment designed for Nucleus and the conduct of ground operations at ASC during the 3 week-long flight campaign leading up to the launch. Nammo had a great collaboration with ASC on the Nucleus campaign, and gathered a rich experience and a countless number of lessons learnt. Using this experience from the Nucleus operations and flight, Nammo intends in this article to discuss and show the advantages and disadvantages of its new Norwegian hybrid rockets versus the traditional solid boosters for completing sounding rocket research campaigns.

Notably, the inert nature of the Nucleus hybrid sounding rocket has allowed for low-cost standard road transportation and for payload and integration and tests to be performed directly on the vehicle without the usual constraints and in a safer environment. Furthermore, Nammo could demonstrate how in the future its hybrid sounding rockets could remain ready for launch at T minus 30 minutes for multiple days, achieving a responsiveness much like that of solid rocket motors, but with more flexibility thanks to for example the possibility to adjust the rocket liquid propellant filling level until the launch day. Finally, a good surprise was the realization that rail post-launch cleaning from plume deposits was unnecessary for the ASC pad personnel. All of these aspects will in this paper be discussed and weighed in to discuss the competitiveness of hybrid versus solid sounding rockets in the delivery of future research payloads.

Atmospheric Physics and chemistry 1

Monday 17 June, Afternoon session – part 2

Room 1

Chair: J. Gumbel

[A-103]

PMWE-1 – THE FIRST SOUNDING ROCKET CAMPAIGN TO STUDY POLAR MESOSPHERE WINTER ECHOES

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In April 2018, the 1st sounding rocket campaign dedicated to the investigation of Polar Mesosphere Winter Echoes, PMWE-1 was conducted at the north Norwegian Andøya Space Center (ASC, 16 °E, 69 °N). Two instrumented sounding rockets were launched. The first rocket PMWE1F was launched into a moderate PMWE layer observed by the Middle Atmosphere ALOMAR Radar System (MAARSY). The second rocket PMWE1D was launched at the last most minute of the launch window when, MAARSY did not observe any echoes because of the very low background ionization as observed by both EISCAT in Tromsø and SAURA MF Radar located near the launch site. Both rocket launches created synthetic radar echo at altitudes of PMWE layers.

In this paper, we give an overview of the measurements conducted during the rocket campaign and discuss first results.

[A-026]

A ROCKET-BORNE MASS SPECTROMETER FOR DETECTION OF HEAVY IONS IN THE ATMOSPHERE – INSTRUMENT DESCRIPTION AND FIRST RESULTS

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We built a compact quadrupole ion mass spectrometer to detect ambient heavy ions in the atmosphere during a sounding rocket flight.

Based on previous instruments from Max-Planck-Institute for Nuclear Physics (MPIK, Heidelberg), the instrument is using a cryogenic pump to maintain high vacuum.

This allows the operation of the instrument at atmospheric pressures above the requirements for the quadrupole and the channel electron multiplier detector.

To improve sensitivity compared to earlier designs from MPIK, a quadrupole lens was placed between inlet orifice and quadrupole.

The quadrupole mass analyser is driven by internal, battery powered electronics.

A measurement mode optimized for mass resolution or mass range can be electronically selected during flight.

The first flight was successfully accomplished during noon in April 2018 from Andøya, Norway. The instrument was part of the PMWE campaign led by Leibniz-Institute of Atmospheric Physics (IAP, Kühlungsborn) to study polar mesospheric winter echoes.

The instrument’s mass range was adjusted to provide mass resolution up to 2000

[A-162]

MESOSPHERIC AND MIDDLE ATMOSPHERIC STUDIES IN NORWAY AND INTERNATIONAL COLLABORATION

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International collaboration can leverage the exploration and scientific investigation of the Earth's middle atmosphere. Northern Norway offers infrastructure for rocket observations, one of the best conditions for optical studies of the polar atmosphere, and infrastructure for observations from ground, including the future advanced multi-static phased array radar project EISCAT_3D. We propose to include this network in an international initiative on mesospheric studies in the form of a large-scale international collaboration effort with coordinated experimental and theoretical research using ground-based instruments, modeling, sounding rocket investigations, and satellite-based instruments. The science questions can include the vertical coupling to the E-region and the lower thermosphere, mesospheric smoke and ice particles, neutral atmosphere dynamics, winds, waves and tides and their influence on coupling of the atmospheric layers, the influence of geomagnetic activity, particle precipitation and possibly dusty plasma phenomena. The initiative which should also include international student participation, could build on experience from the ongoing international grand challenge initiative, GCI cusp and aim to work across disciplines. GCI cusp included a dedicated student rocket (G-CHASER) which was launched early 2019. It has been an exercise in coordination and a precursor for future studies of e.g. aurora and mesospheric smoke, and a feasibility study for new types multipoint high-resolution electron density measurements. The ESA PAC meeting provides an opportunity to discuss future collaborations.

[A-027]

VORTEX: A NEW ROKET EXPERIMENT TO STUDY MESOSCALE DYNAMICS AT THE TURBOPAUSE

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The Earth's turbopause and mesopause are both at around 100 km altitude and mark a transition from gravity wave (GW) propagation and small-scale turbulence in the weakly stratified upper mesosphere to the strong winds and extreme wind shears in the highly stratified lower thermosphere. Observations of kinetic energy wavenumber spectra and latest GW-resolving GCMs all show evidence for a universal spectral regime at mesoscales (10-500 km), often with a transition in the spectral power law around 200 km. The goal of this new investigation is to better understand nonlinear GW interactions in the upper mesosphere and lower thermosphere (UMLT), and the formation of vortices and stratified turbulence.

The "VortEx" sounding rocket experiment will comprise two salvoes to be launched from Andøya Space Center, Norway in winter (February 2021). One rocket in each salvo will deploy 16 TMA ampules for horizontally and vertically distributed wind and vorticity measurements and also carry ionization gauges to measure neutral temperatures and density fluctuations. The other rocket will deploy TMA trails for wind measurements and observing the evolution of the turbulent structure function. The ampule subpayloads are based on technology developed for the AZURE (April 2019) and C-REX missions. The launches will be supported by the AMTM to image temperatures, GWs and small-scale activity in the OH layer near 87 km. Strong GW activity in the common volume with the rocket measurements would trigger the launch sequence. The MMARIA network of meteor radars in northern Norway will provide detailed wind maps between 80 and 100 km that allow the observation of horizontal divergence and relative vorticity. The ALOMAR RMR Doppler lidar will provide wind and temperature profiles up to 80 km, and an analysis of the background GW activity.

We will combine observational data with numerical modeling of nonlinear gravity wave dynamics around the mesopause and turbopause. Time-dependent background profiles of wind and temperature will provide basis for simulating gravity wave propagation, instability, secondary wave and turbulence generation. Numerical results will include simulations of airglow and tracer species density perturbations, to enable comparisons with observed small-scale structures. In this talk, we will present experiment design, recent related observations, and simulations of wave dynamics across the turbopause.

[A-129]

D-REGION OBSERVATIONS BY VHF AND HF RADARS DURING A ROCKET CAMPAIGN AT ANDØYA DEDICATED TO INVESTIGATIONS OF PMWE

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In April 2018, the PMWE1 sounding rocket campaign was conducted at the Andøya Space Center. The Middle Atmosphere Andøya Radar System (MAARSY) was operated to detect polar mesospheric winter echoes (PMWE) with multiple beam directions to propose favorable launch conditions. A dedicated experiment configuration with 5 different beam positions was used to point the radar beam along the predicted trajectory of the payload. This special radar experiment allowed to obtain basic information about the spatial structure of the PMWE and its dynamical behavior around the flight of the two rockets. Furthermore, real common-volume observations by rocket instruments and radar soundings could be carried out within the PMWE layer on up-leg and down-leg of the rocket flight. The Saura MF radar was operated during both flights probing the mesosphere with a multiple beam scan experiment to derive horizontal winds and electron density profiles. The obtained PMWE characteristics will be discussed on the basis of signal strength and spectral width of the received radar signals as well as estimated horizontal winds and electron densities with particular emphasis to the launch times of the sounding rockets. Results from the rocket probes measuring e.g. meteor smoke particles, temperature and turbulence along the rocket trajectory will be compared with the radar measurements.

[A-113]

IN-SITU MEASUREMENTS OF NEUTRAL AIR AND DUSTY PLASMA PARAMETERS DURING PMWE-1 SOUNDING ROCKET CAMPAIGN

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In April 2018, the 1st sounding rocket campaign dedicated to investigate Polar Mesosphere Winter Echoes, PMWE-1 was conducted at the north Norwegian Andoya Space Center (ASC, 69°N, 16°E). Two instrumented sounding rockets were launched when the Middle Atmosphere ALOMAR Radar System (MAARSY) was monitoring PMWE. Both payloads were equipped with instruments to measure densities of neutral air and all the constituents of the D-region dusty plasma with very high spatial resolution. Apart of absolute density profiles these measurements yield fluctuation data which might be produced by dynamical processes like neutral air turbulence or plasma instabilities.

In this paper, we present and discuss first results obtained from in-situ measurements.

[A-073]

ANALYSIS OF THE TURBULENT ENERGY SPECTRA OBTAINED DURING THE WADIS-2 SOUNDING ROCKET CAMPAIGN

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In the present study, we analyze recent sounding rocket mesospheric measurements of fluctuations in density of neutral air obtained during WADIS-2 sounding rocket campaign conducted in March 2015 at the Andøya Space Center (16°E, 69°N).

A theory of strongly stratified turbulence (SST) is used to explain the power spectra densities of the relative fluctuations of neutral air density which is a turbulent passive tracer. Measurements obtained in a wide range of parameters such as the buoyancy Reynolds number [10, 1000] and the horizontal Froude number [0.0001, 0.007] are utilized to explain the behavior of the vertical energy spectrum in SST regime.

It is shown that the data supports scaling of vertical spectra inferred from the theory of SST. Moreover, it is found that at high buoyancy Reynolds numbers and sub-critical horizontal Froude numbers vertical spectra exhibit a new scaling dependence unreported so far. The new scaling law spans over a large vertical wavenumber range between the buoyancy scale and Ozmidov scale. Results obtained during this study suggest that the winter Mesosphere is in strongly stratified turbulent regime.

Technology & Infrastructures for Sounding Rockets 1

Monday 17 June, Afternoon session – part 2

Room 2

Chair: L. Poromaa

[A-072]

THERMAL CONTROL SYSTEM FOR THE MAIUS ATOM INTERFEROMETER PAYLOAD AS A VSB-30 SOUNDING ROCKET

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In 2017, the MAIUS experiment demonstrated the first Bose-Einstein Condensates in Space in the challenging environment aboard a two-staged VSB30 sounding rocket. Two follow-up mission, MAIUS-2 and MAIUS-3 are currently prepared.

In order to achieve this ambitious scientific goal all payloads are using various sensitive instruments giving hard requirements on the thermal (and mechanical) design of the scientific payload.

This paper gives a summary of the thermal requirements on the thermal control system (TCS) of the complex scientific payloads MAIUS-1 and MAIUS-2. Moreover, the TCS designs of both payloads, which are meeting these requirements, are presented. A detailed description of the water cooling umbilicals to provide water for controlling the temperatures of the payload until lift-off will be presented, as well as the design of the chillers and their housing, which have been designed for operation on the launch pad close to the rocket.

As many components, that have been used in MAIUS-1 will also be included into the MAIUS-2 TCS design, the performance of the MAIUS-1 TCS during flight and in the laboratory will be evaluated and compared to the results of simulations performed. The resulting lessons learned as well as their impact on the current TCS design will be presented.

[A-079]

FOREIGN OBJECT DAMAGE – IMPACT TESTS ON SOUNDING-ROCKET FIN STRUCTURES

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In aviation as well as space flight Foreign Object Damage (FOD) are damages caused by any objects or substances alien to the respective craft or related system. 15 years after Space Shuttle Colombia's disastrous foam strike accident, DLR's Mobile Rocket Base (MORABA) performs high velocity impact tests on Improved Orion (IO) fin structures thus supporting the failure investigation of the REXUS-24 flight anomaly.

The respective test campaign was conducted at DLR's Institute of Structures and Design, which is running different gas gun test beds for high velocity impact tests on diverse structural elements. In total, seven impact shots were carried out using original sized and downscaled 320gram hatch assemblies as projectiles. Here the impactor's flight behaviour before and after impact as well as its induced damage pattern under different impact scenarios were the campaign's main objectives.

This work describes the test setup, its test articles used, its performance and the discussion of its related results as well as the failure theory being supported by this test.

[A-065]

SEARCH AND RESCUE – DEVELOPMENT AND VERIFICATION OF A MODERNISED PASSIVE FLOATING SYSTEM FOR PAYLOAD SEA RECOVERY

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For most suborbital space flights, the successful recovery of the experimental payload is a critical point at the very end of the mission. Beside land based recovery, particular missions require a sea recovery in the Arctic Ocean. Therefore, a variety of passive floating systems have been used by DLR's Mobile Rocket Base (MORABA).

Using the vast experience of multiple successful sea recoveries over the last decades, some of the latest development work has been dedicated to a modernised version. In cooperation with TEXCON GmbH, improved long-term floating behavior and a considerably reduced packing volume have been achieved by using innovative materials and manufacturing technologies.

Prior to the first successful operation of the optimized passive floating system, various tests had to be performed to verify the floater's functionality and durability. In this context, the Neutral Buoyancy Facility's (NBF) diving pool of ESA's European Astronaut Centre (EAC) in Cologne was offered for investigating different recovery scenarios.

This paper describes the development and verification process of the modernized passive floating system. Furthermore, results of the first successful operation during the PMWE mission are presented.

[A-049]

E4T – NEW ETHERNET BASED TELEMETRY SYSTEM FOR TEXUS

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Since December 1977, 55 TEXUS rockets and 9 MAXUS rockets have been launched from ESRANGE Space Center in Sweden. The main objectives of these scientific rocket missions is fundamental, physical, material and biological research under microgravity conditions. For the communication between ground and onboard systems, a command uplink with a proprietary data transmission standard is used and an IRIG based standard from board to ground, providing i.a. for low rate serial communication. The objective of the Ethernet for TEXUS Project (E4T) is to provide with an Ethernet based communication standard interfaces for current and future experiments. The envisaged hardware, based on commercial, of the shelf products, provides for transparent Ethernet connection on both sides. This allows the much easier integration of user provided experiments with use of TCP/IP services for bi-directional, flexible communication from the experiment control workstation to the experiment on board. E4T first application is planned for the Perwaves experiment to be flown on TEXUS-56 mission.

[A-057]

THE PAYLOAD SERVICE SYSTEM OF KUNPENG-1B SOUNDING ROCKET

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On April 27, 2016, Kunpeng-1B sounding rocket launched successfully from Chinese Hainan sounding rocket range, conducted by Chinese National Space Science Center, which carried out exploration of space science and technology experiments. In China, it is the first time to develop attitude control system for sounding rocket, and the first time to flight up near to 320km, which improves the Ionosphere and middle and upper atmosphere in-situ detection. Also, the Kunpeng's payload service system provides flight status monitoring and an integrated design of integrated electronic. This paper introduces the payload service system of Kunpeng-1B sounding rocket, and the flight result.

MAGNESTOSPHERE AND IONOSPHERE 1

TUESDAY 18 JUNE, MORNING SESSION – PART 1

ROOM 1

CHAIR: J. MOEN – A. SPICHER

[A-195]

EXPLORING EARTH-SPACE CONNECTIONS IN THE COOLEST PLACE ON EARTH

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The Grand Challenge Initiative – Cusp (GCI-Cusp) is a multinational campaign to gather exciting and multi-faceted data in and near Earth's northern geomagnetic cusp. The cusps are regions where the Earth's magnetic field, instead of acting as a "shield" to keep out the ionized gas of the solar wind, provides a "funnel" that allows direct access of solar wind plasma to the upper atmosphere. This solar wind-atmosphere interaction drives a variety of fascinating phenomena that can only observed in and near the cusp region – ranging from heating and inflation of the neutral atmosphere to the acceleration of oxygen ions by factors of 100 to achieve escape velocity, producing the "auroral wind".

GCI-Cusp consists of a set of nine sounding rocket missions, provided by the US, Norway, and Japan, spanning the interval December 2018 through winter 2020. These rockets provide unique observations of the upper atmosphere and ionosphere, and are strongly complemented by extensive observations from the ground, including radars (EISCAT), all sky imagers (e.g. the Kjell Henriksen Observatory), and ground-based magnetometers.

The GCI-Cusp missions utilize two launch facilities operated by Andøya Space Center – the "standard" launch site in Andenes, and a special launch site in Ny Ålesund, Svalbard (which saw its first launch in 1997). At various times throughout the GCI-Cusp, both sites are used, and in December of 2018 each site had two payloads ready simultaneously, in order to target the cusp along two different trajectories and maximize the chances of launching within the brief windows afforded by moon-down polar night conditions with an active cusp and low wind.

This campaign has been tremendously successful so far, due to the tireless efforts of NASA and ASC staff, as well as our hosts at Kings Bay AS in Ny Ålesund. To date, five of the nine missions have launched, all successfully, and comprising a total of eight separate rocket payloads.

I will share some of the preliminary results from the GCI-Cusp rockets, as well as discuss the multinational partnerships that have made it possible, as well as describe the plans for making the GCI-Cusp data publicly available so that researchers around the world can participate in the analysis.

[A-052]

SS-520-3 SOUNDING ROCKET EXPERIMENT TARGETING THE CUSP ION OUTFLOW

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In order to achieve collective understanding of the microphysics and its role (scale coupling) in the global to meso scale phenomena in the polar ionosphere, Japan-Norway sounding rocket experiment program is now in progress. SS-520-3 sounding rocket is planned to be launched from Ny-Ålesund, Svalbard in Spitsbergen in January 2020. The main objective of this sounding rocket is to understand the particle acceleration processes that cause the ion outflow by making in-situ observation of the wave-particle interaction in the cusp region.

SS-520-3 sounding rocket experiment aims to resolve the wave-particle interaction by making in-situ measurements in the polar cusp with newly developed instruments for the satellite mission. Since these wave-particle interactions are predicted to be effective above 800km altitude, a two-stage sounding rocket SS-520 whose apex can be higher than 750km is necessary. The rocket range where SS-520 can be launched targeting the cusp region is only Ny-Ålesund in Svalbard. Since simultaneous ground based optical observation of the cusp aurora is necessary to decide the launch timing, the best launch period is determined from the conditions of both the sunlight and the moonlight. From the sunlight condition, the best launch period is in the winter polar night that is around the winter solstice. On the other hand, two weeks before/after the new moon is the best launch period from the condition of the moonlight. Launch window for each day is 0700UT-1130UT (0800LT-1230LT: 1000MLT-1430MLT) when the cusp is possibly on the same magnetic field line as the trajectory of SS-520-3.

SS-520-3 sounding rocket experiment is a part of the comprehensive observation campaign including ground-based radar and optical observations. SS-520-3 sounding rocket experiment is also one of the projects participating in “A Grand Challenge Initiative (GCI) Cusp program” that is a large-scale international collaboration for targeting advancement in the common understanding of cusp region space physics.

Although SS-520-3 was planned to be launched in December 2017, the launch was postponed due to mal-function of the timer equipment that was found during the final stage of the integration test. The timer equipment problem has already been completely fixed. However, the severe budgetary situation at ISAS in 2018 prevented the launch of SS-520-3 in winter 2018-2019. Approaching the solar minimum that will be in 2020 in this solar cycle, the opportunities that satisfy the launch condition will decrease since the latitude of cusp becomes higher comparing the apex latitude of SS-520-3. SS-520-3 Payload Instrument team is also considering the possibility to add possible ion outflow over morning side polar cap aurora as an alternative target.

[A-153]

THE TWIN ROCKETS TO INVESTIGATE CUSP ELECTRODYNAMICS 2 MISSION

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As part of the Cusp Grand Challenge, the Twin Rockets to Investigate Cusp Electrodynamics 2 (TRICE-2_ mission was launched from Andoya Space Center on December 8, 2018. The mission consists of two, well-instrumented sounding rockets launched two minutes apart into the Earth's cusp. The TRICE-2 mission uses the two rockets to investigate signatures of magnetic reconnection in the cusp as well as other cusp electrodynamics. The relevant details of the mission will be described including experiment compliment and overall science objectives along with initial experimental results from both payloads.

[A-165]

THE CUSP ALFVEN AND PLASMA ELECTRODYNAMICS 2 MISSION

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Wave-Particle interactions (WPI) play an important role in space physics through formation of electron or ion beams, pitch-angle scattering of charged particles, and plasma heating. As a result, many experiments have been flown to study WPI, but relatively few have probed the unique plasma and magnetic field conditions of the polar cusps. The Cusp Alfven and Plasma Electrodynamics Rocket 2 (CAPER-2) mission was conceived to fill this gap. CAPER-2 included instrumentation to measure both high frequency WPI involving Langmuir waves and low frequency WPI involving Alfven waves, as well as address other pertinent topics in cusp physics such as the nature and sources of electron density structuring and the origins of complex frequency fine structure of cusp Langmuir waves. CAPER-2 was launched successfully Jan 4, 2019, to 774 km in the cusp ionosphere over Svalbard. Ground based optical and radar diagnostics were critical for determining the launch conditions. This talk will review science goals, instrumentation, launch conditions, and preliminary data analysis. CAPER-2 was part of the Cusp Grand Challenge initiative comprised of twelve rocket launches from Andoya and Ny Alesund rocket ranges in 2018-2019.

[A-086]

INVESTIGATION OF F-REGION PLASMA IRREGULARITIES BY THE GRAND CHALLENGE INITIATIVE-CUSP MULTI-ROCKET PROJECT

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The Grand Challenge Initiative – Cusp (GCI-Cusp) is a strategic effort between NASA, JAXA and the University of Oslo (UiO) and Svalbard Integrated Arctic Earth Observing System (SIOS), to coordinate individual sounding rocket missions into a joint initiative in order to strengthen the potential for a breakthrough in answering grand challenge questions about Solar Terrestrial coupling to the polar cap ionosphere. In this talk we will present the launch conditions for the VISIONS-2, TRICE-2, and CAPER-2 missions, comprising a total of five sounding rockets. In different flight geometries, all of them encountered transient cusp auroral forms.

Particular focus will be laid on plasma irregularities measured with UiO's multi-Needle Langmuir Probe System, and on how regions of plasma irregularities/turbulence relate to mesoscale gradients in the plasma density, the imposed electric field, and to Birkeland current/electron precipitation. The possible irregularity formation mechanisms will be discussed. At the end, information will be given about the SIOS data management system for storing and making data open, accessible and reusable for new research projects developed also outside the GCI-cusp consortium.

[A-157]

OBSERVATION OF MESOSPHERIC SMOKE PARTICLES AND IONOSPHERIC CONDITIONS DURING THE G-CHASER ROCKET CAMPAIGN

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The G-chaser student rocket was successfully launched from Andøya 13. January 2019 09:13:00 UTC. Onboard were 8 student experiments, including one from the University of Tromsø (UiT): the Smoke Particle Impact Detector (SPID). The goal of our experiment was to observe mesospheric smoke particles (MSPs) and secondly investigate the relation of MSPs to Polar Mesospheric Winter Echoes (PMWE).

The SPID design is based on two previous faraday cup impact detectors, MUDD and DUSTY, that were successfully used to measure ice embedded MSPs during the summer. The instrument design was changed for detection of the smaller MSPs, present in the polar winter mesosphere. Numerical simulations were carried out, they include neutral and charged flow simulations inside the probe. The simulations helped to define electrical settings and optimizing the mechanical design to increase the flow through the instruments.

Many researchers believe that the presence of charged dust, possibly MSPs, is important in the formation process and occurrence of PMWE. PMWE are strong radar echoes that are observed at altitudes from 50-80 km. To monitor the mesospheric activity during the campaign (from 9. to 13. January), we followed the observations of the MAARSY radar that was operated with five beams in the direction of the predicted trajectory. However, MAARSY did not show PMWE prior to and during the launch. EISCAT VHF and UHF located in Ramfjormoen were also operated (daily from 03:00 to 12:00 UTC). EISCAT UHF pointed toward the volume over Andøya in the predicted trajectory, while the VHF was set to 90 degrees elevation. Both the VHF and UHF observations showed strong electron precipitation down to 80 km on the launch day. Neither radar observed PMWE during the rocket flight.

The lack of PMWE could indicate an absence of charged particles, and a higher content of neutrals. This is in line with our first view of the SPID data. The measurements suggest that the majority of the detected particles were neutral. Further inspection of the observations from EISCAT will give more information on the background ionospheric conditions. We investigate the radar and the SPID measurements to derive the particle flux and possibly an estimate of particle radii and discuss the possible link to radar observations.

Technology & Infrastructures for Sounding Rockets 2

Tuesday 18 June, Morning session – part 1

Room 2

Chair: K. Blix

[A-059]

FIRST TRIPLE REXUS CAMPAIGN – FLYING SYSTEMS TWICE ON ONE ROCKET CAMPAIGN

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For the first time in 12 years of REXUS history an on-range reconditioning of flown systems was performed. The Mobile Rocket Base (MORABA) accomplished an "on-range check" to reuse two already flown modules during the same campaign. The trigger was the REXUS 24 non-nominal flight. Because of this REXUS 23 was on hold and finally was accepted to launch during the REXUS 23/ 25/ 26 triple campaign. The campaign was executed with just two service and two recovery systems for three rockets. This means a reuse of systems on the same campaign was crucial for a successful three-launch campaign. Using a new procedure for checking the systems' condition, MORABA could reduce the costs without affecting the quality of the additional flight, provided the flown systems' were in proper shape after their first flight. The aim of the paper is to illustrate the campaign procedure as well as the benefits and the disadvantage of the used "on-range check" for the service and recovery module.

We analyse and compare the REXUS triple campaign with a usual REXUS double campaign. We discuss the different technical procedure, the risks of an "on-range check" and the outputs of the campaign activities. In conclusion, the "on-range check" makes the campaign more effective but it also holds unforeseen risks.

[A-069]

VALIDATION OF THE T-MINUS DART ROCKET SYSTEM USING A STEPWISE TEST APPROACH

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The T-Minus DART rocket system is designed for scientific research in the middle and upper atmosphere, as successor of the unavailable Viper and Super Loki rockets previously used in the atmospheric research field. The performance of the DART compared to its predecessors is much higher, and in combination with robust and durable active payloads, the introduction of the system enables a new research in the atmospheric science domain.

The flight vehicle and the rocket motor are developed following a stepwise test approach. This limits the operational safety risk as well as the cost of testing. Critical elements are tested on a small scale first, when the TRL is low. Knowledge gained in these tests is implemented in the larger-scale tests, leading to a full-scale validation of the system.

For the flight vehicle, the test vehicles TV-01 to TV-03 were flown to lower altitudes to test certain subsystems, such as booster-dart separation, electronics functionality and aerodynamic stability. TV-04 and beyond will be flown from the EASP ranges to 140+ km beginning from May 2019.

The motor of the DART vehicle features a segmented propellant grain, which allows a stepwise motor validation program by testing increasing number of segments. Next to that, it leads to a customizable motor design. For validating the propellant formulation of DART, a small 70 mm test-set-up was devised to characterise the burning characteristics. After that, a single DART motor segment was produced and a so-called "SGM-test" or Single Grain Motor" was performed. This SGM in itself is already a flyable 5 kNs rocket motor. After the SGM test series, a "DGM test", or "Dual Grain Motor" series was performed, testing the interaction between the burning propellant and the casing. These tests accumulated to a full-scale DART motor test-campaign, validating the DART rocket motor for the TV-04 flight campaign.

The motor performance data obtained in these tests was used as input for the flight trajectory simulation of the EASP ranges that support the flight safety assessment.

[A-044]

FROM GROUND-BASED FACILITIES TO SUBORBITAL FLIGHTS

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The Center of Applied Space Technology and Microgravity (ZARM) founded in 1985 is part of the Department of Production Engineering at the University of Bremen, Germany. ZARM is mainly concentrated on fundamental investigations of gravitational and space-related phenomena under conditions of weightlessness as well as questions and developments related to technologies for space. At ZARM about 100 scientists, engineers, administrative staff, and many students from different disciplines are employed. Today, ZARM is one of the largest and well-known research center for space sciences and technologies in Europe.

With a height of 146 m the Bremen Drop Tower is the predominant facility of ZARM and also the only drop tower of its kind in Europe. ZARM's ground-based laboratory offers the opportunity for daily short-term experiments under conditions of high-quality weightlessness at a level of 10-6 g. Scientists may choose up to three times a day between a single drop experiment with 4.74 s in simple free fall and an experiment in ZARM's worldwide unique catapult system with 9.3 s in microgravity. Since the start of operation of the drop tower facility in 1990, over 8500 drops or catapult launches of more than 250 different experiment types from various research fields like fundamental physics, combustion, fluid dynamics, planetary formation / astrophysics, biology, chemistry, and materials sciences have been accomplished so far. In addition, more and more technology tests have been performed under microgravity conditions at the Bremen Drop Tower, in order to prepare single space instruments or appropriate space missions in advance.

In this paper, we demonstrate a simple approach to realize microgravity experiments on suborbital flights by preparing and qualifying the setups at the Bremen Drop Tower. It means a full payload integration into the specific sounding rocket module to perform preliminary drop tower experiments under short-term microgravity conditions with the identical suborbital hardware, e.g. testing the overall setup, probing experiment parameters, obtaining first results in microgravity, etc.. A full qualification of the integrated flight module, doing additional shaker or thermal vacuum tests for instance, is also offered with the help of services by ZARM Test Center. In this way, a comprehensive preparation and qualification of sounding rocket setups is possible at ZARM.

Furthermore, we report about our experiences of such an approach during a suborbital flight with the New Shepard vehicle of Blue Origin in the USA in 2018, at which we were the first commercial customer to fly research payloads from Europe. Also, the status of experiment preparations utilizing the Bremen Drop Tower for the very first upcoming suborbital payload flight on the new European sounding rocket, MIURA 1, of PLD Space (Spain) is presented.

Finally, we introduce a novel ground-based facility called GraviTower Bremen - Prototype (GTB-Pro), which is currently under construction at ZARM. This GTB-Pro represents an actively driven drop tower system that is capable to perform over 100 short-term microgravity experiments per day. It offers a further alternative performing dedicated microgravity research or preparing experiments for suborbital flights.

[A-112]

SHEFFIELD UNIVERSITY NOVA ROCKET INNOVATIVE DESIGN ENGINEERING (SUNRIDE)

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Sheffield University Nova Rocket Innovation Design Engineering (SunrIde) was the first ever and only student-led rocketry team from the UK to participate in Spaceport America Cup (SA Cup) 2018, the largest space industry-backed annual rocketry engineering competition in the world. The University of Sheffield team launched and recovered a self-designed, payload-carrying rocket that reached an altitude of 10,017 ft (≈3,053 m) above ground level (AGL), winning the James Barrowman Award for Flight Dynamics for the most accurate altitude prediction, at 99.83%. The success recorded by SunrIde at SA Cup 2018 sets an important precedent for aspiring students in the STEM field across the UK. It encourages them to expand their engineering skills within the academic framework by means of a practical project, increasing the UK's presence on the scene of international high-power rocketry.

Project SunrIde was started in October 2017, with the help of Dr Viktor Fedun and a majority of MSc students from the Departments of Automatic Control and Systems Engineering (ACSE) and School of Mathematics and Statistics (SoMaS) of the University of Sheffield (UoS), as part of its Sheffield Space Initiative (SSI). The team was also proud to collaborate with Charles Simpson from the UK Rocketry Association (UKRA) through their Team Project Support (TPS) scheme, which offers essential practical advice on projects that fall outside the traditional scope of the UKRA level 1-3 certification training programme due to their completion by a team.

The main agenda of the SunrIde team was to research, design and build a payload-capable high-power reusable rocket that would qualify for competing in SA Cup 2018 under the category '10,000 ft above ground level (AGL) apogee with commercial-off-the-shelf (COTS) solid propulsion system'. According to the competition rules, the rocket was to reach the projected 10,000 ft (≈3.048 m) mark at apogee within the smallest margin possible, while carrying either a 3-unit CubeSat non-functional 'boiler-plate' payload or a scientific experiment, both hefting no less than 8.8 lb (4 kg), with a 5% weigh-in allowance.

Keywords: High-power rocketry, ACSE, UKRA, Spaceport America Cup, SunrIde, University of Sheffield, IREC, ESRA

[A-099]

A COMBUSTION STABILISATION METHOD IN A NITROUS OXIDE BASED HYBRID ROCKET ENGINE

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Combustion instabilities are a major concern during the development of compact and high power hybrid rocket engines. Results of experiments reported in the literature suggest that stable combustion cannot be achieved if the oxidiser mass flux through the combustion chamber port exceeds approximately 700 kg/s/m2. This paper describes a new combustion stabilisation method, which focuses on the shape of the port inside the fuel grain. Thanks to modification of the port shape the engine can operate steadily with the oxidiser mass fluxes greater than 1000 kg/s/m2. This allows to build a very compact combustion chamber and/or maintain a high thrust of the engine. The effectiveness of this kind of stabilisation method was proved in a series of experimental tests during which different combustion chamber geometries were compared in terms of combustion stability. As a result of the experimental tests the novel combustion chamber design concept proved to be successful in a wide range of engine sizes, with a peak thrust ranging from 0.3 kN to 10 kN and the total engine impulse from 1.5 kN·s to 200 kN·s. This method was developed by a Polish company SpaceForest, while working on a line of SF (SpaceForest) hybrid rocket engines built to power in-house developed sounding rockets.

Utilisation of Rockets for Research Applications 1

Tuesday 18 June, Morning session – part 1

Room 3

Chair: F. Huber

[A-166]

BEXUS 27 LUSTRO – DESIGN AND TEST OF THE LIGHT AND ULTRAVIOLET STRATO- AND TROPOSPHERIC RADIATION OBSERVER

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The "Light and Ultraviolet Strato- and Tropospheric Radiation Observer" (LUSTRO) student experiment is based on the idea of completion of satellite- and ground-based measurements of ultraviolet radiation observation (>200nm) during balloon flight. Collected data are examined in terms of differences in reflection and absorption in the troposphere and lower layers of the stratosphere, especially through the clouds.

Measurements part is composed of low-cost rotating-mirror camera, creating an image; the radiation-sensitive elements are UV/VIS photodiodes. On board computer collects additional data from IMU (inertial measurement unit), RTC (real time clock) and encoders. Information from all sensors are correlated in post-analysis. As result, it should present the three-dimensional UV and VIS intensity of radiation. This can be compared with ground and satellite measurements. It should prove itself to be more intuitive for the experiment crew and other researchers to define the structures of the UV reflection and absorption regions. Typical, full-semiconductor matrix UV cameras present high financial issues - LUSTRO is to overcome these issues, providing an affordable way of creating scientifically valuable data of ultraviolet structures in the atmosphere.

On the 18th of October 2018 a test flight took place. During the Launch Campaign of REXUS/BEXUS programme (cycle 11) the prototype of device was prepared and tested. The data was collected from takeoff to 20 km height by a radio communication with a ground station. At 20 km the connection was lost. After landing the failure investigation was performed. The cascade problem with subsystems was detected and a low temperature was the cause. However, the basic objectives of experiment were achieved and the results could be presented.

[A-160]

MORABA ACTIVITIES IN RETROSPECT – NEW FLIGHT TEST CAPABILITIES & COMPETENCES

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Sounding rockets continue to form a cornerstone of flight testing capabilities in Europe. They support research areas such as microgravity, aerothermodynamics, atmospheric physics and astronomy. DLR's Mobile Rocket Base (MORABA) develops and utilises technologies in medium and large sized sounding rocket vehicles in order to secure the testing capabilities for the established research fields. The continuous extension of the performance and flight envelopes through improvements in flight hardware of the vehicle, along with thermal protection systems, allow the advancement of sounding rockets into new experiment classes.

Within the MAPHEUS program, rocket motor combinations like S31-IM and IM-IM are developed and flight qualified to form up-to-date vehicles. The very large S50 motor, consisting of twelve metric tons of composite propellant, will be the core stage for the suborbital VS-50 vehicle and the micro-satellite launcher VLM-1, developed through the international collaboration with DCTA/IAE. A new three-stage vehicle (S31-IM-IO), as part of the STORT program, will offer velocities up to Mach 10 at altitudes below 50 km, so called suppressed trajectories.

MORABA has established a strong capability in customization and operation of flying testbeds for space transportation technologies. This capability serves the development of TVC systems as well as control strategies, materials and in-flight health monitoring. Mission design and operations is presently becoming a field of major interst as payload reusability with low maintenance requirements and immediate re-flight is gaining importance. Developments and modernisations in payload support technologies such as recovery and service systems ensure that the researcher is provided with state of the art capabilities and infrastructure for the conduct of experiments.

Student programs such as REXUS/BEXUS and STERN ensure hands-on education and motivation of students in the field of space transportation. The success of the existing programs impressively demonstrates the usefulness of such programs and demands their further development.

[A-155]

SOUNDING ROCKET SHARE-RIDE CONCEPT FOR EVERYONE

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Sounding rocket missions have the past decades generally been used by Space Agencies or large organisations that fly experiments, being the single user of the platform. The cost for development of experiments and the cost for rocket payload integration and launch ("flight ticket") often exclude organisations with small or single experiments – and small budgets – from using sounding rockets as test platform. With a ride-share concept, where a scientific payload is constituted by experiments of several users of different funding organisations, the availability and cost of sounding rocket flight becomes affordable also for users not filling up a whole payload. The flight ticket cost is distributed over a handful of customers, each user's cost being significantly less than it would be for a single-use flight.

SSC re-introduced in 2017 the concept shared payload with accommodation of several customers; agencies, academia and commercial on the same mission, with the objective that the flight opportunity should be available for everyone. The interface to the payload is straight-forward and easy to adapt to any specific experiment requirements. The shared-ride flight concept offers frequent flight opportunities for small payloads that otherwise in the best of cases would play the role of secondary payload, with late-confirmed flight opportunity, on someone else's sounding rocket mission.

The specific platform in this case is the MASER microgravity sounding rocket. In order to expand flight opportunities for the community, SSC has made an announcement of MASER flight opportunity every 18 months, with next flight opportunity planned for November 2020 (MASER 15).

MASER microgravity sounding rocket programme is run by SSC, Sweden since 1992 with launches from Esrange Space Center in northern Sweden and ground impact in a restricted vast area. Experiments are recovered within hours after the flight. In combination with the microgravity experiments, the platform can accommodate mechanisms for releasing free-flying bodies for very high altitude drop tests (260 km), which extends the share-ride concept to many other research and technology disciplines.

This paper elaborates on the shared-ride concepts of sounding rockets launched from Esrange Space Center – on microgravity missions as well as on very basic sounding rocket platforms.

[A-135]

THE NAMMO NUCLEUS LAUNCH: SOUNDING ROCKETS FLIGHT RESULTS

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On Thursday 27 September Nammo successfully completed the first launch of Nucleus, a new sounding rocket powered by its new hybrid rocket motor. Nucleus launched at 14:16 local time from Andøya Space Center (ASC) in Northern Norway, and reached an altitude of 107.4 km. That made it not only the first rocket powered by a Norwegian motor design to cross the Karman line, the commonly recognized border to space, but also the first European hybrid rocket motor to do so in more than 50 years.

Nucleus is a Norwegian sounding rocket, designed to lift scientific instruments into the upper layers of the atmosphere. It is 9 meters long and has a total weight of around 800kg, including 70kg of payload. The hybrid rocket motor powering Nucleus has been developed by Nammo at Raufoss in Norway, as part of ESA Future Launchers preparatory Programme (FLPP). It uses liquid high concentration hydrogen peroxide and a rubber-type solid fuel as propellants, generating a thrust of 30 KN (3 tons) for 40 seconds duration.

For this first flight, Nucleus carried 4 technical experiments aloft. The main one is the Nammo hybrid propulsion, for which the Nucleus was the first flight demonstration, aiming at showing future capabilities for sounding rockets and micro-launchers. In the Andøya Space Center payload, the most important experiment was the ASC/UiO 4D-SPACE module loaded with its 6 daughter payloads. During flight, the daughters were released 2 at the time when the rocket passes 60 km altitude. They measured small-scale plasma structures and transmitted data back to the main 4D-Space module. In addition, ASC also tested a newly self-developed pyrotechnical system and an inertial unit (IMU) from Sensonor AS.

The Nucleus launch was a complete success both in terms of the experiments on board and of the vehicle trajectory. Furthermore, all flight on-board data was successfully acquired through telemetry signals. This article will present the results from the flight, detailing the behavior of the Nammo hybrid rocket engine and Nucleus sounding rocket in flight. It will show how Nucleus enabled successful experiments to be carried out, and can do so again in the future.

[A-068]

SOUNDING ROCKET ACTIVITIES SUPPORTED BY CHINESE MERIDIAN PROJECTS

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During the period from 2010 to 2016, several sounding rockets, named KUNPENG, were launched from Chinese Hainan sounding rocket range, which were supported by the Chinese Meridian Space Weather Monitoring Project I(Meridian project for short). With support of the ongoing Chinese Meridian project II, more sounding rockets are planned to be developed and launched in the near future.

Conducted by Chinese National Space Science Center, Scientific payloads for sounding rockets were developed and carried out with altitude up near 320km, to detect ion density, electron density, electric field strength, magnetic field strength of Ionosphere, and temperature, density, wind field, of the middle and upper atmosphere. And, the payload service system has been developed to support attitude control, telemetry, data management, and so on.

The paper gives a brief overview of these sounding rocket activities, launched in recent years or scheduled for launch in the near future supported by Chinese Meridian Projects.

MAGNESTOSPHERE AND IONOSPHERE 2

TUESDAY 18 JUNE, MORNING SESSION – PART 2

ROOM 1

CHAIR: J. MOEN

CHARGING AND DETECTION OF MESOSPHERIC DUST WITH INSTRUMENT SPID ON G-CHASER ROCKET

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The student rocket G-Chaser was launched successfully on the 13th of January 2019 from Andøya, Norway. It was a part of the Grand Challenge Initiative; a collaboration between Colorado Space Grant Consortium, NASA Wallops Flight Facility, Andøya Space Center and University of Oslo. The University of Tromsø developed a probe called SPID; Smoke Particle Impact Detector, situated on the top deck of the G-Chaser rocket. SPID is designed to measure dust, presumably mesospheric smoke particles at altitudes of 50 to 80 km. These smoke particles are relatively unknown and to understand their role in atmospheric processes and phenomena they need to be studied extensively. This is hard due to their small size and location high in the atmosphere; making rocket measurements an important tool.

SPID is a faraday type instrument where several grids with a bias voltage shield out the ambient plasma. A larger concentric and inclined grid in the middle is used to measure the dust particles. The particles are charged when they encounter the grid, because the difference in the work function of the particles and the inclined grid causes a charge transfer from the particles to the grid or vice versa. And since the work function is dependent on the composition and size of the particles the total current measured on the impact grid can give information on the smoke/dust particles.

First results show that the instrument worked nominally; the current measured right after the nosecone was ejected suggests that the instrument was most likely hit by neutral dust particles. From simulations of the airflow around the instrument we estimate the size of particles that could enter. We investigate the secondary charging of the dust in the detector and the payload charging to derive dust properties from the measured currents.

ON THE SOURCE AND NATURE OF IONOSPHERIC PLASMA IRREGULARITIES: ADVANCES MADE THROUGH THE INVESTIGATION OF CUSP IRREGULARITIES SOUNDING ROCKET PROGRAM

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Plasma density irregularities are very common in the F region ionosphere at high latitudes. Small-scale irregular structures of the order of a few meters to a few kilometers are important for space weather applications, as they can affect high frequency (HF) radio communication and cause ionospheric scintillations, degrading Global Navigation Satellite Systems (GNSS) signals. In order to develop accurate models of ionospheric space weather, it is essential to investigate and understand the underlying small-scale physics responsible for ionospheric irregularities, which may involve plasma waves, instabilities, and turbulence.

With for challenging goal to resolve the mechanisms responsible the formation of scintillation irregularities at high latitudes, a sounding rocket program was started at the University of Oslo: the Investigation of Cusp Irregularities (ICI) sounding rocket program. As a result, significant progress have been made in characterizing the sources and nature of high latitude plasma irregularities, and some of the most important findings are reviewed here. In particular, further evidences of the importance of the gradient drift instability and of direct particle precipitation for plasma structuring at medium and small scales are given. In addition, it is shown that micro-scale instability mechanisms may be active and act on larger scale inhomogeneities as a two-step process. At last, unresolved issues and the future of the ICI program are presented, i.e., the ICI-5 sounding rocket, the Norwegian contribution to the Grand Challenge Initiative – Cusp.

[A-125]

MAPPING OF TURBULENCE AT THE HIGH-LATITUDE IONOSPHERE USING ICI-2 AND ICI-3 SOUNDING ROCKET DATA

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The primary objective is to explore the physical properties of plasma turbulence in the F-region ionosphere. The aim is to obtain a quantitative characterization of turbulence in the cusp/polar ionosphere, which yet is still poorly explored. Spicher et al. 2014 reported a direct observation of double-slope power spectra for plasma irregularities and Kelley 2009 suggested the presence of different current-driven instability may dominate the kinetic processes at the highest frequencies.

Investigation of the plasma structures using methods based on cross-correlation between the signals obtained by the different sounding rockets is necessary. This approach reveals important information regarding the scales involved, the level of turbulence in the fluctuations observed, and a quantitative measurement of the intermittency developed. The electron density and the electric field fluctuations from ICI-2 and ICI-3 missions have been analysed using time-series analysis techniques and standard diagnostics for intermittent turbulence. The following parameters have been obtained: the autocorrelation function; the associated energy power spectrum; the Probability Distribution Functions (PDFs) of the scale-dependent increments and the kurtosis. The autocorrelation function gives useful information about the correlation scale of the field (Pope 2000); the energy power spectrum shows a power-law scaling exponent with a mean value ~ -1.7, not far from the Kolmogorov value $-5/3$ observed at MHD scales (Leamon 1998), while a steeper power law is suggested below kinetic scales (Sahraoui 2006) with exponent which we find in the range between -2.1 and -2.8 (similar results were found in Spicher et al. 2014). The observed spectra seem to indicate that the typical behaviour of space where turbulence might be developing as a consequence of, or superimposed to, the Kelvin-Helmoltz instability. The PDFs of the scale-dependent increments show a typical deviation from Gaussian characterized by high tails that increase towards small scales due to intense field fluctuations, indication of the presence of intermittency (Frisch 1995, Sreenivasan 1999, Bruno 2005). Finally, the kurtosis scaling exponent (Anselmet 1984, Sreenivasan 1994) is consistent with an efficient intermittency, usually related to the occurrence of structures. The analysis tool will help to pave the way for the incoming data from the missions involved in the Grand Challenge Initiative-Cusp (GCI), of which the UiO is partner having multi-Needle Langmuir Probe instruments onboard CAPER-2, VISIONS-2 and TRICE-2 rockets that were launched during the winter of 2018/2019. Data from these rockets will be analysed with the same analysis tool to claim the robustness of the observed results and will be also used to prepare the ICI-5 4DSpace rocket experiment, in order to create a forecast mapping of the turbulence that we will expect to find.

[A-175]

ESTIMATION OF TURBULENT ENERGY DISSIPATION RATE BASED ON SPORADIC-E PARAMETERS

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Eddy turbulence plays an important role in the lower ionosphere. Above an altitude of 80 km a source of the turbulence may be destruction of the atmospheric gravity waves and tides propagating from the lower atmospheric layers and also the nonlinear interaction of planetary waves and tides. Large-scale atmospheric motions responsible for a vertical shear of the neutral wind are necessary for the production of mid-latitude-type sporadic-E layer. The sporadic-E layer is a bright example of the ionosphere-atmosphere interaction. If the sporadic-E height is below the homopause level (about 120 km), the turbulence exerts an essential influence on sporadic-E parameters. Therefore, parameters of the turbulence can be determined with the use of sporadic-E ones. A fundamental parameter of turbulence is the mean rate of turbulent energy dissipation. Estimation of the rate by using sporadic-E parameters is the purpose of this report. To obtain an expression that connects the dissipation rate with sporadic-E parameters, the results of sporadic-E wind-shear theory and the Richardson–Obukhov law for turbulent diffusion are used. The derived formula permits to estimate the turbulent energy dissipation rate if one knows the sporadic-E thickness, the Hall parameter for ions in the plasma layer, and measurable parameters of the vertical shear in neutral wind that produced sporadic-E. Results of sounding rocket experiments will be very useful to verify correctness of the obtained expression.

[A-055]

THERMAL ELECTRON ENERGY DISTRIBUTION IN THE LOWER ATMOSPHERE

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Sounding rocket "S-310-44" was launched from Uchinoura Space Centre in Japan on January 15, 2016 to investigate electron heating and the related anomalous phenomena near the Sq current focus in the lower ionosphere. A total of 5 instruments were installed to measure electron energy distribution, electric field, magnetic field, and plasma wave on this rocket. These parameters are believed to dominate the physical process responsible for the electron heating. In this presentation, we will discuss a result of our recent analysis on the electron energy distribution obtained during the rocket flight.

In the measurement of Fast Langmuir Probe (FLP), one of the five onboard instruments, it is possible to estimate energy distribution of thermal electrons from the second derivative of the probe current with respect to the applied voltage once the space potential can be determined on the rocket.

The FLP Data obtained in the altitudes below 100 km show ordinary energy distribution of ionospheric electrons by which the electron temperature and density can be calculated from the gradient in the electron deceleration region and the space potential. The electron temperature derived from the electron energy distribution was slightly (~200 K) larger than the background temperature at 100-110 km altitude. On the other hand, it becomes difficult to determine a position of the space potential in the altitude range between 100 and 110 km probably due to electron density irregularity in this region. Another feature is that bimodal peaks in the second derivative were found to exist in the higher energy range with respect to the space potential above 110 km altitude. A possible cause of such bimodal energy distribution will be 1) Bi-Maxwellian energy distribution with two different temperatures, 2) Electron temperature anisotropy, and 3) Two distributions consisting of stational ionospheric electrons and higher energy electrons. In addition, another characteristic of the observed energy distribution is that the peak current in the second derivative has a periodic variation according to the phase of rocket spin, which may be related to the cause of such a distribution. In this presentation, we will discuss the latest result of our analysis of the electron energy distribution.

[A-088]

BALLOONS IN THE EARTH'S AURORAL SCIENCE

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In addition to its unique features of cost efficiency and student training, scientific balloons also fill the gap between ground- and space-based auroral observations. Since 1892, when an aurora was first imaged by Martin Brendel, a German physicist, auroral forms and their dynamics have been acquired only when the aurora is in darkness. For ground-based observations, it has been a long-term challenge and curiosity to image sunlit aurora, mainly due to sunlight contamination from Rayleigh scattering. In addition, other constraints exist, such as moonlight contamination, cloud occultation, and the limited land area available for installing imagers near the auroral zone in both hemispheres. While auroral imaging from space provides auroral global dynamics or small scale-structures depending on the spacecraft orbit, the image quality is affected by low spatial and temporal resolutions, sunlight, and the lack of traceability of auroral variations (e.g., TIMED/GUVI, a spectrograph). Consequently, we have little knowledge of sunlit auroral forms and their dynamics, as well as their coupling to conjugate aurora. Given the fact that the solar wind-magnetosphere-ionosphere coupling is initiated in the dayside, understanding sunlit auroras becomes very interesting and important. Atmospheric models predict that sky brightness decreases with increasing altitude and wavelength, suggesting that it is possible to image the aurora at near-infrared (NIR) wavelengths from sufficient altitudes. This is later confirmed by imaging the N_2^+ Meinel band auroral emissions at ~1100 nm from Poker Flat, Alaska, during twilight when the sky brightness is similar to that at ~40 km altitude in the Antarctic summer. The Meinel band auroral emissions occur with all types of aurora in similar brightness of the oxygen forbidden lines, and are generated by precipitating electrons at few 100 eV to few 10s of keV. Imaging aurora from a balloon overcomes the limitations from ground and space, meanwhile making good coordinate observations with them. The development of large-format InGaAs detectors in the NIR imaging industry makes this project as ready as it will ever be. Currently, we are designing the imaging system, including the NIR camera, the onboard data processing unit, and the optical section. This paper also discusses the science objectives, technical methodology, and mission requirements.

[A-040]

A HISTORIC SURVEY OF AURORAL HYDROGEN EMISSIONS

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On the 18th of October 1939 Lars Vegard discovered H alpha (656.3 nm) and H beta (486.1 nm) spectral lines of the Balmer series, in northern lights. After World War II, spectroscopists Vegard, Gartlein and Meinel investigated other characteristics of the hydrogen emissions. The 3rd line in the Balmer series, $H\gamma$ at 410 nm, was demonstrated prior to the space age. Based on satellite observations, the Balmer H delta and H epsilon lines - at 410.13 nm 396.97 nm, as well as the extreme ultra-violet Lyman alpha line at 121.6 nm of hydrogen, have also been detected. Hydrogen emissions often appear as wide proton-arc-ovals of light. Before magnetic midnight the hydrogen oval lies equatorward of electron generated aurorae. After magnetic midnight H-emissions are mainly observed poleward of the electron oval. Sounding rocket data showed that hydrogen radiation mostly comes from altitudes between 105 and 120 km, but new measurements are needed.

Doppler blue shifts in hydrogen lines, first established in the 1940s, indicated that emitting particle energies often extended well into the keV range corresponding to proton velocities > 1000 km/s. This in turn, suggested that protons of solar origin precipitated into the topside ionosphere, where they undergo charge-exchange events with atmospheric neutrals. Newly excited hydrogen atoms then emit the observed Balmer radiation.

The H alpha and $H\beta$ emissions in the northern lights are sub-visual. The strongest Halpha emissions seldom reach half a kR. Statistical studies show that H alpha emissions are 3 to 5 times more intense than those of $H\beta$. However, during some events, ratios between 2 and 10 have been found. When the ratio between the intensities of the 1st Negative Band of N_2^+ at 427.8 nm and H alpha falls to less than 3, such events are called pure proton aurorae.

Data from satellite-borne sensors have made two significant contributions, (1) Energetic particle detectors demonstrated the existence of regions in the magnetosphere, conjugate to night-side proton aurorae, where conditions for breaking the first adiabatic invariants of keV protons prevail, allowing them to precipitate through continuously refilled atmospheric loss cones. They also reflect effects of different drift paths allowed to electrons and protons. (2) EUV imagers showed that dayside hydrogen-emissions appear in response to changes in either the solar wind's dynamic pressure or the interplanetary magnetic field's north-south component.

UTILISATION OF BALLOONS FOR RESEARCH APPLICATIONS 1

TUESDAY 18 JUNE, MORNING SESSION – PART 2

ROOM 2

CHAIR: V. DUBOURG

[A-142]

TOWARDS A EUROPEAN STRATOSPHERIC BALLOON OBSERVATORY: THE ESBO DESIGN STUDY

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Stratospheric balloons offer very attractive observational and operational conditions for many fields of astronomy. Yet, only a comparatively small part of the respective astronomical communities makes regular use of the possibilities offered by balloons. Surveying these research groups, the most prominent reasons seem to be a combination of the challenges associated with large balloon payloads (such as safe payload recovery and precise pointing) and the specialized expertise required for large stratospheric balloon missions and their payloads that most astronomical research groups do not have. While a visible trend towards providing more specialized equipment to address the needs of astronomical missions exists within the scientific ballooning community, a true operating institution for astronomical missions, in the sense of e.g. the European Southern Observatory for ground-based observatories, is missing. We propose to work towards forming such an institution within Europe. Our concept thereby focuses on offering regular flights of reusable platforms, with exchangeable instruments and potentially exchangeable telescopes. Such an institution would provide research groups with options to fly their own instruments, but also proposal-based access to observation time, opening up the stratosphere for many more astronomers.

Within this paper, we present the corresponding concept of a European Stratospheric Balloon Observatory (ESBO) as well as the work currently being undertaken within the ESBO Design Study to establish such an infrastructure.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 777516.

[A-163]

A BUS SYSTEM FOR SMALL HIGH ALTITUDE BALLOON EXPERIMENTS

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BUBBLE (Buoyancy Balloon Bus Lifted Experiment) is a program of the student-run small satellite group (KSat) of Stuttgart, who will launch stratospheric high-altitude research balloons regularly. A bus system is being developed for the gondola, which provides the power supply and data communication to the ground station. In addition, the BUBBLE program includes the setup of the sounding balloon as well as its launch and recovery. The program enables high-altitude flights for research projects.

The BUBBLE 1 project is the first balloon to be built as part of the program and was launched on January 22, 2019. The first payload comes from the Institute for Space Systems (IRS), University of Stuttgart.

The bus system of the gondola consists of a Raspberry Pi, by which BUBBLE can be controlled. Python is used as the programming language. During the flight, the balloon's position is continuously transmitted to the ground station via satellite and radiosonde. Other sensor data is sent via RTTY (Radio Teletype) and IRIDIUM. Thus, the communication system is redundant. The software of the sounding balloon has different software interfaces, which enables it to coordinate different programming languages of the various payloads. Therefore, it is possible to promote a large number of research projects. For the first flight, the payload and the bus system used the same programming language. Another special feature is that researchers can use BUBBLE´s sensors so that they do not have to install them themselves. Further sensors will be installed in subsequent BUBBLE projects in order to provide a wide range of test facilities for the payloads. All electronic devices, including the payload, are supplied with a rechargeable battery.

The gondola itself consists of two separate pyramids in order to increase stability and to protect the electronics from external influences like foreign particles and rain. In addition, access to the payload and bus components is simplified. A special attribute for the first payload is that a pool noodle is mounted to the lower pyramid, which increases the inertia of the gondola to stabilize the flight.

The helium-filled balloon is designed to burst after approx. 2 hours of flight time at a height of 33 kilometers. The gondola will glide gently with a parachute to the ground.

Launch and landing of the BUBBLE 1 gondola were successful.

This paper will present the BUBBLE program along with the detailed design and first flight results of BUBBLE 1.

[A-145]

STRATOSPHERIC MUON DETECTION – CADMUS BEXUS 24

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The decay of muons created from cosmic rays is strongly affected by relativity, as their half-life undergoes the relativistic effect of time dilation at a measurable scale. Assuming that there is a continuous beam of muons coming from space due to cosmic rays, it is possible to estimate which exponential curve fits better with the muon decay function so as to calculate their half-life, by measuring the muon flux at different altitudes in the atmosphere.

This experiment seeked to confirm that Special Relativity works for particles that travel close to the speed of light, by experimentally obtaining the half-time of muons. To do so we measured the flux of muons at a continuous rate, all through the atmosphere (from 0 to 30 km from the Earth surface) building a cloud chamber, a simple particle detector that, thanks to a supersaturated atmosphere of alcohol, can keep track of the charged particles that cross the detector.

This project was part of BEXUS24 and was developed by a team of 5 students at UPC - BarcelonaTech. It consisted in recording images of the chamber at a fast rate and tracking at which altitude each picture was taken, during the ascent phase and float of the flight (up to 30 km). The experiment was launched on the 18th of October 2017. Due to a technical problem at launchsite, data had to be taken during the descent phase of the flight, and consequently not enough quality data could be gathered in order to process it computationally and obtain substantial information on muon flux through the atmosphere.

[A-012]

ULTRA-LONG WAVELENGTH RADIO ASTRONOMY BALLOONING EXPERIMENT

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The ultra-long wavelengths (ULW) of 0.3-30MHz remain one of the last unexplored frequency ranges in radio astronomy. However, due to strong man-made radio frequency interference (RFI) and ionospheric distortion, Earth-based observations at this wavelength is not readily achievable, or at the very least challenging. Therefore, one of the solutions is to observe from outer space, far away from Earth. Our vision is to build a low frequency radio telescope in outer space to observe at ULW. We call this experiment OLFAR – the orbiting low frequency antennas for radio astronomy, which will enable unique science cases in this spectrum, including for e.g., the radio detection of exoplanets and creating maps of the very early universe.

Our immediate goal, is to understand the RFI at these ULWs, which is one of the many limitations for ULW observations from Earth. Moreover, the RFI at different altitudes from surface of the Earth is poorly understood at these wavelengths. To address this challenge, we propose a series of high-altitude balloon experiments, to determine the radio environment for ultra-long wavelength radio astronomy at various altitudes. Secondly, multi-balloon experiments will be conducted to enable interferometric measurements. Furthermore, the impact of the ionosphere on observations will be determined by measuring extra-terrestrial signals.
In addition to the science goals, various technological goals also exist in this project. The first step will be to bring the OLFAR technologies to a higher TRL level and secondly, testing them in harsh conditions (e.g., temperatures and vibrations), such as the antenna system, which is crucial for the OLFAR mission. The size of the antenna system is very large due to the frequency range of the instrument. Dipole antennas with a tip-to-tip length of at least 10m are expected in order to make observations for good science cases. Measuring the antenna properties of that size antenna system in conditioned rooms is almost impossible. Using high altitude balloons opens the possibility for measuring antenna performance both electrically and structurally.

The measurements themselves are straight forward. We will monitor the spectrum from 0.1 to 50 MHz. This will give us information about the present interfering signals and noise around the location of the launch site. We realize that this does not give enough information about all the possible RFI situations. Therefore, we will also engage, as a simple model for an interfering signal, a frequency swept signal using a precise radio transmitter at a well-defined location to determine propagation of this signal to one or maybe more balloons through the ionosphere.
The sampled data of all the experiments will be accurately timestamped and stored on the balloon, including the 3D-location at the time the sample was acquired. This makes off-line data processing possible.

In this paper, the roadmap, science opportunities, and the technological and programmatic challenges will be presented.

[A-106]

WAKE INFLUENCES ON ASCENDING BALLOONS: IMPLICATIONS AND SOLUTIONS

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Ascending balloons are a widely-used tool for atmospheric in-situ measurements. They come in a great variety of sizes from small meteorological balloons carrying a few grammes to large aerostats with several tonnes of payload. However, all these platforms have one thing in common: they produce a turbulent wake downstream (below) of the balloon. This wake may hit the sensors on the payload and lead to considerable distortions of atmospheric measurements. These distortions are relevant for all high-resolved measurements like temperature and humidity soundings and for turbulence soundings in particular.

In this paper, we will present a method to calculate the likelihood for encountering the balloons wake on the payload. This is based on radiosonde data but can be used with any three-dimensional wind measurement taken on the payload. We will provide access to a software that will allow the user to estimate the wake encounter probability for any radiosonde profile. Applying this software to a generic set of measurements, we find an average wake encounter probability of 28 % on a standard radiosonde. We demonstrate the impact of wake-related distortions with our Leibniz-Institute Turbulence Soundings in the Stratosphere (LITOS) payload and present measurements from descending balloons, which completely avoid these influences.

[A-176]

HEMERA BALLOON LAUNCH FROM ESRANGE 2019

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Within the HEMERA program 3 balloons will be launched by SSC at ESRANGE Space center in Kiruna.

The first one is planned for August - September 2019. The other two in 2020 and 2021.

There was a "Call for Proposals" during 2018 where 39 proposals were submitted. These have then been evaluated by a Peer Review group and ranked from a science perspective.

5 experiments have then been decided by the HEMERA Steering Committee to fly on the ESRANGE balloon in 2019.

This paper will focus on the scientifical content of the experiments, the Campaign at ESRANGE, the specific launch requirements for these experiments and other interesting aspects of this first HEMERA balloon.

UTILISATION OF ROCKETS FOR RESEARCH APPLICATIONS 2

TUESDAY 18 JUNE, MORNING SESSION – PART 2

ROOM 3

CHAIR: R. KIRCHHARTZ

[A-078]

TEXUS – LATEST DEVELOPMENTS AND NEW PERSPECTIVES

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In December 1977, the first TEXUS launch was successfully performed from the Esrange Space Center in Sweden with the German Space Agency DLR as customer. It marked the beginning of the successful Sounding Rocket Program for research under microgravity conditions at Airbus. Until the end of 2018 a total of 6 MiniTEXUS, 55 TEXUS and 10 MAXUS missions were flown for DLR and the European Space Agency ESA under Airbus responsibility.

In 2017 - 2018 three more launches were performed: MAXUS 9 for ESA and TEXUS 54 & 55 for DLR. Onboard these rocket flights were several newly developed experiments as well as re-flights covering a broad spectrum of scientific disciplines.

Upcoming missions are the Texus 56 mission for ESA and Texus 57 & 58 as double campaign for DLR.

The paper will give an overview of the missions and their results / plans.

In addition, the paper will also present on-going program improvements to further enhance industrial services to provide best science

[A-158]

TRACZ – TESTING ROBOTIC APPLICATIONS FOR CATCHING IN ZERO-G DURING REXUS 26 CAMPAIGN

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Grasping different objects by robots in space conditions are in many cases neither effective nor convenient. Lack of general-purpose device which can grab differently shaped and sized elements made from various materials is one of many issues in space missions. A classical approach towards gripping objects by human-like rigid effector requires sophisticated trajectory planning algorithms, numerous sensors, and complicated mechanical design. Another approach is to use soft, elastic materials manipulated by pressure to adjust to an irregular-shaped object and catch it. Soft grippers are less complicated in construction and use, furthermore they seem to be more all-embracing.

TRACZ is an experiment which aims to investigate the possibility of application of an elastic gripper in space, where negative differential pressure is impossible to obtain and lack of gravitation may cause the granular substance inside the gripper to behave in an unpredictable manner. During the REXUS rocket flight, in microgravity and vacuum conditions series of catches will be performed on a single object and the force with which the object is held will be measured. The results will be compared with an on-ground experiment and the utility of the aforementioned gripper in the space applications will be discussed.

[A-056]

REXUS-23, ARES-II, AXIAL RETENTION EXPERIMENT FOR PMD SPONGES II

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The experiment revolves around propellant management device, also called "sponge", composed of a series of radial panels, tapering towards their center to collect liquid at a desired position. These devices are used in the space propulsion community to guarantee the delivery of bubble-free propellant to the liquid propulsion engines when high reliability is needed. This component is based on surface tension forces to control and deliver fluid to a particular location in microgravity environments. Surface tension is produced by asymmetry of molecules at surface of liquids. The resulting force is small in comparison to gravity on Earth. However, the opposite happens in microgravity: surface tension dominates gravity.

From the beginning of the 1980s sponges were known and used in space vehicle. Though, no general public documentation is available at the moment about liquid behavior under axial acceleration. The purpose of this experiment is to partially fill this void by putting sponges in microgravity environment and acquire images of the fluid distribution around it under controlled axial acceleration.

The experimental setup is designed to carry four sponges composed by eight radial panels around a conical shape, filled with different proportions of fluid. During its flight, on board of REXUS 23, it will achieve a phase of microgravity.

In microgravity environment, the sponges will be subject to variable axial accelerations and the liquid behavior will be recorded.

The focus is put on capacity of the sponges to retain the liquid under axial acceleration and behavior of droplets ejected from the sponges when a sufficient acceleration will be achieved.

Experimental results will then be compared with ground-based tests and numerical analysis using the same boundary conditions as the experiment to verify the numerical models and characterize the geometrical influence of sponges on liquid behavior.

[A-032]

ELVIS – THE EXPLORATION OF LOW-VELOCITY COLLISIONS IN SATURN'S RINGS. AN EXPERIMENT ONBOARD THE REXUS26 SOUNDING ROCKET

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ELVIS is a part of the REXUS 25/26 campaign which launches in march 2019. The scientic objective is to get a better understanding of low-velocity collisions in Saturn's main rings. These rings primarily consist of water ice. The most common particle size ranges from 1 cm up to about 10 m. Previous work has shown that the collision properties of low-temperature water ice are similar to those of silica glass, but at tenfold of the velocity. The goal of this experiment is to clarify the collision outcomes between Saturnian ring particles by observing mutual collisions among cm-sized glass marbles in microgravity. It is expected that binary collisions under Saturn-ring conditions result in the cohesion among the glass beads when the impact speeds are suciently small. However, it is unclear to what sizes agglomerates can grow by successive sticking collisions and what the collision properties of the forming clusters are.

We intend to present the results of ELVIS at this symposium and discuss their implications.

[A-140]

REXUS24: WOLF EXPERIMENT AND HOW EVERYTHING CAN GO WRONG IN A FEW SECONDS

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The challenges of flying and performing experiments in space have always been huge: starting from defeating the Earth's gravity; finding all the resources needed for conceptualizing and designing an experiment; to the point of building a reliable system so that in its one-shot flight, the experiment can verify the objectives.

WOLF (WObbling controL system for Free falling unit) is a student experiment developed in the frame of REXUS/BEXUS programme, launched in March 2018 on-board the RX24 sounding rocket. The primary objective of the experiment was to demonstrate a system to suppress the wobbling of Free Falling Units (FFUs) ejected from a spinning rocket. Unfortunately, due to the non-nominal flight of the RX24 rocket, none of the objectives were verified. Moreover, there were some mechanisms and parts of the WOLF experiment which are believed that had contributed to the non-nominal flight of the entire rocket.

This contribution aims at describing the setup of the WOLF experiment and all the critical parts which are believed to be the cause of the non-nominal flight. Two of the components, i.e. the inflight actuated hatches and the retention cables, are considered to be the cause of an early release of the FFUs which induced high lateral forces and perturbed the powered phase motion of the rocket. A qualitative analysis and to some extend a quantitative one of these components is done with respects to the all system and forces induced by the launch. The study also aims at comparing the results with the findings which are yet to be reported by the official investigators who studied the failure.

The results summarized in this paper will not only be important for future experiments with inflight actuated hatches, but also generally applicable for the process of conceptualizing and building an experiment. For this matter, some lessons learnt will be provided, along with an overview of the entire experience as part of the WOLF project.

Keywords: WOLF; REXUS; Free Falling Unit(s) – FFU(s); inflight actuated hatches; retention cables; rocket crash.

[A-190]

REXUS 24 FAILURE INVESTIGATION

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On Monday, March 12 at 14:30 UTC, 2018, the sounding rocket REXUS 24 was launched from Esrange Space Center. After T+8.9 s, the payload separated unintentionally from the motor. The payload impacted 2 km north east of the launcher. The thrusting motor continued to fly down range. All objects were contained within safe areas, causing no damage on human beings or property.

In order to identify the failure cause and to suggest recommendations and restrictions, a Failure Investigation Board (FIB) was established. The FIB was composed of members from the Swedish Space Corporation (SSC), Mobile Rocket Base (MORABA) and the Center of Applied Space Technology and Microgravity (ZARM). The FIB led the failure analysis process which involved experts from the different organizations. Finally, a failure report was prepared describing the results of performed analyses and identifying the most probable failure cause.

The presented paper introduces the methodical approach of the FIB and explains what has been identified as the most probable failure cause. A summary of performed investigations is given and it is described how the most probable failure cause was deduced. Finally, recommendations and restrictions referring technical and procedural aspects are covered which are planned to be applied in future campaigns.

ATMOSPHERIC PHYSICS AND CHEMISTRY 2

TUESDAY 18 JUNE, AFTERNOON SESSION – PART 1

ROOM 1

CHAIR: I. MANN

[A-136]

USING SOUNDING ROCKETS, BALLOONS, RESEARCH AIRCRAFTS, AND GROUND-BASED REMOTE SENSING TO EXPLORE THE UNKNOWNS OF THE MIDDLE ATMOSPHERE

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The middle atmosphere, that is the stratosphere and mesosphere, is an integral and important part of the coupled atmosphere. During the last decade, the middle atmosphere's important role in climate and weather as well as for driving near Earth's Geospace has been established. Yet, many important processes are still poorly understood. Notably, the details of wave and instability dynamics and the accompanying transport of energy and momentum over large vertical and horizontal distances are still not adequately characterized experimentally and, hence, are also poorly represented, e.g., in climate models. A striking example illustrating our lack of sufficient understanding is the fact that modern climate models still fail to properly reproduce the thermal and dynamical structure of the Southern polar stratosphere in late winter and early spring. This is a period in which important phenomena like the ozone hole occur. More than thirty years after the discovery of the ozone hole this underlines the need to finally make progress regarding this important issue. It is being speculated that it is the poor representation of gravity waves in these climate models accounting for this. Yet, compelling proof for this claim by conclusive observations is still pending. Other unresolved phenomena are issues like the nucleation of noctilucent clouds where small scale dynamics has recently proposed to lead to spatially and temporally localized regions of supersaturation where nucleation might occur. Also, the nature of fundamentally important species like aerosol particles of meteoric origin has still not been settled satisfactorily. All these issues call for coordinated efforts to observe the middle atmosphere over a large range of temporal and spatial scales employing the full suite of available techniques from sounding rockets, balloons, research aircraft, and ground based instruments. This paper presents selected results from such coordinated efforts. That is, results from recent sounding rocket campaigns and balloon-borne long duration lidar observations of mesospheric aerosol layers and their inherent small scale dynamics will be presented. Furthermore, we will demonstrate how research aircraft can be equipped with in-situ and remote sensing instruments and combined with ground based observations to gain insight into the dynamical coupling processes described above. Finally, plans for an international research campaign in September 2019 will be presented. This campaign will target the Earth's strongest hot spot of gravity wave activity and atmospheric coupling, namely, the Southern tip of South America and the Antarctic Peninsula and will attempt to clarify its role in determining the dynamical and thermal conditions involved in the Antarctic ozone hole.

[A-096]

THE MATS SATELLITE MISSION – GRAVITY WAVE STUDY BY MESOSPHERIC TOMOGRAPHY AND SPECTROSCOPY

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Global three-dimensional data are a key to understanding gravity wave interactions in the mesosphere and lower thermosphere. MATS (Mesospheric Airglow/Aerosol Tomography and Spectroscopy) is a new Swedish satellite mission that addresses this need. It is currently being prepared for launch in late 2019. MATS applies space-borne limb imaging in combination with tomographic and spectroscopic analysis to obtain gravity wave data on relevant spatial scales. Primary measurement targets are O2 Atmospheric Band airglow in the near infrared, and noctilucent clouds in the ultraviolet. While tomography provides horizontally and vertically resolved data, spectroscopy allows analysis in terms of mesospheric temperature, composition, and cloud properties. Based on these dynamical tracers, MATS will produce a climatology on wave spectra during a 2-year mission. Major scientific objectives concern a characterization of gravity waves and their mesospheric interactions, as well as their relationship to conditions in the lower and upper atmosphere. The wide field of view and spatial resolution of the tomography provide outstanding opportunities for co-analysis with ground-based and rocket-borne in-situ measurements. This presentation provides an overview over the MATS scientific goals, measurement concepts, and analysis ideas.

[A-046]

SEASONAL CYCLE OF GRAVITY WAVE POTENTIAL ENERGY DENSITY FROM LIDAR AND SATELLITE OBSERVATIONS AT 54°

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Gravity waves (GW) play an important role in transporting energy and momentum and in influencing the general circulation and the thermal structure of the atmosphere. Ground-based observations allow for experimental studies of GWs at very high spatial and temporal resolutions which are not accessible by other means.

In this study, we compare the climatology of the Gravity Wave Potential Energy Density (GWPED) retrieved from temperatures, observed by two lidar systems, located in Kühlungsborn, Germany (54ºN, 11ºE) and in Andenes, Norway (69ºN, 16ºE). Both lidars have the unique capability of measuring during both day and night covering an altitude range from 30 to 80 km. Three methods are applied to estimate the GWPED for the years 2012-2016, namely: subtracting a constant mean background, vertical and temporal filtering with a fifth order high-pass Butterworth filter at cutoffs of 15 km and 8 hours, respectively.

From latitudinal comparison, we found that GWPEDs are similar at both locations. While a seasonal behavior is clear in the vertically filtered data with a winter maximum and summer minimum (winter/summer ratio of ~ 3), such behavior is not pronounced in the temporally filtered data obtained at either of the locations. Comparisons of our results to SABER satellite outcome reveal good qualitative and quantitative agreement.

[A-080]

RECENT FINDINGS ABOUT GRAVITY WAVES IN THE ALPINE REGION BASED ON NDMC MEASUREMENTS

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In and near the Alpine region, the densest sub-network of identical NDMC instruments (Network for the Detection of Mesospheric Change, https://www.wdc.dlr.de/ndmc/) can be found: six stations are equipped with OH*-spectrometers which deliver a time series of mesopause temperature each cloudless or only partially cloudy night. At three of these stations OH*-cameras are deployed.

This instrument suite allows us to derive a variety of parameters referring to gravity waves. Depending on the specific parameter, additional information about wind or the vertical temperature gradient are necessary. They are taken from meteor wind radar and satellite based temperature measurements.

Here, a summary of our recent work will be given. It comprises the evaluation of one to two years of camera data regarding horizontal and temporal wave parameters at two different stations and the investigation of four years of spectrometer data with respect to the potential energy density at four different stations as well as the discussion of the results. But cases studies will also be shown. Based on only one OH* spectrometer addressing one vibrational-rotational transition, the complete wave vector and the periods of gravity waves can be derived. For the camera systems, we present examples for the estimation of turbulence parameters and for the three-dimensional representation of waves based on stereo imaging.

[A-179]

IMPACT CHARGING OF NANOSCALE ICE AND METEORIC SMOKE PARTICLES

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In this work, we study the impact charging of low energy impacts, representable for sounding rocket measurements, of nanoparticles in Faraday cups. We focus on the low particle energy limit where impact ionization is not expected. We find that existing models for contact charging of conducting particles is consistent with findings from sounding rocket measurements from the MAXIDUSTY campaign of 2016; that the charging probability is proportional to particle cross-section. Our measurements give supporting evidence towards that MSPs are embedded with significant filling factors inside ice particles in the mesosphere. Our results can also be utilized in dust detection in spacecraft in the low impact energy limit.

Technology and Infrastructures for Balloons 1

Tuesday 19 June, Afternoon session – part 1

Room 2

Chair: H. Eriksson

[A-004]

HEMERA BALLOON RESEARCH INFRASTRUCTURE

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Stratospheric balloons are useful platforms for various research and technology applications. They allow to collect valuable data in many science fields, e.g. atmospheric science and astrophysics. They can be used for example for demonstration experiments in preparation of new space and Earth observation missions, for calibration/validation data for Earth observation space missions, or for dropping test objects from the stratosphere.
In support of the different objectives, various types of balloons are available: Zero Pressure Balloons (ZPB) for heavy payloads (100 kg to 3 tons) and short to medium duration (1 day to several days), Sounding Balloons (SB) for very light payloads (3 kg) and only ascent and descent to the stratosphere.
Payloads can be flown to various altitudes ranging between the ground and up to 40 km, according the type of balloon and the kind of mission. Compared to satellites, stratospheric balloons can be operated at relatively low cost and with shorter lead times from the experiment idea to the flight.
Mid-2017, a new Research Infrastructure called HEMERA has been selected by the European Commission within its Horizon 2020 program. The HEMERA objectives are to:

- Provide better and coordinated balloon access to the troposphere and stratosphere for scientific and technological research, in response to the scientific user needs.
- Attract new users to enlarge the community accessing the balloon infrastructure and foster scientific and technical collaboration.
- Enlarge the fields of science and technology research conducted with balloons.
- Improve the balloon service offered to scientific and technical users through innovative developments.
- Favor standardization, synergy, complementarities and industrialization through joint developments with greater cost-effectiveness.

The project is coordinated by CNES and involves 13 partners from various European institutions and from Canada. The project started in January 2018 and will last until end of 2021.
Six ZPB flights with a target payload mass of 150 kg are scheduled within HEMERA, offering free of charge access to users and scientists for various science measurements and/or for technology tests. In addition, several SB flights are planned. The launch sites will be Esrange in Sweden, Timmins in Canada for the ZPB and Aire sur l'Adour in France for the SB.
Two Calls for Proposals are planned in the HEMERA project, one has been organized in 2018 and the second will be issued beginning of 2020. The selected experiments will fly on balloons during the years 2019-2021. In the frame of the first call, 39 proposals from 12 countries have been received which are presently evaluated.
In addition, Open Access to the collected scientific balloon data is being organized and the data will be made available to interested users via a Data Center. Networking activities are planned in order to promote the Infrastructure in the European countries, and Joint Research activities are conducted in order to improve as far as possible the balloon offer in the view of the user needs.

[A-022]

BALLOON CAPABILITIES UPGRADES – CURRENT AND PLANNED, AT ESRANGE SPACE CENTER

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Esrange Space Centre, located in the North of Sweden and run by SSC, - Swedish Space Corporation, is one of the launching facilities from which industry and the science community may launch their systems and experiments. As a consequence, SSC shall uphold and improve such capabilities, both in the frame of sounding rocketry as well as high altitude ballooning. During the last half decade, SSC have invested in the upgrade of both rocket and balloon capabilities, where the scope of this presentation outlines the later. The journey starts with NIMA, - "NOSYCA Integration of the Multipurpose Antenna", that added a campaign activated telemetry ground station for the NOSYCA system, accepted during the CNES KASA campaign in September 2016. During the same period, SSC also devised a system called EMPIRE, - "Esrange Multi-purpose Iridium RElay", which mainly provides a Beyond-line-of-sight position and termination module. Up until now, the system has flown on multiple missions over the last three years. The PoGo+ mission and the OLIMPO mission, in 2016 and 2018 respectively, required extended service system functionality which led to the procurement of a temporary system from PSL in USA. As a consequence SSC has initiated the project BOSS, -"Balloon Operation Service System", which now have finished the requirement phase and is moving towards a design approach, for a permanent upgrade of the SSC balloon service portfolio. With the OLIMPO mission requirements another capability sprung to life, where flight path trajectories based on stratospheric wind predictions aimed for long term flights, needed to be both simplified and automated. The result became an add-on functionality to the SSC Gale software. Coming to present time and early future, SSC is developing a new balloon spool together with CNES, constructing a gondola for the HEMERA initiative and upgrading the UPS for the balloon facilities. Lastly SSC is looking at constructing another balloon preparation hall, but that is yet to be decided.

[A-114]

CNES SUPER-PRESSURE BALLOONS UPGRADE FOR STRATEOLE-2 CAMPAIGN

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The French Space Agency, CNES, has developed, for about twelve years, super pressure balloons (SPB) that float on constant density (isopycnic) surfaces in the lowermost stratosphere, carrying 40 to 50 kg payloads, during typically three months. These SPB have been successfully deployed in flotilla of about 20 balloons for different scientific campaigns all over the world in different configuration sizes from 8.5 to 12 m diameter, mainly to document the chemistry and dynamics of the atmosphere, to study gravity waves, and to provide in-situ atmospheric profiles thanks to the NCAR driftsonde payload.

The SPB housekeeping gondola used from 2005 to 2011 has been upgraded in order to increase the flights' safety and to improve its performance with up to date equipments. The control center is also redesigned. These modifications take into account the experience acquired during the last SPB campaigns, mainly during CONCORDIASI, with 19 flights over Antarctica from September 2010 to January 2011. The project is now finalizing the qualification phase and prepares a validation campaign with six flights from fall 2019 to spring 2020.

This new system is developed for STRATEOLE-2, a project dedicated to coupling processes between the troposphere and the stratosphere in the deep tropics, using several types of instruments, both for in situ and remote measurements in the atmosphere. STRATEOLE -2 includes two measurement campaigns, three years spaced to study the two phases of the quasi biennial oscillation. The scientific payload are fully self-standing, but some technical solutions are common with the CNES housekeeping gondola, such as the renewable power system.

This paper will describe the developments conducted on the SPB system upgrade for the STRATEOLE-2 project.

[A-133]

PRELIMINARY THERMAL DESIGN OF SCIP INSTRUMENT

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The SUNRISE Chromospheric Infrared spectroPolarimeter Optics Unit (SCIP-O) is one of the instruments on-board the Sunrise-3 balloon borne telescope, and it is being developed by NAOJ. The SCIP-O is located inside the Post Focus Instrumentation (PFI) of Sunrise-3 and it consists of an optical bench mounted in the PFI by means of three titanium mechanical interfaces. These interfaces provide low thermal coupling with the PFI structure. The bench is covered above by an aluminium case and below by a Single-layer insulation (SLI). Additionally, the top cover area, which is not intended as a radiator, is insulated with polystyrene foam. Therefore, the unit is conductively and radiatively insulated from its environment.

On the bench the optical elements, including three cameras, are located. To reduce stray light, interior metallic surfaces are black anodized. The unit is thermally designed to reject the heat, originated due to electronic components dissipation and coming from the PFI radiative and conductive environment, to space through dedicated radiators located on the top of cover of the unit. Three different radiators are considered, each one approximately centred above a camera. Each radiator is conductively connected to each camera cold finger by means of a copper thermal strap. The CMOS sensor of each camera is cooled down through direct contact with the camera cold finger.

In order to guarantee the thermal stability in some critical parts, stabilization heaters based on set-points are placed. Thermal stability of the sensor is achieved with a dedicated heater located in the cold finger of each camera. Temperature and thermal stability requirements of the optical bench are achieved by a series of heaters situated on the bottom surface of the bench. The location of the optical bench heaters is under assessment to minimize temperature spatial gradients.

PICO Posters Sessions

Tuesday 19 June, Afternoon session – part 2

Room 1

Chair: M. Becker

[A-141]

STUDIO: A FIRST STEP TOWARDS A STRATOSPHERIC BALLOON OBSERVATORY

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For most astronomical measurements, observations in the ultraviolet (UV) at wavelengths below ~320 nm are not possible from the ground because of atmospheric extinction by the atmosphere. Early on, observers started using stratospheric balloons as relatively flexible and affordable means to access ultraviolet wavelengths, thus overcoming most atmospheric limitations.

The STUDIO (Stratospheric Ultraviolet Demonstrator of an Imaging Observatory) mission consists of the development and construction of a prototype versatile gondola and telescope, which shall perform technology tests as well as deliver first scientific results from astronomical observation during its maiden flight planned for 2021. Its main optical payload includes:

- A 50 cm aperture telescope
- An advanced photon-counting, imaging microchannel plate (MCP) detector that shall perform observations in the UV band from approximately 180 to 300 nm
- A visible light imaging instrument that will mainly serve as the tracking sensor in a closed-loop fine image stabilization system, but that will also be used as an auxiliary science instrument

Additionally, the gondola will house other add-on instruments.
Two science cases motivate the UV scientific part of STUDIO, namely; a. the search for variable hot compact stars, and b. the detection of flares from cool dwarf stars.

The second objective of ESBO DS is the development of a strategy for the establishment and operation of a balloon-based observatory – including the study of the technical feasibility of balloon flights with larger systems:

- For the mid-term: 1.5 m telescopes for the mid-term for visible and near infrared observations.
- And for the long-term: 5 m aperture class telescopes for far infrared observations.

The purpose of this paper is to present a general overview as well as the work progress and scientific & technical objectives of STUDIO.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 777516.

[A-109]

A BALLOON BORNE LAUE LENS TELESCOPE FOR GAMMA-RAY OBSERVATIONS

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The future of gamma-ray astronomy (>100 keV) depends mainly on the development of focusing instrumentation. Laue lenses represent a viable technology to fulfil this requirement. In this work we propose a balloon–borne experiment based on a 10 m focal length Laue lens made with bent crystals capable to focus photons in the 50–300 keV energy range. The proposed configuration is fully feasible for a balloon flight. For the lens fine tuning we propose an active alignment system, capable to optimize the Laue lens performances. The broad–band optics will be coupled with a compact focal plane detector based on a mosaic of high performance pixel CZT spectrometers units for a sensitive area of few tens of square cm. This balloon payload will be a pathfinder for a future challenging satellite mission such as the ASTENA mission concept proposed within the H2020 project AHEAD. We will present a possible Laue lens telescope configuration and its expected performances estimated for a medium/long-duration balloon flight compared with those achieved with previous balloon and space–borne experiments.

[A-041]

BACK TO THE BEGINNING: STUDYING THE ORIGIN OF MICROGRAVITY-INDUCED ALTERATIONS IN THYROID CANCER CELLS ON AN UPCOMING TEXUS SOUNDING ROCKET FLIGHT

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Thyroid cancer cells form compact multicellular spheroids (MCS) when they were exposed to long-term microgravity in space or simulated by a random positioning machine on-ground. Results indicate that the altered growth behavior is accompanied by an initial re-differentiation of malignant cells. We have recently investigated human FTC-133 cells during the CellBox-2 ISS mission. After 5 and 10 days in space we observed altered secretion of extracellular matrix components, angiogenesis and growth factors suggesting that MCS cells build their own spheroid microenvironment. These changes are genetically controlled. Several genes belonging to growth, adhesion, matrix and regulation of cellular processes were found downregulated after 5 d and upregulated after 10 d. To determine the very early effects of real microgravity on thyroid cancer cells and perhaps to elucidate the first steps in the induction of re-differentiation, we are currently preparing a sounding rocket mission. FTC-133 cells will be exposed to 6 minutes of microgravity during a TEXUS flight and subsequently analyzed on the transcriptional and translational level. We hope to find answers to the question how thyroid cancer cells switch between increased malignancy, which was discovered after short-term impulses of microgravity during parabolic flights, and later re-differentiation.

[A-025]

HIGHLIGHTING OF GRAVITY EFFECTS ON SOLIDIFICATION STRUCTURE FORMATION BY USING IN-SITU AND IN REAL TIME X-RADIOGRAPHY

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The mechanical properties of materials are directly related to their solidification structures, so that a precise control of growth process is crucial in engineering. Two main types of grain structures are commonly obtained during metal alloy solidification: a columnar grain structure with directional properties, and an equiaxed grain structure with more uniform and isotropic properties. A fine and homogeneous grain structure is required in most aluminum-based alloys used in industrial applications. This feature is achieved by adding refining particles to the liquid metal, which act as preferential heterogeneous nucleation sites during the solidification phase. The efficiency of refining particles and the final grain morphology are strongly dependent on the solidification parameters, namely the cooling rate and the temperature gradient.

On Earth, gravity-related phenomena such as thermo-solutal convection (caused by density gradients in the melt) and buoyancy forces (caused by the difference of solid and liquid phases) can affect drastically both the grain size and their morphology. For these reasons, fundamental studies comparing the influence of solidification parameters with and without gravity effects are unique to obtain benchmark data useful to understand and then control the final structure of materials in industrial processes.

In the present work, the impact of the solidification parameters on the dendritic grain structure formation and on the final grain size and shape was investigated in-situ by using X-radiography for three different growth orientations with respect to gravity. Directional solidification experiments of Al-20wt.%Cu alloy refined with 0.1wt.%Al-Ti-B were carried out using sheet-like samples (thickness ≈ 250 µm) in the laboratory device SFINX (Solidification Furnace with IN situ X-radiography). In a first step, experiments were performed with various solidification parameters, with the furnace in horizontal position and with the main surface of the sample perpendicular to gravity direction. This configuration was chosen to limit gravity-related phenomena, and more particularly the grain floatation. In a second step, experiments were carried out with identical solidification parameters but with the furnace in a vertical position, and for both upward and downward solidifications. In that cases, we focused on the characterization of grain floatation during upward solidification and the interaction between dendrite growth and solute rich-plume evolution during downward solidification. A comparative study between horizontal and vertical experiments were carried out to analyze and highlight gravity phenomena.

[A-036]

GENETIC ALTERATIONS OF THYROID CANCER CELLS DURING A SOUNDING ROCKET FLIGHT (TX53)

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Human follicular thyroid cancer cells (FTC-133) were sent to space via a sounding rocket during the TEXUS-53 mission to determine the impact of short-term microgravity on these cells. To enable cell culture and fixation in real microgravity, an automated experiment container (EC) was constructed. As sounding rocket flights consist of several flight phases with different acceleration forces, rigorous control experiments are mandatory. Hypergravity (hg) experiments were performed at 18g on a centrifuge in simulation of the rocket launch as well as µg was additionally simulated by a random positioning machine (RPM).

To determine the suitability of the cell culture chambers (CC) for cell culture on a sounding rocket, cells were tested for viability in these CCs. Tests revealed that the chambers material allowed for cell growth as well as production of a sufficient amount of cell material for further analysis. In addition, the material was stable in contact with the fixative RNAlater.

During the sounding rocket flight, the cells were fixed after pre-determined g-phases to give a broad overview on their impact on gene expression levels. After the gene expression analysis, we found a down-regulation of genes belonging to cytoskeletal architecture (TUBB1, VIM, RDX), extracellular matrix (LAMA1), growth factors (EGF) and apoptosis (BAX, BCL2, CASP3) after the µg phase. The gene expression measured from cells collected after the other TX53 phases was not remarkably changed.

Pathway analyses of these probes revealed a central function of VEGFA and EGF during a sounding rocket flight. EGF upregulates aspartate beta-hydroxylase (ASPH), which in turn influences CASP3. In contrast to the TX53 samples, hyper-g simulation experiments generating 18g for 1min, revealed a significant up-regulation of TUBB1, VIM, RDX, CAV1, VEGFA and BCL2.

Our findings indicate that µg during a sounding rocket flight is a stronger trigger for gene expression changes than the initial hyper-g during the flight. It takes at least 18g for 1min to induce contradictory results to µg. It also allows us to reduce the number of control samples in favour of samples of interest to strengthen the statistics in future experiments.

[A-030]

VIRTUAL RECONFIGURATION OF THE SATELLITE SYSTEMS

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Satellite technologies are actively used in solving problems of studying the earth and near-earth space, the implementation of various space missions.

Previously, we proposed an integrated concept in which, along with the technological module, a laboratory satellite module is being developed, which is used during satellite flight to verify the functioning of the satellite, as well as to ensure the educational process.

Today, the main trend in the satellite development is the use of universal satellite platform. However, universal platforms with various tools for solving specific problems (earthquake prediction, space weather research, remote sensing of the earth’s surface and outer space) using advanced hardware and software tools implemented as hierarchical universal technological systems, such as plug-and-play, can lead to excessive mass and energy costs.

Therefore, the use of universal satellite platform requires a certain adjustment. In addition, in order to effectively solve the problem, it is desirable to adjust the hardware-software satellite systems during the flight using the telemetry and payload data.

In addition, failures can occur during the satellite operation. It in turn may also require tuning of the satellite hardware and software systems.

Earlier, we considered the hardware and software reconfiguration of satellite systems based on the iterative process, implemented separately and sequentially on the ground and space platforms.

Using the experience of developing a satellite for the study of ionospheric earthquake precursors and remote sensing of the Earth's surface, as well as the experience of developing means for increasing fault tolerance, the problem of virtual reconfiguration of the on-board software (through Master-Slave technology) and hardware (FPGA-based) is considered here. It is assumed the presence of an additional ground module, which, together with the satellite platform, forms a virtual reconfiguration resource for parallel use.

[A-074]

COLLECTING MICROMETEOROIDS AND OTHER COSMIC-DUST-PARTICLES

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After many years of research, the composition of the upper atmospheres is still relatively unknown. This applies especially to the remains to meteors hitting the earth's atmosphere. As BEXUS provides an easy access to those atmospheric layers, an inexpensive experiment shall be designed to collect those remains. Due to the fact that not much research has been done, the origin of those meteoroids and their age as well as their chemical structure is still widely unknown. While some particles may come from our closest neighbours, some may even be interstellar. Through asteroid research and analysing the meteorites reaching earth's ground, we can suspect that some meteoroids are also made out of iron-nickel-compound. Collecting those meteoroids can easily be done by using magnets to attract them. Covering the magnets with a sticky material can help to hold onto the meteoroids as well as giving a chance to collect even non-magnetic particles. Compared to the bigger meteoroids, the micrometeoroids we want to collect will probably never reach the earth's ground. This is due to the fact that those particles are in the order of 50 μm. Therefore, they are sensitive to the winds at high altitude and insensitive to the earth's gravitation. In consequence, those micrometeorites are mostly unknown, as they are hard to reach and even harder to collect.

[A-147]

SP.ACE 2017-2019: SECONDARY SCHOOL STUDENTS USING THE GEIGER-MÜLLER COUNTER'S ANISOTROPIC SENSITIVITY TO INVESTIGATE THE ANGULAR DISTRIBUTION OF ATMOSPHERIC GAMMA RADIATION DURING THE ASGARD-VIII AND –IX BALLOON FLIGHTS

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The Asgard-VII sounding balloon flight of April 2017 carried a high school student payload that used a coincidence circuit of 3 Geiger-Müller Counters; 2 for horizontally, 2 for vertically moving gamma photons, one counter being common to both measurements. It was determined that the vertical component of the gamma radiation is larger than the horizontal component at altitudes below the Pfotzer Maximum (at an altitude of 18km), while above this altitude somewhat more horizontal radiation is detected. However, the latter difference barely exceeds the stochastic limit. The determining factors of this particular setup are the modest size of the Geiger-Müller Counter tubes and the flight profile of the Asgard balloons. The former entails a relatively small signal (about 2000 cpm at 18km), which is compounded by the coincidence circuit which lowers the signal by another order of magnitude. The latter on the other hand results in a limited time at altitude as the latex balloons burst upon reaching apogee. Both of these factors (small count numbers and limited data collection times) make the conclusion that there is more horizontal radiation above the Pfotzer Maximum uncertain at best.

A method was therefore developed to gain more significant information about the angular distribution of the atmospheric gamma radiation, relying on the use of the anisotropic sensitivity of the Geiger-Müller Counter tube. The elimination of the coincidence circuit would allow an order of magnitude increase in signal, which should suffice to determine whether the preponderance of horizontal radiation above the Pfotzer maximum was indeed a genuine fact of nature or a stochastic effect.

The different factors causing the anisotropy of a Geiger-Müller Counter tube are handled quantitatively, and a new tube arrangement is presented. This new setup was already flown on the Asgard-VIII balloon flight over Belgium in April 2018. Data obtained during this flight are discussed and compared with the results of 2017. The results were analysed further for the purpose of improving the setup running up to Asgard-IX balloon flight in April 2019, and as a contribution to the STRAINS experiment package (STRatospheric RAdiation INStruments) for possible participation to the HEMERA and/or HASP (High Altitude Student Platform) LBD (Long Duration Balloon) flights. These improvements are presented, and the results of the Asgard-IX flight analysed.

[A-150]

SP.ACE 2017-2019: SECONDARY SCHOOL STUDENTS DETERMINING THE ENERGY SPECTRUM OF ATMOSPHERIC GAMMA RADIATION DURING THE ASGARD-IX BALLOON FLIGHT

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Atmospheric gamma radiation originates from several sources: part of it is generated in violent processes in the distant universe (black hole and neutron star mergers, supernovae, ...) while part is generated in situ by interaction of solar protons or galactic cosmic rays with the upper atmosphere. Standard attenuation, energy-selective absorption, Compton scattering and the generation of secondary gammas in annihilation processes of exotic particles created in so-called atmospheric showers all contribute to make the study of atmospheric gamma radiation a particularly intricate - if very rewarding - field of research.

While secondary school teams have flown radiation experiments on high-altitude balloon flights in the past, these were generally Geiger-Müller Counter experiments. However, one of the limitations of Geiger-Müller Counters is that they are unable to distinguish gamma photons of different energies, making them unsuitable for spectrographic applications, which are essential to identify the processes that generated the gamma photons in the first place. For example, Compton scattering will generate gammas over a wide range of energies, while positron annihilation will cause a narrow peak at 511keV. Other particles created in atmospheric showers (π-mesons, muons, ...) may cause other peaks, whose energies may allow the (tentative) identification of these particles. Atoms in the atmosphere can be ionised by the remaining gamma radiation and can be given kinetic energy, causing more gamma radiation - again of different energies - to be produced as Bremsstrahlung.

An experimental scintillation detector with a Th-doped Sodium Iodide crystal and photomultiplier tube was developed. The power supply, detection- and amplification electronics was modified from COTS parts to operate under Arduino control. The setup is being tested and prepared for flight on the Asgard-IX educational high altitude balloon mission set to fly over Belgium in April 2019. The setup itself, the development and testing processes and data from the flight will be discussed and the instrument will be evaluated in view of an eventual participation in a HEMERA and/or HASP (High Altitude Student Platform) long duration balloon flight.

[A-151]

SP.ACE 2017-2019: SECONDARY SCHOOL STUDENTS INVESTIGATING ATMOSPHERIC GAMMA RADIATION ON THE ASGARD-IX BALLOON FLIGHT USING AN ENCAPSULATED PHOTODIODE PARTICLE DETECTOR AND VARIOUS METAL FILTERS.

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The Asgard-VII and Asgard-VIII sounding balloon flights of April 2017 and 2018 carried a number of traditional Geiger-Müller Counters, available from different suppliers as Arduino-compatible modules. However, these Geiger-Müller Counters have several drawbacks: there's the safety issue with the high voltages needed, the sensitivity isn't all that good and it's a relatively bulky device (and 'small is beautiful' as the available payload volume is limited). A solid-state particle detector seems to be a better option, especially the encapsulated photodiode. Such a photodiode is a compact sensor with a rather high sensitivity, which only requires low voltages (5VDC).

A dual experiment is therefore being developed for the Asgard-IX balloon flight in April 2019. The aim of this project is to send both types of detectors to an altitude of 30 to 35 km and to measure the intensity of the gamma-rays during both the ascent and descent phases. This will permit the sensitivities of both detector types to be compared.

Furthermore, it was decided to develop a double filter wheel which would carry different metals to sandwich the solid state detector (which is nearly impossible to do with the Geiger-Müller Counters because of their size: the mass penalty would be prohibitive). This makes it possible to gather information about the gamma-spectrum. The filter would be a rotating wheel to which different metals would be attached in two layers: one layer to slide over the detector and one to slide underneath it. Rotating the wheel will cause the detector to be flanked sequentially by different metals (though always the same above as beneath) that operate as a filter (a reference measurement without filter is also planned). Due to the fact that every metal has a different halving thickness for gamma photons of a specific energy, and that this halving thickness varies with photon energy in different ways for different metals, different parts of the spectrum will be preferentially passed or absorbed by the different metals. Using different metal filters and comparing radiation levels coming through at different altitudes during the balloon flight should therefore permit certain inferences to be made about the energy distribution of the incoming gamma radiation as a function of altitude.

The setup is being tested and prepared for flight on the Asgard-IX educational high altitude balloon mission set to fly over Belgium in April 2019. The setup itself, the selection of particular metals - including halving thickness considerations - and the data from this flight will be discussed and the instrument will be evaluated in view of an eventual participation in a HEMERA and/or HASP (High Altitude Student Platform) long duration balloon flight.

[A-169]

HEDGEHOG – HIGH-QUALITY EXPERIMENT DEDICATED TO GRAVITY EXPLORATION, HEAT FLOW AND OSCILLATIONS FROM GDANSK

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In this paper, we propose HEDGEHOG (High-quality Experiment Dedicated to microGravity Exploration, Heat flow and Oscillation measurement from Gdańsk) REXUS experiment to investigate vibrational and heat flow phenomena during the whole (ascent, microgravity phase, descent and recovery) flight of a sounding rocket. First, a proposed system of cantilever beams is discussed to study dynamic behaviour of dummy payload. Dimensioning has been chosen as a results of initial FEM analysis. Secondly, a novel approach to measuring heat flux has been proposed, according to team leader's pending patent. An inverse heat transfer problem (IHTP) has been solved for SMARD (REXUS-18 experiment) data to enable for dimensioning of the experiment. Finally, an initial design is briefly described. We put high emphasis on the fact that it is an educational, technical but also student project. Since Polish space sector is relatively young (Poland joined ESA in 2012), the need for student experiments is immense. This is congruent to Polish Ministry of Development's Responsible Development Plan where space industry is explicitly named as a key branch. All these circumstances result in interesting opportunities for technical university students interested in space and satellite technologies. As a team performing a space project, we face various challenges, ranging from technical – design and construction of a proper scientific experiment, up to organizational – search for sponsors, management of social media, communication inside a group. There have been known cases of proper companies being formed out of similar successful space project experience. Our team has been accepted to REXUS 11th cycle.

[A-154]

MASER 14 MICROGRAVITY SOUNDING ROCKET MULTI-CUSTOMER MISSION

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The SSC sounding rocket mission MASER 14 is scheduled for launch in June 2019 from Esrange Space Center in northern Sweden. The rocket will carry a mixed payload consisting of four experiments of three customers sharing the payload capacity; two ESA scientific experiments developed under ESA contract; ARLES and XRMON-GF2, one Surface Tension Tank (STT) experiment of Space Solutions in Korea and the JAXA/DLR experiment DUST.

The ARLES experiment, developed under ESA contract, (science coordinator Pr. D Brutin, IUSTI Université Aix-Marseille) intends to mainly study evaporating drops of pure fluids, which contain a low concentration of nanoparticles, under the influence of an electric field. The scientific objectives are directed towards study of the flow motion and the flow instabilities occurring in the drop, at the droplet interface and in the vapour phase. They also deal with the pattern formation on the substrate after the evaporation of the volatile phase, as well as the eventual heat transfer enhancement.

The XRMON-GF2 experiment, developed under ESA contract, (science team coordinator Pr. H Nguyen-Thi IM2NP, Université Aix-Marseille) aims at studying the directional solidification (columnar and equiaxed dendritic growth in purely diffusive environments) of an Al-Cu system by in-situ real-time X-ray radiography. Special attention will be put on the aspect of nucleation, segregation and impingement.

The XRMON program contains a series of in-situ radiography experiments on metallurgical processes related to solidification phenomena under microgravity and terrestrial conditions. A number of experiments have already been carried out on sounding rockets in the frame of this program; XRMON-Metal Foam on MASER 11; XRMON-Diffusion on MAXUS 8 and 9; XRMON-Gradient Furnace on MASER 12; XRMON-Solidification on MASER 13, as well as parabolic flight campaigns with Metal Foams, Gradient Furnace and Solidification experiments.

The objective of the STT experiment is to study the drainage of a liquid from a pressurized tank equipped with a liquid surface tension and capillary system designed to collect the liquid at the outlet of the tank. The objective of the DUST experiment (Hokkaido University and Braunschweig University) is elucidation of formation processes of carbonaceous dust.
The MASER 14 vehicle will provide 6 minutes of high quality microgravity conditions. MASER serves as a platform for performing experiments under short-duration microgravity flights, providing the scientific community with an excellent research tool and a full European access to space.
MASER programme is run by SSC and has provided for 13 successful flights from Esrange Space Center with 6-8 minutes of high-quality microgravity, with residual accelerations as low as 1 µg. The MASER payload accommodates up to 5 experiments of high complexity and offers – with its high speed telemetry system – real-time digital video monitoring as well as ground command capabilities during the flight of the scientific experiments.
With the 2015 ALAT/CNES Cryofénix mission, SSC introduced provision of low gravity levels to experiments, in this case 1.75 mG and 7 mG, by applying thrusts of 7 N and 28 N.
The paper provides an overview of the MASER sounding rocket microgravity platform as well as a description of the scientific experiments of the MASER 14 payload.

[A-048]

OPTIMIZATIONS IMPLEMENTED TO AND PLANNED FOR TEXUS SERVICE SYSTEMS

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Even after 40 years of TEXUS project run-time system optimizations are performed in order to improve the system performances or to provide new, adapted services to the experimenters. Modification of the motor data interface coming along with data merging processes, establishing of 80Hz housekeeping data acquisition, a new TV/TM concept and optimized re-entry strategies, influenced by the payload CoG and rate thresholds, TEXUS timer upgrade are some examples for this. The paper will summarize and describe all kinds of optimizations done in the recent past and future.

[A-122]

DEVELOPMENT OF A WINGED REUSABLE SOUNDING ROCKET

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Dawn Aerospace develops a winged, liquid rocket powered Unmanned Aerial Vehicle to serve as a small reusable sounding rocket. The objective of the vehicle is to be highly responsive, flexible and cost-effective alternative to traditional expendable solid rocket systems. This goal is achieved by employing a UAV operations model in combination with a uniquely designed fixed-wing vehicle. The vehicle features a semi- and fully autonomous guidance system, and is equipped with a bi- propellant rocket propulsion unit allowing it to employ trajectories unattainable by traditional fixed-wing UAV as well as traditional sounding rocket systems.

Technological and operational aspects in this new vehicle class were explored through a pathfinder project, which included an experimental airframe carrying all subsystems such as avionics, reusable liquid rocket propulsion, propellant management, and communication. Dawn Aerospace conducted flight test activities over the course of 2018, to characterise all relevant technical and operational metrics on pathfinder level [ref 1] .

Based on these encouraging results, Dawn Aerospace has initiated the development of a new generation rocket powered UAV, named Valentia, to enable suborbital access and hypersonic flight time. This vehicle will have a take-off mass of 250 kg and will be able to carry a 3-kg payload to altitudes in excess of 100 km and to velocities of Mach 5. Dawn Aerospace plans to initiate flight tests on the Valentina vehicle in the beginning of 2020 and expect to be ready for payload carrying flights from the second half of 2020.

This paper outlines the design of the Valentina vehicle, reports on the current development status, presents simulated flight trajectories and will discuss those matters in light of overall flight performance as well as cost reduction in comparison to traditional expendable sounding rockets.

[A-203]

CHALLENGES OF A SPACE ROCKET LAUNCH FROM THE STRATOSPHERE

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Since 2016 a group of engineers and space enthusiasts from Latvia are testing possibilities of launching a rocket to the altitude of 100km from a stratospheric platform. Several technical and organizational challenges have been identified to reach the goal: a) Designing a simple, reliable, lightweight, energy-efficient and cheap communication systems; b) designing a rocket stabilisation system for a launch from the stratosphere; c) designing a simple and lightweight stratospheric platform stabilisation and orientatin system; d) legal aspects of rocket launch from stratosphere. Since the start of the project, the team has conducted more than 15 test launches of rockets and stratospheric launch platforms. There have been many fails and several accomplishments: a) the team has developed and tested on numerous missions a very simple, reliable and cost-effective communication solution based on LORA protocol; b) there have been unsuccessful tests of a rotating rocket launch; c) a simple aerodynamic stabilisation system has been tested successfully; d) a successful testing of vertically oriented LTE network; e) unsuccessful rocket launches from stratosphere; f) successful discussions with local Civil Aviation Administration on legal aspects of the flight; g) successful outreach activities and publicity on the national level. The team is planning to have the first successful rocket launch from a stratosphere in 2019 and reach a goal of 100km in 2020.

[A-204]

ON BALLOON AND ROCKET RESEARCH PROJECTS IN VIETNAM: SOME PRIMARY CALCULATIONS AND DESIGNS FOR MULTI-STAGE LAUNCHING VEHICLE

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Recently, sounding rockets and stratospheric balloons have played a crucial role in implementing National Scientific Research Program on Space Science and Technology in Vietnam. The research focus in approaching and testing stratospheric balloons with the equipment which can be applied in measurement, monitoring, navigation, finding and rescue (balloon research project). It also mainly researches, designs and manufactures of rocket samples for purpose of researching and carrying scientific equipment for high atmospheric exploration (rocket research project). In the paper, we will introduce and present specific objectives as well as expected results of these 2 projects.

This paper also shows the results of optimal programming of critical time sequence in launching sounding rocket in order to maximize altitude for the case of multi-stage rocket propulsion systems. A mathematic model of the one-dimensional rocket momentum equation including thrust, gravitational force, and aerodynamic drag is proposed. The flight is separated into time segments, defined as critical time sequence of launching process, corresponding working or burn-out of sequence of rocket propulsion stages. The highest altitude - apogee - of sounding rocket payload can be changed with selection of activations or ejections of the propellant jet. A combination of analytic and numerical methods is provided to find optimal programming of the critical time sequence for maximizing apogee at given conditions of launching propellant jet configuration.

Keywords: Sounding rockets; Balloons; Multi-stage sounding rocket; Optimal critical time sequence; Maximizing altitude

[A-081]

FROM ARCTIC BUOY TO STRASTOSPHERIC BALLOON: BECOOL, A MICROLIDAR DESIGNED FOR CIRRUS AND CONVECTIVE OVERSHOOT STUDIES

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1. Scientific context and objectives

The CNES project Strateole 2 aims at deploying different configurations of multi instrumented open stratospheric balloons (OSB) in the tropical area to improve our knowledge of air-masses transport and dehydration via the study of the tropical tropopause layer (TTL). Relationship between temperature anomaly and cirrus occurrence was highlighted thanks to previous measurements performed during the ATTREX campaign with a lidar system embedded onboard an unmanned aircraft system. These measurements, obtained in small areas during short flights, showed the necessity to organize longer flights in and above the TTL.

The BeCOOL (Balloonborne Cirrus and convective overshOOt Lidar) system was conceived to be embedded onboard one of the OSB configuration. With a nadir view this instrument will focus on getting atmospheric profiles particularly to deduce optical properties of cirrus and convective system.

2. Instrumental development

The BeCOOL system is based on the biaxial microlidar architecture developed for the French IAOOS project which aimed at deploying a network of multi-instrumented buoys in the Arctic region.

The microlidar is equipped with a fibered laser diode emitting around 802 nm with a FWHM less than 0.6nm. The laser pulse width is about 150ns at a rate of 4.8 kHz and energy around 10µJ per pulse. The reception optic includes an interferential filter with FWHM of 0.6 nm, and is optically fibered to the telescope and to the detector. The use of optical fibers between the components of the microlidar eases the integration of the system, particularly to separate the telescope (located in the "cold" area of the gondola) and the thermally sensitive parts. A specific laser driver board and on onboard computer were developed respectively to handle the supply of the laser diode and its thermal regulation, and to deal with data acquirement and communication with the gondola.

Compared to the IAOOS project, conception and tests were trickier especially because of the tougher environment. First of all, solution had to be found to put all the components, but the telescope, in a very small volume. It includes appropriate insulation for the thermally sensitive parts like the laser diode and the interferential filter. The weight was also decreased by removing some parts of the IAOOS telescope and using lighter materials. Numerous tests were performed in climatic chamber at very low temperatures and low pressure to ensure a proper behaviour of all the components. The thermal regulation of the laser diode was particularly difficult to handle because of the lack of convection in the OSB. Eventually a very first flight was successfully achieved within the STRATOSCIENCE campaign in August 2018 in Timmins, Canada.

In parallel with the scientific objectives of the Strateole2 campaign, this development of a balloonborne system is also an opportunity to increase the technology readiness level (TRL) of this microlidar so that, with other future instrumental improvements, it may be embedded in the long term onboard small satellite or rover for planetary missions.

[A-071]

N20 TEMPORAL VARIABILITY IN THE UTLS BASED ON IN-SITU OBSERVATIONS DURING THE PERIOD 1987-2018

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Nitrous oxide (N2O) is the third most important greenhouse gas in the atmosphere and is now considered as the most important emissions of stratospheric ozone (O3) depleting gas. Its sources are both natural and anthropogenic, mainly as an unintended byproduct of human food production activities. We present an estimation of the N2O trend in the upper troposphere and lower stratosphere (UTLS), based on observations from research aircraft and balloon campaigns during the period 1987-2018. Using statistical methods, the measurements have been quality-controlled and regions of the globe with sparse observations filled in. This consistent dataset is also used to study the N2O seasonal cycle in direct relationship with its emission sources. The preliminary results show a long-term increase in global N2O concentration in the UTLS similar to that found with ground measurements. This tendency is also evaluated using satellite measurements during the period 1992-2017 from ATMOS during ATLAS missions and ACE-FTS (SCISAT) and compared to the one obtained previously in our study with the in-situ observations.

In parallel, we simulate N2O concentrations from 1979 to 2014 with the climate model WACCM (Whole Atmosphere Community Climate Model; Marsh et al., 2013). This version of WACCM uses the specified dynamics option where temperature, zonal and meridional winds, and surface pressure are used to drive the physical parameterization that control boundary layer exchanges, advective and convective transport, and the hydrological cycle. The meteorological analyses for this study are taken from the NASA Global Modeling and Assimilation Office Modern-Era Retrospective Analysis for Research and Applications (MERRA) (Reinecker et al., 2011). By using seasonal zonal means and correlations between the measurements and the simulations, we are evaluating the ability of the model to reproduce the observations. This approach gives confidence in the spatial and time variations of the N2O sources used in the model.

[A-011]

TROPOSPHERIC OZONE OVER BEIJING: OBSERVATION AND CORRECTION

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Tropospheric and lower stratospheric ozone has been observed by instruments carried by balloons for more than ten years over Beijing. A double-cell ozonesonde has been developed at the Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences, replacing the single-cell GPSO3 ozonesonde at 2013. However, significant bias exists between double-cell ozonesonde and single-cell GPSO3 ozonesonde. Taking MLS and total column ozone datasets observed at Beijing as the reference values, we compare the differences of ozonesonde observation from reference values before and after 2013. Based on probability and cumulative functions of Weibull distribution, we make corrections to ozonesonde observation before 2013. The result shows that single-cell GPSO3 ozonesonde onboard balloon exaggerate ozone compare to double-cell ozonesonde. The most significant bias exists in middle and upper troposphere. Although the bias based on MLS is greater than based on total column ozone, ozone trends based on these two datasets are almost the same. Tropospheric ozone keeps increasing over Beijing until 2012 when a dramatic drop occurs. Since then, the tropospheric ozone remains stable over Beijing.

[A-111]

VALIDATION OF MEASUREMENTS OF NEURAL AND ELECTRON DENSITIES CONDUCTED BY NEW TURB3D SATELLITE IN THE MIDDLE ATMOSPHERE DURING PMWE-1 ROCKET CAMPAIGN

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In April 2018 two sounding rockets were successfully launched during PMWE-1 campaign at the north Norwegian Andoya Space Center (ASC, 69°N, 16°E) . During this campaign, we validated a Turb3d satellite under realistic flight conditions. The complete Turb3d instrument consists of three free falling satellites measuring neutrals and electrons in the middle atmosphere/lower thermosphere with unprecedented precision and uniquely high time/space resolution. Each satellite caries a ionization gauge sensor combined with an electrostatic probe.

From small scale analysis and simultaneous measurement of absolute density and temperature we derive high precision turbulent parameters, i.e. energy dissipation rates. The additional electrostatic probe allows investigations of dynamic interactions of neutrals and electrons in a common volume.

We give a technical description of the instrument and demonstrate technical performance. Moreover, we show first geophysical results as well as validation results and new features.

[A-130]

NEW INTERCOM SYSTEM AT ESRANGE SPACE CENTER

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Science Services at Esrange Space Center has been in need for a new intercom system for a long time. The old system was built as an analog star network distributed on copper wires, where all units looked alike. In complement with a mixer unit, all eight channels can be listened simultaneously, while talking is only possible on one channel at a time. This system was getting outdated, spare parts are difficult to find, and maintenance is expensive. The process for finding a new intercom system was initiated as early as 2012 after understanding the needs and requirements of the department. The early idea was to get a digitized system that was network based, and several companies were contacted in order to find a suitable system. A lot has happened since 2012, and in 2018, the team started to look into a temporary solution that can be beneficial over a long time, easy to integrate with the old system and further, can be useful when the system is upgraded to the fully digitized system. After studying different options, the team decided to purchase a smaller intercom system that could also work together with the public address (PA), and the short-wave radios. The smaller intercom is a matrix based system developed by Clear-Com and it consists of a matrix, eight intercom units, and a HelixNet system for two of the launchers. There is also an integrated recording system so all launch attempts can be recorded. The old intercom system, the PA system, and the radio are seamlessly integrated with the new system. This is however a preliminary solution until the final investment is decided and the rest of the system is procured. When the system is finalized we will have around 40 intercom units around the site.

[A-128]

A NOVEL FOURIER TRANSFORM LIMITED DOPPLER LIDAR FOR THE TROPOSPHERE/STRATOSPHERE

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Doppler lidar with daylight capability are challenging and expensive systems because of the small FOV, spectral filtering and other additional subsystems required compared to observations at night. Consequently, only a few systems with this capability exist so far.

The Institute of Atmospheric Physics has developed a new approach. A complete Doppler lidar with all required technologies for automatic operation is assembled in a few months for a fraction of the cost of former systems. Beside very compact and less complex, this technology is applicable to a large variety of lasers as Doppler Rayleigh, Doppler Mie or Doppler Resonance lidar.

Since the novel approach is wavelength independed, relative cheap and reliable laser at any chosen wavelength allows a further reduction of the cost of instruments in the future for the lower atmosphere. We demonstrate such a Fourier transform limited Doppler lidar achieving ~5 KHz resolution (~1 mm/sec line of sight wind) in laboratory for Doppler-Mie observations without the need of expensive Q-switch laser. This solar background free technology allows the detection of aerosols and gravity waves days and night year-around in the lower atmosphere. Depending on the laser system eye safe and robust lasers simplifies operation for monitoring the lower atmosphere over long periods.

[A-201]

EXPLORATION OF EARTH'S MAGNETIC FIELD BY HIGH ALTITUDE BALLOONS

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Earth's magnetic field is assumed to be a superposition of three main sources: the Earth's core field, the Earth's crustal field and the combined disturbance field produced by currents flowing in upper atmosphere and magnetosphere. Magnetic measurements which are taken from satellites are relatively far from local magnetic anomalies and therefore lack detailed magnetic data at stratospheric and tropospheric altitudes. One the other hand, land and airborne surveys are sensitive to local magnetic anomalies due to the relative vicinity to the Earth's non-homogenous crust, however difficult to conduct at stratospheric altitudes. Thus high altitude balloons are most attractive platform for exploring the Earth's magnetic field at variety of altitudes.

The chances for reusing a magnetic survey system carried by a balloon are quite low, especially because the landing location may take place unfortunately over water. This fact alone dictates a low cost survey system intended for one-time usage. Usually a scalar magnetic sensor such as a proton magnetometer or an Overhauser magnetometer is used for moving platforms. Such a sensor is the most expensive and power consuming element in the all system. Significant reduction of the overall system cost, power consumption and weight was accomplished in our system by using a three-axis fluxgate magnetometer (FGM) instead.

We designed and constructed a low cost and lightweight FGM based magnetic measurement system. In order to overcome FGM imperfections such as dis-orthogonally, offsets and drifts with temperature, an enhanced 48 parameters non-linear calibration model was chosen. We calculated the FGM calibration parameters at temperatures ranging from -20°C to 35°C. Our system uses an off-the-shelf radiosonde with a built-in GPS receiver, RF transmitter and an auxiliary digital data input for connecting additional sensors. A microcontroller was also incorporated for synchronizing the FGM with the radiosonde. Position, magnetic data and temperature readings are transmitted by the radiosonde every second to a ground station. The Ground station includes a matching off-the-shelf radio receiver with a PC to display and log all data.

We conducted an experiment with the system carried by a high altitude balloon. The balloon gained an altitude of over 28km and reached a range of 350km before communication was lost. Afterword, the magnetic readings were post-processed and compared with three Earth magnetic models: International Geometric Reference Field (IGRF), World Magnetic Model (WMM) & Enhanced Magnetic Model (EMM). The mean overall error between the measurements and EMM2017 is quite small and thereby validates the experimental results. The resemblance of the experimental results to the EMM2017 model may be accounted to the fact that the model includes 790 coefficients deduced from marine, aeromagnetic and ground magnetic surveys on top of satellites and ground magnetic observations used by the other two models. We plan to conduct more balloon based experiments in the future for both exploring different location and for statistical enhancing.

LIFE AND PHYSICAL SCIENCES 1

WEDNESDAY 19 JUNE, MORNING SESSION – PART 1

ROOM 1

CHAIR: A. PETERS

Plenary Invited Lecture

[A-194]

FREQUENCY COMBS AND CLOCKS ON SOUNDING ROCKETS: TOWARDS OPTICAL CLOCKS IN SPACE.

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Research on optical clocks, based on optical lattices and trapped ions is making fast progress. Today instabilities starting at the mid 10^{-17} level in 1 s, averaging down to mid 10^{-19} in 10,000 s are pushing the limits of what applications are conceivable. But not only the most advanced clocks and and most demanding applications can benefit from optical clock technology. Also the well established 10^{-13} to 10^{-16} stability range can be targeted. The well established H-Maser is now rivalled by optical clock counterparts that promise better stability and accuracy in a comparable form factor or better robustness and less environmental sensitivity in an even smaller package.

An indispensiable part of every optical clock is a frequency comb. The frequency comb provides the clockwork that connects the optical frequencies of 100s of THz with other optical frequencies and the RF world. Since its invention 20 years ago, the technology has come a long way. Small, robust, and 100% maintenance-free combs systems with low power consumption have been developed.

Several sounding rocket missions within DLR's TEXUS program have been our vehicle to increase technology readiness level and bring combs and clocks in space closer to reality. Currenlty differnent IOV missions are under discussion.

Many other applications on the ground and in space will benefit from optical frequency combs, e.g. direct- and dual-comb spectroscopy, attosecond physics, photonic microwave generation, accurate absolute distance measurements, optical reference lines for LIDAR, spectrograph calibration and even gravitational wave detection.

This talk will shed light on the complex interplay between performance, size, weight and power as well as technology readiness level for different mission scenarios and applications.

[A-144]

SOUNDING ROCKET MISSION MAIUS-1: ATOM INTERFEROMETRY IN SPACE

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At the beginning of 2017 the sounding rocket MAIUS-1 was launched from Esrange in Sweden. Onboard it carried an atom optical experiment aimed at creating the first Bose-Einstein condensates in space and using this quantum degenerate matter as a source for matter wave interferometry. Here we will present the results of the experiments during the flight, including the first creation of a Bose-Einstein condensate in space and interferometric measurements. The successful operation of the atom-chip based BEC source marks a major advancement in the effort of performing matter wave interferometry on space vehicles. Due to their small initial size and low expansion rates BECs are the ideal source for such an interferometric measurement in space.

MAIUS-1 opens a new path towards space born inertial sensing employing atom interferometers with high accuracy and unprecedented sensitivity. In the recent past several missions were proposed ranging from a test of the universality of free fall using a dual-species atom interferometer to gravity gradiometry for earth observation. There are two follow-up sounding rocket missions planned which will include dual-species atom interferometry using Rubidium-87 and Potassium-41. The findings of these missions will also contribute to the NASA CAL project and BECCAL, a joint endeavor of NASA and DLR in the realm of experiments with BECs in space.

[A-138]

MAIUS-2/-3: A SYSTEM FOR TWO-SPECIES ATOM INTERFEROMETRY IN SPACE

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After the first demonstration of coherent matter-wave manipulation with Bose-condensed Rubidium-87 atoms in space during MAIUS-1, we aim for the implementation of a dual-species Mach-Zehnder atom interferometer in the successor missions MAIUS-2 and -3. This interferometric sequence utilizing Rubidium-87 and Potassium-41 atoms comprises the experimental techniques which are necessary to perform tests of the universality of free fall in future satellite missions.

Based on the mission goals, the higher complexity of the payload asks for a well-conceived design of the subsystems while it has to maintain the same technical constraints given by the VSB-30 vehicle. In particular, the addition of a second atomic species doubles the number of required lasers and their respective control electronics such as current drivers, frequency- and temperature stabilization.

While the system is currently in the construction phase, extensive experiments regarding the cooling and manipulation of the two-atomic species Potassium-41 and Rubidium-87 are performed on a ground-based setup which resembles the flight system and serves as a testbed for the experimental sequences on the planned sounding rocket missions and future endeavors like BECCAL.

Here we will present the goals of the missions MAIUS-2 and -3 and the resulting requirements on the system components. The measured performance of the Potassium-41 and Rubidium-87 cold atom source and future plans of ground-based measurements before the launch will be discussed.

[A-013]

IN-SITU OBSERVATION OF EQUIAXED DENDRITES SOLIDIFYING UNDER REDUCED GRAVITY CONDITIONS DURING THE TEXUS-55 MISSION – THE MEDI-2 EXPERIMENT

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To improve solidification processes the understanding of microstructure formation is of essential relevance. For many technical applications, a microstructure consisting of equiaxed dendritic grains is preferred, because of more homogeneous material properties. Up to now, it is largely unexplored, whether the crystallographic orientation of the equiaxed dendrites affects their nucleation and growth behaviour. To investigate this topic, the organic transparent alloy Neopentylglycol-20.0wt.-%(d) Camphor was used, which crystallizes with similar dendritic morphology as metallic alloys. The experiment MEDI-2 was carried out onboard the sounding rocket TEXUS-55 mission in 2018, where convection of the melt and sedimentation of the dendrites is negligible. The experimental conditions were chosen such as to obtain an equiaxed dendritic structure with diffusive conditions for heat and mass transport during the microgravity period. The dendrites were observed in-situ with two different optical systems to analyze the global and the microscopic features of equiaxed solidification. As a result, equiaxed dendrites with six dendrite arms growing perpendicular to each other were detected, which is characteristic for to a <100> crystallographic orientation. From the experiment the nucleation rate, the growth rate of the dendrite arms as well as the nucleation undercooling distribution were determined for diffusive growth conditions. To study the effect of different crystallographic orientations on the solidification behaviour in more detail, in future, these benchmark data will be compared to results obtained during the former microgravity experiment MEDI, where growth of equiaxed dendrites with <111> crystallographic orientation was investigated.

[A-168]

IN-SITU OBSERVATION OF FOREIGN PHASE PARTICLES IN FLUIDS AND THEIR INTERACTION WITH A SOLIDIFICATION FRONT

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The incorporation of foreign phases during the solidification of materials is a difficulty occurring in different material systems and techniques. One prominent example for a lowered yield due to incorporated foreign phases is VGF solar silicon. In this case, the main impurities are silicon nitride (Si_3N_4) and silicon carbide (SiC) forming within the melt by supersaturation of carbon and nitrogen. The particles show sizes in the range of several micrometers to millimeters, have an increased hardness compared to silicon and partly lower resistivity, and therefore lead to a considerable material loss due to sawing damage and/or electrical shunts.

The avoidance of the particle formation during the industrial production of VGF solar silicon is very difficult and originates from the crystal growth setup. The only chance to increase the yield in order to reduce costs is to control the incorporation of the present particles. Motivated by the question of the PV- industry, it is important to investigate and understand more in detail the behavior of such particles inside the melt and especially their interaction with the solidification front. Therefore, different particle materials, sizes, and morphologies are chosen as relevant particle species and were inserted into a transparent melt. This ensures the determination of the influence of different density ratios, wetting behavior, thermal capacities and conduction, and interaction areas between particle and phase boundary.

To determine the behavior of the particles at the solidification front, a high-speed camera system is installed on a double-ellipsoid-mirror-furnace to record in-situ the current state in melt. This system is built up in that way to be implemented later in a sounding rocket for experiments under reduced gravity.

First observations show that a flat solidification front can be reached and the different particle materials can be tracked within the melt and at the phase boundary. A critical value (vcr) for the particle velocity was found. Independent on the particle size, below this vcr particles stay within the present convection roles and do not touch the phase boundary while those particles with higher movement velocities penetrate an observed, 800 µm thick boundary layer between solidification front and residual melt body and are then engulfed and incorporated.

Additionally, by inserting small-sized particles it is possible to calculate the velocity and depth of activity of the Marangoni as well as the buoyancy convection what gives information about material specific characteristic numbers. This is important for the data implementation in numerical models.

[A-033]

MARANGONI FLOW IN A FREESTANDING LIQUID CRYSTAL FILM

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Liquid crystals (LC) combine properties of fluids (e.g. fluidity) with several properties of solids (e.g. orientational and partial positional order). In addition to their application in everyday life, LCs show a rich variety of features that are interesting from the point of view of fundamental physics. For example, smectic LC films can serve as model systems for two-dimensional fluids. These films can have lateral extensions of several centimeters at submicrometer thicknesses. Their aspect ratio may exceed 106. In our study, we investigate thermocapillary effects in freely suspended fluid films. In detail, we focus on thermally induced flow in the film plane.

While the influence of gravity on the shape of such films is negligible, it is hardly possible to avoid the effect of buoyancy driven airflow under conditions of normal gravity. Such flow advects the thin free-standing films and masks the genuine effects of LC thermocapillary forces. In order to avoid any such influences, the experiment was performed during the microgravity phase of the TEXUS 52 and Texus 55 suborbital rocket flights launched in ESRANGE (Sweden).

In the first 30 seconds of the microgravity phase we prepared a thin film with a film thickness of about 170 nm, that was in contact with two temperature controlled posts. During the whole flight, the support frame temperature was set to a constant background temperature, and we applied temperature gradients up to 4.8 K/mm inbetween the posts. The transport processes in the film plane were observed with a CCD camera. Flow in the film was identified from the displacement of smectic C Schlieren structures in polarized light.

We demonstrate that the temperature gradients induce flow from the warm post to the cold one without a measurable threshold. This is accompanied by material redistribution. Excess material collects at the cold post. It is shown that a reversal of the temperature gradients leads to a reversal of the flow.

The reason for the oberserved flow is a temperature dependent surface tension of the film material. We developed a hydrodynamic model that describes our experimental findings quantitatively [1]. The model shows that the temperature difference between the posts is the relevant control parameter. This is in contrast to Benard-Marangoni or Rayleigh-Benard convection, where the temperature gradient plays the essential role

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TECHNOLOGY & INFRASTRUCTURES FOR SOUNDING ROCKETS 3

WEDNESDAY 19 JUNE, MORNING SESSION – PART 1

ROOM 2

CHAIR: A. VERGA

DEVELOPMENT OF NEW PAYLOAD MODULE FOR 4D MEASUREMENTS

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Traditionally the sounding rocket carries a payload in which all instruments are mounted in a payload section on the main rocket body. A nosecone and/or doors protects the payloads' instruments during the rockets' ascent until the area of interest has been reached and nosecone and doors are ejected to expose the instruments.

Although the sounding rocket can reach areas of the atmosphere to perform in-situ measurements that balloons and satellites cannot, it only performs such measurements during a very brief moment in time and at particular place governed by the ballistic trajectory of the rocket.

To be able to determine the dynamic properties of a particular phenomenon or the scale of such phenomena, it must be possible to perform measurements covering a larger area as well as over an extended time interval than what is possible with a single sounding rocket payload.

In order to allow researchers to see a bigger picture of the phenomenon that is being investigated, Andøya Space Center (ASC) has initiated a development of a new payload module for sounding rockets that will allow for four-dimensional (4D) measurements (3D space and time). The purpose of the new development is to be able to eject a large number of miniaturized payloads in different directions at predefined times during the ascent of the rocket. The miniature payloads carry the identical instruments and sensors, which then allows for measurements to cover a much larger area and thus form a 3D mapping. Depending on the direction the miniaturized payload is ejected, a measurement of the same position at different times during the flight of the rocket is possible. As such, the free flying miniature payloads can be seen as forming a cloud. While they propagate along the ballistic path of the sounding rocket the fourth dimension, time, is realized.

The first phase of the project was to flight qualify a module that fits on a 14inch payload. This was done on the Nucleus launch in 2018. The module released 6 daughter payloads into one plane, making 3D measurements (2D space through time). The system is easily scalable to fit larger payloads and to add more daughter payloads as necessary. In January 2019, a module scaled up to 16 inches was launched with Rocksat XN (G-Chaser) as part of the Grand Challenge Initiative. This was also the first launch where the daughter payloads contained mNLP-probes.

The next launch with the 4D-Space module will be ICI-5 in December 2019, also a part of the Grand Challenge Initiative. This payload will contain two modules, with a total of 12 daughter payloads.

The development of the new payload module is done in close collaboration with the University of Oslo and their 4DSpace initiative.

[A-042]

DEVELOPMENT OF A LIGHTWEIGHT CARBON COMPOSITE ROCKET MODULE WITH INTEGRATED FIBER OPTICAL TEMPERATURE SENSORS AS PART OF EXPERIMENT " TESOS " ON REXUS23

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Structural parts of rockets are exposed to substantial mechanical and thermal loads. Sounding rockets as used in the REXUS program consist of several identical structural modules carrying the scientific payload. The design of a module includes a cylindrical outer shell and thick, monolithic load input rings with a defined assembly interface. Up to now all REXUS modules are made out of aluminum. [1]

Reducing the structural weight allows higher payloads, higher apogees or reduced fuel consumption. Carbon fiber reinforced plastics (CFRP) have higher specific stiffness and strength compared to aluminum and therefore bare a high lightweight potential [2]. Fiber optical sensors (FOS) allow for integration into the CFRP laminate and structure-internal measurements due to their small size and fiber shape.

The task of this project was to develop a manufacturing concept for a thermoplastic CFRP module with integrated FOS. This included a structural analysis, qualification and testing of the structure together with an implementation of a FOS measurement system for temperature measurements during flight.

The concept comprises two separate manufacturing steps for the load input rings and the cylindrical shell. The rings were manufactured by press-forming of long fiber thermoplastic material (LFT), the shell structure by Thermoplastic Automated Fiber Placement (TP-AFP). TP-AFP allows an in-situ consolidation of the shell on the previously manufactured rings without additional adhesive or mechanical fasteners. Polyetheretherketone (PEEK) was chosen as matrix material due to its excellent mechanical properties under thermal loads and its compatibility with the chosen processes.

A finite element (FE) structural analysis of the module based on given loading conditions defined the geometrical dimensions of shell, rings and the required joining area. The laminate lay-up was optimized to fulfill the required module stiffness. Coupon level characterization of the LFT and TP-AFP materials at room temperature and service temperature were carried out to obtain input parameters for the structural analysis. Sub component tests of the in-situ joint between shell and ring material as well as screw insert pullout tests covered critical aspects of the module design. Full scale tests were performed for a defined spectrum of vibrations and a maximum bending load.

Capsuled fiber Bragg grating (FBG) sensors were integrated into the TP-AFP laminate during manufacturing. This will allow temperature measurements in between the plies during flight. The experimental payload of the module will consist of a fiber optical measurement device to operate the FBGs, electrical reference sensors, a computer for data storage and downlink and a power board. CFRP module and experimental setup will be part of REXUS 23 scheduled for launch in March 2019.

The proven concept of in situ bonded TP-AFP tapes on complex monolithic LFT structures has different potential applications within aerospace but also automotive structures and will be further investigated.

References:

[1] Schüttauf, K. et al, (2018): REXUS User Manual V7.16, http://rexusbexus.net (Last retrieved: Jan 20, 2019).
[2] Baker, A.; Dutton, S.; Kelly, D. (2007): Composite materials for aircraft structures. Norwich, NY: Knovel (AIAA education series).

[A-050]

RADIATIVE WARMING FROM A ROCKET PLUME WITH TWO-PHASE FLOW

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Thermal control is necessary for launch vehicles since there are some heat sources that can jeopardize their functioning and result on mission failure. One of these heat sources is the plume generated by the rocket propulsion system exhaustion. The plume transfers significant heat by radiation when the rocket propulsion is based in solid rocket motors. In this case, the radiation came from solid particles present in the plume called alumina. During the flight, as the vehicle reach elevated altitudes the atmospheric pressure is reduced what makes the plume expands making its radiation hit the vehicle base where there are radiation-sensitive components. The situation is even worse when the base area is significant, relatively the plume emission area. The importance of the problem requires that an aerothermic analysis must be conducted to estimate the impact of the radiation loads on the base and dimensioned the thermal protections necessary. In this study, two methods are presented to deal with this problem. The first is based on unidimensional simplified engineering approach. The second method is based on a CFD of the plume multiphase flow using the Discrete Phase Method (DPM). Both methods are applied to the VS50 Rocket Nozzle, in development at the Institute of Aeronautics and Space – IAE, São José dos Campos, Brazil. The results from the two methods are presented and compared. Additionally, a sensibility analysis of the flow parameters regarding the base heating is conducted. The engineering method applied to simulate the two-phase flow in the nozzle considers the presence of alumina particles that resulted from the aluminium combustion in the engine chamber. Although the calculation using a two-dimensional two-phase simulation using a CFD package presents higher accuracy, the use of a simple one-dimensional engineering approach is acceptable for the initial phases of the design.

[A-087]

PR3: PAYLOAD FOR RADIO-INTERFEROMETRY AND RADIATION MEASUREMENT ON REXUS25

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The PR3 payload flies on Rexus 25 and will perform two experiments inside a single rocket module.

The first experiment will use radio-interferometry to precisely localize the sounding rocket during both the ascent and descent stages. An accuracy in the range of 10 centimeter is expected, with an update rate 1KHz. In order to achieve these three antennas mounted on the outside of the rocket module transmit unmodulated carrier signals at three distinct wavelengths around 70cm. These carrier signals are received on six ground stations that are placed around the Esrange launch site. Each ground station contains three antennas and uses phase difference measurements to compute a vector pointing in the direction of the rocket. All six vectors computed by the ground stations are combined to find a solution of the rocket position. Since there are three different frequencies transmitted, three sources can be identified which should give an attitude estimate besides to rocket position.

The second experiment evaluates three types of commercial-of-the-shelf cameras for suitability for detecting ionizing radiation. The cameras have different properties with respect to the camera sensor technique used (CCD versus CMOS) as well as different resolutions. The particle interactions are processed on board and the particle counts are made available via the telemetry link. Raw data is stored for post-flight processing. As a reference a scintillator based radiation sensor is used, allowing the camera results to be compared to a sensor with know properties.

[A-091]

GPS-BASED ALTITUDE RECONSTRUCTION FOR FREE FALLING/FLYING UNITS

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Knowledge of a payload's attitude is of the utmost importance when using directional instruments such as electric field probes. Electric field probes are usually metallic spheres deployed radially from the payload on long booms, and measure the electrical potential between the probe and the payload hull. This effectively measures the projection of the electric field along the probe/boom vector. Such measurements is by design taken in the inertial reference frame of the payload, and knowledge of the probe orientation in space (i.e. full attitude) is mandatory to properly retrieve the measured electric field vector in a scientifically useful reference frame (e.g. geocentric coordinate).

On spacecraft, attitude information is usually obtained using a sun sensor and/or a star tracker. However, the lack of space makes these methods difficult to implement onboard small payloads ejected from sounding rockets. This is particularly relevant for payload studying auroral surges launched in night-time condition, where the auroral background makes the detection of stars complicated.

Nonetheless, such payload is usually equipped with a GPS antenna for position information, as well as internal gyroscopes to record the change of angular rates. The presented paper describes a method to obtain the payload attitude solely using the GPS antenna and gyroscopes measurements. Knowledge of the GPS antenna diagram is used to model the GPS Carrier-To-Noise (CN0) signal for each of the five most visible GPS satellites. These modeled CN0s depend on the payload attitude history which was measured internally by the gyroscopes, therefore only leaving the initial three Euler angles between the inertial reference frame to the geocentric reference frame to be found by comparing these simulated CN0s with the actual CN0s measured during the flight. This method was applied to the flight data of the SPIDER sounding rocket, launch in February 2016. During the flight, 10 free falling units (FFUs) were ejected from the rocket, each equipped with its own GPS receiver and gyroscopes, as well as deploying electric field probes on 2-m long wire-booms. The retrieved attitude from three of the recovered FFUs will be presented and applied to their onboard electric field measurements. As a conclusion, a comparison of the electric field vectors measured onboard each of the three FFUs will be discussed.

Astrophysics, Astronomy and Cosmology 2

Wednesday 19 June, Morning session – part 1

Room 3

Chair: J.Montel

XL-CALIBUR – A SECOND GENERATION BALLOON-BORNE HARD X-RAY POLARIMETRY MISSION

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Black hole binaries, neutron stars, and other compact objects are too small and distant to be imaged. Information on source geometry and high-energy emission mechanisms is instead derived from spectral and timing measurements. Results are often model dependent with interpretation subject to degeneracies which cannot be resolved. X-ray polarimetry provides a valuable independent source diagnostic. Characterising the source emission with two additional observables, the linear polarisation fraction and the linear polarisation angle disentangles geometrical and physical effects, thereby opening a new window on the high-energy universe. Only a few reliable observations of the brightest celestial X-ray sources have been made to date. Future satellite missions stand to open an observation window with unprecedented sensitivity for the classic X-ray astronomy energy range centred around a few keV. Stratospheric ballooning platforms offer an attractive way to make headway in the hard X-ray (>20 keV) regime.

The XL-Calibur mission is a continuation of the X-Calibur mission which has conducted several test flights, culminating in observations of the accreting X-ray pulsar GX 301-2 during a flight on Antarctica in December 2018 (Kislat et al., this conference). XL-Calibur is a second-generation instrument which achieves approximately six times better sensitivity than X-Calibur due to several improvements. Most importantly, the 8 m long optical bench and the InFOCμS X-ray mirror will be replaced by a 12 m long optical bench and the spare mirror of the hard X-ray telescope of the Hitomi mission. The mirror provides an approximately four times larger effective area than the InFOCμS mirror in the key energy range from 20-40 keV and an even larger improvement at higher energies. Furthermore, modifications of the polarimeter and the anticoincidence shield will reduce the background by a factor of approximately two.

XL-Calibur will study a sample of archetypical X-ray sources (15-80 keV), including but not limited to, stellar mass black holes in X-ray binaries such as Cyg X-1 and GX 339-4, accretion and rotation powered neutron stars such as Her X-1, Vela X-1, GX 301-2, and the Crab, as well as a sample of flaring binaries. Simultaneous observations between XL-Calibur and the Imaging X-ray Polarimetry Explorer (IXPE) mission are foreseen, allowing the polarization of different emission components to be distinguished.

[A-199]

A BALLOON BORNE 3D CZT SPECTRO-IMAGER PROTOTYPE FOR HARD X RAYS MEASUREMENTS.

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The creation of a new generation of telescopes for hard and soft gamma X-ray astrophysics (10-1000 keV) requires, at the same time, the development of high performance detectors capable of allowing high efficiency and high quality measurements in spectroscopy, timing, imaging and last but not least, due to its importance, in polarimetry. In this direction, our group has been engaged for several years in the development of image spectrometers based on CZT sensors, with high segmentation, sensitive to the position in three dimensions (3D CZT sensor), able to meet the requirements of these new class of telescopes.

In particular, in the framework of a project funded by ASI, we are building a small prototype consisting of a few of these sensors for a total sensitive volume of about 8 cm^3. Thanks to a new electrode configuration, based on drift-strips for anode and orthogonally segmented cathodes, coupled to the signals reading implemented, this prototype will achieve a high spatial resolution (<0.5 mm in each direction) together with fine energy resolution (1-2 % at 511 keV), by means of a relative small number of front-end electronics channels (100). We must underline that the product of this project will be the prototype of the basic modules to be used for the realization of a high performance focal plane like the one required for a space telescope based on wideband Laue lenses (see presentation by Virgilli et al at this conference, in the session of astrophysics and cosmology).

After a deep measurements phase at ground using both radioactive sources and high-energy facilities like ESRF (Grenoble, France), we are planning to build a small balloon-borne experiment based on the final prototype, able to achieve both technological and scientific targets. The main technological target will be to verify the robustness and reliability in a pseudo-spatial environment of the solutions adopted. In particular, we will test the procedures used for the realization of the individual sensors and their packaging. The main scientific objectives are to perform a measurement of both particles and photons background, in order to verify the reliability of discrimination methods based on the information that can be obtained from the 3D imaging capabilities coupled with expected fine spectroscopy.

Given the objectives expected for this payoload, there are no particular constraints of trajectory and/or latitude and not even in the pointing requirements and moreover the payload can be embarked on a platform togheter with other experiments. In particular, our plan is to submit the instrument for a balloon flight to the last call (2021) envisaged by the European HEMERA project funded under the H2020 program. In this presentation, we will first describe the ongoing developments and the performance we expect to obtain from the prototype and the information we could obtain from its implementation on a stratospheric balloon flight. Moreover, we will describe the characteristics of the balloon payload that we could realize by specifying the resources required by the experiment in terms of volumes, weights, power and telemetry.

[A-009]

GETTING READY FOR THE 3RD SCIENCE FLIGHT OF SUNRISE

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SUNRISE is a balloon-borne, stratospheric solar observatory dedicated to the investigation of the structure and dynamics of the Sun’s magnetic field and its interaction with convective plasma flows and waves. The previous science flights of SUNRISE in 2009 and 2013 have led to many new scientific results, so far described in around 90 refereed publications. This success has shown the huge potential of the SUNRISE concept and the recovery of the largely intact payload offers the opportunity for a third flight.

The scientific instrumentation of SUNRISE 3 will have extended capabilities in particular to measure magnetic fields, plasma velocities and temperatures with increased sensitivity and over a larger height range in the solar atmosphere, from the convectively dominated photosphere up to the still poorly understood chromosphere. The latter is the key interaction region between magnetic field, waves and radiation and plays a central role in transporting energy to the outer layers of the solar atmosphere including the corona.

SUNRISE 3 will carry 2 new grating-based spectro-polarimeters with slit-scanning and context imaging with slitjaw cameras. The SUNRISE UV Spectro-polarimeter and Imager (SUSI) will explore the rich near-UV range between 300 nm and 430 nm which is poorly accessible from the ground. The SUNRISE Chromospheric Infrared spectro-Polarimeter (SCIP) will sample 2 spectral windows in the near-infrared, containing many spectral lines highly sensitive to magnetic fields at different formation heights. In addition to the two new instruments the Imaging Magnetograph eXperiment (IMaX), an etalon-based tunable filtergraph and spectro- polarimeter flown on both previous missions, will be upgraded to IMaX+, enhancing its cadence and giving access to 2 spectral lines in the visible spectral range. All three instruments will allow investigating both the photosphere and the chromosphere and will ideally complement each other in terms of sensitivity, height coverage and resolution.

A new gondola with a sophisticated attitude control system including roll damping will provide improved pointing/tracking performance. Upgraded image stabilization with higher bandwidth will further reduce residual jitter, maximizing the quality of the science data.

The presentation will focus on the SUNRISE-3 mission, and will also include the scientific highlights of the first two SUNRISE flights.

SUNRISE 3 is a joint project of the German Max-Planck-Institut für Sonnensystemforschung together with the Spanish SUNRISE consortium, the Johns Hopkins University Applied Physics Laboratory, USA, the German Kiepenheuer Institut für Sonnenphysik, the National Astronomical Observatory of Japan and the Japan Aerospace eXploration Agency (JAXA).

[A-058]

SHEFFIELD UNIVERSITY SOLAR BALLOON LIFTED TELESCOPE (SUNBYTE – BEXUS 25)

***Y-H Cho*[1], *I. Bobrov*[1], *SunbYte Team*[1], *V. Fedun*[2]**

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Sun surveillance from the ground is often difficult as the thick atmosphere of the Earth blocks and distorts much of the incoming light. Learning about the Sun is critical in modern society when solar flares have the potential to cripple telecommunication and global navigation systems. In the UK alone, €22mn was invested in the Space Situational Awareness program emphasising the need to better understand and predict solar events. Project SunbYte (Sheffield University Nova Balloon Lifted Telescope) aims to develop an advanced instrument for high-quality solar observations by using a high-altitude balloon.

SunbYte is a University of Sheffield student-led project with academic and industry partners – University of Hong Kong, Northumbria University, Queen's University of Belfast, University of Hull, Andor Ltd, Astrograph Ltd, and Alternative Photonics.

The first prototype of the robotic telescope was initially launched on BEXUS 25 from ESRANGE, Sweden in Oct 2017 as part of the REXUS/BEXUS programme. Subsequent re-flights were made with NASA as part of the High-Altitude Student Platform (HASP). In this paper, we will focus on solar tracking and pointing (two-axis gimbal) capabilities developed within the framework of these programmes. We will also discuss the scientific results of two past missions, provide technical analysis and discuss future development. Finally, we will present our new educational initiatives in research-led teaching that was developed at Sheffield as a result of the team's participation in the aforementioned programmes.

The REXUS/BEXUS programme is realised under a bilateral Agency Agreement between the German Aerospace Center (DLR) and the Swedish National Space Board (SNSB). The Swedish share of the payload has been made available to students from other European countries through the collaboration with the European Space Agency (ESA).

Experts from DLR, SSC, ZARM, and ESA provide technical support to the student teams throughout the project. EuroLaunch, the cooperation between the Esrange Space Center of SSC and the Mobile Rocket Base (MORABA) of DLR, is responsible for the campaign management and operations of the launch vehicles.

Keywords: solar astronomy; sun tracking; University of Sheffield; telescope; Balloon;

[A-173]

THE CHROMOSPHERIC LAYER SPECTRO-POLARIMETER (CLASP2) SOUNDING ROCKET MISSION: FIRST RESULTS

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A major remaining challenge for heliophysics is to decipher the magnetic structure of the chromosphere, because of its vital role in the transport of energy into the corona and solar wind. Routine satellite measurements of the chromospheric magnetic field will dramatically improve our understanding of the chromosphere and its connection to the rest of the solar atmosphere. Before such a satellite can be considered for flight, we must refine the measurement techniques by exploring candidate emission lines with a range of magnetic sensitivities. In September 2015, CLASP achieved the first measurement of the linear polarization produced by scattering processes in a far UV resonance line (hydrogen Lyman-alpha), and the first exploration of the magnetic field via the Hanle effect in quiet regions of the chromosphere-corona transition region. These measurements are an important first step towards routine quantitative characterization of the local thermal and magnetic conditions in this key layer of the solar atmosphere.

Nonetheless, Lyman-alpha is only one of the magnetically sensitive spectral lines in the UV spectrum. The reflight of CLASP in 2019, reported here, extends the capability of UV spectropolarimetry by acquiring ground-breaking measurements in the Mg II h and k spectral lines near 280 nm, whose cores form about 100 km below the Lyman-alpha core. These lines are compelling because they are sensitive to a larger range of magnetic field strengths than Lyman-alpha, through both the Hanle and Zeeman effects. CLASP2 will capture measurements of linear and circular polarization — a first in chromospheric ultraviolet radiation — to enable determination of all 4 Stokes parameters. Coupled with sophisticated numerical modeling of scattering and magnetic effects (Zeeman, Hanle, magneto-optical), CLASP2 is a pathfinder for determination of the magnetic field's strength and direction, as well as scattering due to non-symmetric illumination, within the solar chromosphere.

CLASP2 is scheduled for launch on a 2-stage sounding rocket from White Sands Missile Range in the spring of 2019. At this symposium, we will show a first look at the data, summarizing the characteristics of the CLASP2 flight, the performance of the UV telescope and spectropolarimeter, and our preliminary findings.

Life and Physical Sciences 2

Wednesday 19 June, Morning session – part 2

Room 1

Chair: A. Verga - A. Peters

Plenary Invited Lecture

[A-180]

METAL FUELS FOR ZERO-CARBON HEAT AND POWER ON EARTH AND IN SPACE

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In order to address climate change, we must transition to a low-carbon economy. Many clean primary energy sources, such as solar panels and wind turbines, are being deployed and promise an abundant supply of clean electricity in the near future. The key question that must be answered to enable the transition away from fossil fuels becomes how to store, transport and trade this clean energy in a manner that is as convenient as fossil fuels. The Alternative Fuels Laboratory (AFL) at McGill University is actively researching the use of recyclable metal fuels as a key enabling technology for a low-carbon society. Metal fuels, reduced using clean primary energy, have the highest energy density of any chemical fuel and are stable solids, simplifying trade and transport. The chemical energy stored in the metal fuels can be converted to useful thermal or motive power through two main routes: the Dry Cycle, where metal powders/sprays are burned with air, or the Wet Cycle, where metal powders are reacted with water to produce hydrogen and heat as an intermediate step before using the hydrogen as a fuel for various power systems. This talk will overview the concept of metal fuels, and the various power system options, for applications on Earth and for space exploration. It will also touch on the combustion and reaction physics of metal fuels, including a discussion of how the PerWaves microgravity experiment, supported by both the ESA and CSA, has advanced our understanding of the fundamentals of metal-fuel combustion. The PerWaves experiment has demonstrated that metal fuels burn in a new type of flame whose speed does not depend on the reaction rate of the metal fuel with the oxidizer.

[A-143]

PERWAVES EXPERIMENT ON THE MAXUS-9 SOUNDING ROCKET: DISPERSION AND COMBUSTION OF SUSPENSIONS OF METALLIC PARTICLES IN MICROGRAVITY

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Reaction-diffusion waves travelling through heterogeneous mixtures of spatially localized sources in an inert medium are encountered in the fields of physics, chemistry, and biology. The recently developed theory of the regime of discrete wave propagation predicts rather unusual properties of the reaction-diffusion wave in these systems, such as, a percolating behaviour, increasing with time, a front roughness and a near independence of the wave propagation velocity on the rate of reaction of the sources. Despite the fundamental importance of discrete waves and a continuously increasing number of theoretical studies, the regime of discrete front propagation has been lacking clear experimental verification due to the difficulty in obtaining well-characterised three-dimensional systems of randomly positioned reacting sources in ground experiments. The current paper presents results of the space experiment that attempted an observation of discrete reacting waves (flames) in suspensions of iron particles in oxygen-xenon mixtures. The PERWAVES (Percolating Waves) microgravity experiment was performed aboard the European Space Agency MAXUS-9 sounding rocket, launched on April 7, 2017 from the Esrange Space Center in Sweden. The tests compared the flame propagation speed in tubes filled with suspensions of iron particles (d_{32} = 33 μm) in two oxygen/xenon gas mixtures, with 20% and 40% oxygen, respectively. Even though the measured combustion time of iron particles in mixtures with a 40% oxygen content was more than three times lower than in mixtures with 20% of oxygen, the overall flame propagation speed in both mixtures was nearly the same, clearly indicating the discrete flame propagation regime. One of the unexpected results of this space experiment was the confirmation of yet another theoretically predicted microgravity effect – the trapping of the heavy particles in two-phase flows by weak vortices. This effect was responsible for a much lower particle concentration in the reactive flow in microgravity conditions as compared to the ground-based calibrated experiments.

AN OPTICAL ABSOLUTE FREQUENCY REFERENCE BASED ON IODINE ON A SOUNDING ROCKET MISSION

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Frequency stabilized laser systems are a key technology for future space missions, in particular for missions using inter-satellite laser ranging for, e.g., space-borne gravitational wave detection and Earth observation.

One method to achieve ultra-stable laser systems is active frequency stabilization of the frequency of a laser to an optical transition in atoms or molecules. This can be achieved by highly sensitive Doppler-free spectroscopy of atoms in a warm vapor cell combined with active laser frequency control resulting in an absolute frequency reference with fractional frequency stability of one part in 10^{15}.

Here we present a compact and autonomous absolute optical frequency reference based on hyperfine transitions in molecular iodine named JOKARUS that was applied on a sounding rocket mission. It is based on a micro-integrated extended cavity diode laser at 1064 nm with integrated optical amplifier, pigtailed second harmonic generation wave-guide modules, and a quasi-monolithic spectroscopy setup with operating electronics. This frequency reference was launched in May 2018 aboard the TEXUS 54 sounding rocket. This mission is an important qualification step towards space application of iodine frequency references and related technologies for inter-satellite ranging. With a fractional frequency instability of better than 6 10-13 we meet the requirements of state-of-the art missions as demonstrated in previous works. JOKARUS operated autonomously and its optical frequency was compared to an optical frequency comb during its space flight. Thereby the combined JOKARUS and FOKUS II mission also demonstrated key technology for the anticipated operation of optical clocks in space. We will report in detail on the design of the JOKARUS instrument and the results of this mission.

This work is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Energy under grant numbers DLR 50 WM 1646.

[A-067]

FOKUS II – SPACE FLIGHT OF A VACUUM COMPATIBLE DUAL FREQUENCY COMB SYSTEM

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Since its invention in the late 1990s, the frequency comb technology revolutionized the world of optical frequency metrology [1] and is now widely available as of-the-shelf product around the globe. While promising use cases for space-based applications exist, the space technology readiness, particularly regarding miniaturization and ruggedness, remains an obstacle for its deployment. In April 2015 and January 2016, the first frequency comb system was launched into space on a TEXUS sounding rocket. The system, FOKUS I (Ger.: Faser-optischer Kammgenerator unter Schwerelosigkeit), was developed by the Max Planck Institute for Quantum Optics (MPQ) and Menlo Systems GmbH funded by the German Aerospace Agency (DLR) demonstrating the robustness and reliability of the technology [2].

Since 2016, we've developed the next generation, FOKUS II, aiming to tackle some major limitations of the first iteration. The system was redesigned from scratch as a double-comb device with special attention to an improved thermal management required for operation under vacuum conditions. Furthermore, the power, mass and volume budget was reduced to 60W, 10 kg and 8 liters, respectively. Within these parameters, two independent frequency combs were implemented into one single instrument, allowing a continuous and absolute frequency determination of a continuous wave laser source. Controlled by a Cortex A8 ARM-based embedded platform governing the combs' high- and low-level functions, the system can operate quasi fully autonomously, effectively minimizing the user interaction. Its operation was demonstrated in combination with the JOKARUS payload, an Iodine referenced external cavity diode laser developed by the Humboldt University Berlin [3], during the TEXUS 54/55 sounding rocket campaign in 2018. The JOKARUS laser was connected to FOKUS-II by a singlemode optical fiber, while both systems operated independently from each other. The TEXUS 54 sounding rocket was successfully launched and recovered on 13. Mai 2018 with the two instruments still well functioning on board after touch-down.

We will present the FOKUS II system design and qualification as well as the results of the TEXUS 54 mission. Moreover, we will give a brief overview on current follow-up projects and possible future space applications of the frequency comb technology.

[1] N. R. Newbury, "Searching for applications with afine-tooth comb," Nature Photonics, vol. 5, no. 4, pp.186–188, Apr. 2011.

[2] M. Giunta, M. Lezius, C. Deutsch, T. Wilken, T. W. Hänsch, A. Kohfeldt, A. Wicht, V. Schkolnik, M. Krutzik, H. Duncker, O. Hellmig, K. Lampmann, A. Wenzlawski, P. Windpassinger, K. Sengstock, A. Peters, and R. Holzwarth, "Optical Frequency Combs for Space Applications," in Conference on Lasers and Electro-Optics, OSA Technical Digest, paper STh4H.5, Jun. 2016.

[3] K. Doringshoff, et al. "A Compact Optical Iodine Frequency Reference on a Sounding Rocket". In 2018 IEEE International Frequency Control Symposium (IFCS) (pp. 1-2). IEEE, May 2018.

[A-148]

VIPER: ICE PENETRATION UNDER EXTRATERRESTRIAL CONDITIONS

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Recent Analysis of scientific data from Cassini and earth-based observations gave evidence of a global ocean under a surrounding solid ice shell on Saturn's moon Enceladus [1]. Images of Enceladus' South Pole show several fissures in the ice shell with plumes exhausting frozen water particles, building up the E-Ring, one of the outer rings of Saturn. In this southern region of Enceladus, the ice shell is considered to be as thin as 2 km, about an order of a magnitude thinner than on the rest of the moon. Under the ice shell, a global ocean consisting of liquid water is expected. Researchers identified chemical signatures in data from Cassini's plume fly-throughs which can be identified as traces of hydrothermal processes [2]. Hydrothermal vents on the ground of the earth's oceans are often referred to as a potential origin of life on earth.

Scientists are discussing different approaches to further investigate the possibilities of taking samples of liquid water. One of the most promising techniques is melting through the ice using a heat probe and taking a water sample [3]. FH Aachen UAS developed a prototype of a maneuverable melting probe which can be equipped with suitable technology to navigate through ice [4]. Melting and navigation have been tested succesfully in terrestrial environment. Whereas on Enceladus, a melting probe would have to deal with nearly no atmospheric pressure, low ice temperatures of around 100 to 150K near the South Pole and much lower gravity of 0,114 m/s^2 or 1100 µg. This is expected to impact performance and functionality of heat probes.

Experiments under two of these conditions are conducted at FH Aachen UAS in 2018 and 2019, which are low ice temperature and low ambient pressure below the triple point of water. Low gravity cannot be easily simulated inside a large experiment chamber, though. As numerical simulations of close contact melting situations indicate a gravity dependence of melting behavior [5], experiments verifying these results are desireable. Besides the larger scale experiments at FH Aachen UAS, VIPER was set up as an additional data source to verify those numerical models.

The REXUS rocket provides about 90 seconds of experiment time in reduced gravity and low ambient pressure. In this time frame, melting speed and contact force between ice and probes are measured, as well as heating power. Apart from that, three-dimensional arrays of temperature sensors provide temperature fields over time for each of the three ice samples. Additionally, visual and infrared cameras are used to observe the melting process. Constraints in respect of energy consumption as well as operational procedures demanded careful thermal management considerations. Mixing high (melting probes, up to 70°C) and low (ice container, -70°C) temperatures inside the very limited space of a standard REXUS rocket module, while ensuring an acceptable precision for measurements led to a sophisticated experiment design. In return, some insights on energy efficiency and melting speed are expected after the prospected rocket launch in March 2019. Afterwards, data shall be used to supplement the experimental data from ground based experiments and to verify and compare with numerical simulation models.

References:
[1] Thomas P. et al. (2016) Icarus, 264, 37-47. [2] Waite J. H. et al. (2017) Science, 356, 155–159.
[3] Ulamec S. et al. (2007) Rev. Environ. Sci. Biotech., 6, 71-94.
[4] Dachwald B. et al. (2014), Ann. Glaciol., 55(65), 14-22.
[5] Schüller K. et al. (2018), Icarus, 317, 1-

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[A-063]

FREE COOLING OF GRANULAR GASES IN MICROGRAVITY

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Granular gases are dilute ensembles of macroscopic particles that interact by occasional collisions but propagate otherwise freely in space. They are in some respect comparable to molecular gases, but their collisions are dissipative: in absence of external excitation, the average kinetic energy of the particles decreases continuously, it is transformed into other energy forms. Granular gases are found in various sizes and compositions, the Saturn rings, snow avalanches or dust storms are representative examples.

While manifold theoretical models have been developed and applied to predict the dynamics of cooling granular gases, there has been only little experimental progress in the past. Haff's fundamental scaling law, derived on the basis of some simplifying assumptions, has been tested numerically, but the experimental confirmation was achieved only 35 years later, whithin our study of cooling of rodlike particles during free fall in drop tower experiments and parabolic suborbital rocket flights.

We present the observed characteristics such as the distribution of kinetic energy among the individual translational and rotational degrees of freedom of the constituents, the cooling rate, the homogeneity of the ensembles and the alignment of the rods with their flight directions.

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[1] K. Harth et al., Phys. Rev. Lett. 120 214301 (2018)

[A-066]

SOUNDING ROCKET EXPERIMENTS ON FIRE SAFETY IN MANNED SPACEFLIGHT, RECENT RESULTS AND PERSPECTIVES

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Accidental fires onboard of a manned spacecraft are amongst the most severe hazards to happen. Even though such events were rare in spaceflights history, accidents as well as scientific experiments have demonstrated that the initiation and spreading of fires in space proceed quite different to all our experience with fires on ground. As a spacecraft cannot be built solely from non-flammable materials and ignition sources cannot be excluded with a 100% reliability it is very important to know about the differences of fire spreading in space as well as about appropriate fire-fighting and post-fire cleanup activities. Fires in space are different from those on ground mostly in the following aspects: 1. in clean microgravity (no motion of air) any fire is self-extinguishing when the ignition source is removed regardless of the ambient oxygen concentration 2. this is not the case when a forced convection induced by air conditioning systems is present 3. the overall heat release and thus the propagation velocities are substantially lower than on ground 4. as buoyant removal of hot exhaust gases from the burning zone is missing, the heat losses are reduced and a fire burns locally hotter than on ground 5. because of this, materials extinguishing on ground may burn self-sustained in space 6. fires produce more particulate containing smoke than released from the same material on ground 7. actual ground based standardized material qualification tests have been demonstrated to be inappropriate to predict the behavior in space. Therefore, new methods to assess the fire hazard are urgently needed all the more when envisaging long duration exploration missions.

Experiments on fire safety in microgravity conditions are difficult to perform as they require long duration (drop towers excluded) and rather large volumes and are naturally dangerous. The paper displays recent results on the flame propagation along cylindrical and structured polymethyl-metacrylate (Plexiglass) samples from a REXUS experiment as well as the plan for a consecutive TEXUS mission on a similar issue.

HOW MICROGRAVITY EXPERIMENTS CAN HELP TO SOLVE CURRENT PROBLEMS DURING PRODUCTION OF SILICON CRYSTALS

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Current and future microelectronic as well as photovoltaic systems are based on silicon crystals which are produced either by crystal pulling from melt after the Czochralski technique or by directional solidification of the melt contained in a crucible. The transport phenomena in the melt, which are strongly influenced by gravity, are determining the process stability and the material quality during industrial production of silicon crystals.

One example of research fields benefiting from research under micro gravity conditions is silicon for solar cells. During its production, the silicon melt is contaminated by nitrogen and carbon. When the solubility limit in the melt is exceeded, SiC and Si3N4 particles are formed. Such particles are harmful for the further production process and reduce the efficiency of the solar cells. For these reasons, the incorporation of such particles needs to be avoided. Another example is heavily doped Czochralski silicon which is needed for power electronic devices. Here, the growth phenomena at the transition between a facetted and non-facetted solid-liquid interface are thought to be responsible for a reduction of the crystal yield during industrial production. These growth phenomena are again strongly affected by temperature fluctuations which occur due to unsteady melt convection.

In this paper, we present how recent and future crystal growth experiments carried out under microgravity conditions onboard TEXUS missions 51, 53 and 55 and planned for upcoming sounding rocket flights will help to get a better understanding of the basic phenomena occurring during silicon crystal growth. We further elaborate on how these findings can be transferred in order to solve current problems during production of multicrystalline silicon for photovoltaics and of heavily doped silicon for power electronics.

ATMOSPHERIC PHYSICS AND CHEMISTRY 3

WEDNESDAY 19 JUNE, MORNING SESSION – PART 2

ROOM 2

CHAIR: A. HERTZOG

LIDAR SOUNDINGS OF NOCTILUCENT CLOUDS DURING THE PMC-TURBO BALLOON MISSION

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Noctilucent clouds are optically thin layers of ice particles occuring around 83 km altitude during polar summer. Their intriguing fine-scale structure provides a means to study atmospheric waves and instabilities in the sensitive mesopause region of our atmosphere. For the first time, noctilucent clouds were observed using a backscatter lidar and multiple cameras from a balloon platform. The NASA long-duration balloon PMC-Turbo was launched in July 2018 from Kiruna, Sweden, and floated at 40 km altitude during six days to northern Canada. During the mission, a large dataset with unprecedented high-resolution soundings of noctilucent clouds down to scales of few meters were obtained. The combination of near-vertical lidar soundings with horizontal structures visible in narrow- and wide-field of view cameras allows to fully characterize the morphological structures of noctilucent clouds that are modulated by gravity waves, and reveal dynamic processes such as the breaking of these waves, the generation of various types of instabilities and transitions to turbulence.

[A-131]

OBSERVATIONS OF NOCTILUCENT CLOUDS FROM THE STRATOSPHERE: A NEW TECHNIQUE TO STUDY LARGE-SCALE WAVE DYNAMICS IN THE MESOSPHERE

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On the night of 5-6 July 2018, the balloon experiment "Stratospheric Observations of Noctilucent Clouds (SONC)" was conducted with the aim to capture noctilucent clouds and to study their large-scale spatial dynamics at scales of more than 100 km. Noctilucent clouds (NLC) are the highest clouds in the Earth' atmosphere occurring at the summer mesopause between 80 and 90 km. The clouds are an excellent natural laboratory to study wave dynamics on various scales from tens of metres to thousands of km.

An automated high-resolution camera equipped with a wide-angle lens of 115 degrees was lifted by a sounding balloon to 20.4 km altitude above the Moscow region in Russia. The camera registered a large-scale field of noctilucent clouds of about 1400 km in the west-east direction, which was modulated by atmospheric gravity waves with horizontal lengths from 10 km to 350 km. The camera captured a unique final stage of the NLC evolution represented by thin parallel bands of gravity waves, after that the NLC completely disappeared in about 20 minutes. Further balloon-borne observations of NLC are needed to confirm if it is a typical final stage of the NLC evolution or not. Balloon-borne observations of NLC provide us with the unique combination to study wave dynamics at scales from metres to thousands of km, which is currently unachievable either from the ground or space. Using big scientific balloons, NLC observations from the stratosphere can be done for 24 hours a day due to very little Rayleigh atmospheric scattering in the visible subrange of the spectrum above 20 km (the sky is almost black above 20 km during daytime and nighttime). A long duration flight of several days and even tens of days around the North Pole is also possible, providing us with the opportunity to investigate large-scale waves such as solar tides and planetary waves using balloon-borne NLC imagery.

[A-024]

LOCAL TIME VARIATIONS OF MESOSPHERIC ICE LAYERS – MODELING BY MIMAS AND OBSERVATIONS BY GROUND-BASED LIDAR AND THE AIM SATELLITE

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The Mesospheric Ice Microphysics And tranSport model (MIMAS) is used to study local time (LT) variations of noctilucent clouds (NLC), also known as polar mesospheric clouds (PMC), in the Northern Hemisphere during the period from 1979 to 2013. In addition, we make use of multi-color lidar observations by the RMR lidar at the ALOMAR observatory located close to the Andoya space center in Northern Norway (69°N). We investigate the tidal behavior of brightness, altitude, and occurrence frequency and find a good agreement between model and lidar observations. At the peak of the PMC layer the mean ice radius varies from 35 to 45 nm and the mean number density varies from 80 to 150 cm^{-3} throughout the day. We also analyze PMC in terms of ice water content (IWC) and show that local time variations are found to depend on latitude and threshold conditions. In particular, relative local time variations decrease with larger thresholds, whereas phases are conserved. A phase shift exists for the IWC local time behavior towards the pole, which is independent of the threshold value. More specifically the IWC maximum moves backward in time from 08:00 LT at mid-latitudes to 02:00 LT at high latitudes.

The persistent features of strong local time modulations in ice parameters are mainly forced by tidal variations in background temperature and water vapor. For a single year, local time variations of temperature at 69°N are in a range of ±3 K near 83 km altitude. At sublimation altitudes, the water vapor variation is about ±3.5 ppmv, leading to a change in the saturation ratio by a factor of about 2 throughout the day.

The combination of satellite observations and modeling studies can help to better understand the variability of PMC throughout the polar region. Our results of modeled PMC parameters are very compatible with AIM satellite observations regarding vertical distribution and distribution functions at the core of the season. Especially when comparing with satellite observations, it is necessary to take into account the local time of the satellite overpass. Most satellites are sun-synchronous and cover only a small local time period. We calculated a climatology of IWC local time variations from a 35-year average from 1979 to 2013 for different thresholds and latitude bands, which might be useful for satellite data analysis in order to perform local time corrections.

ANALYSIS OF PARTICLE SHAPE AND DEPOLARIZATION IN ARCTIC CIRRUS CLOUDS: A CASE STUDY

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Cirrus clouds play an important role in the radiation balance of the atmosphere. They can have a warming and cooling effect. The resulting net effect depends on particle properties such as size, shape and number concentration.

To obtain information about these properties we perform in-situ balloon-borne measurements with the Balloon-borne Ice Cloud Particle Imager (B-ICI) launched from ESRANGE, Sweden. We compare the in-situ measurements with concurrent LIDAR measurements. The extinction coefficient of the cloud can be derived from both measurement methods and thus directly compared. However, due to cloud inhomogeneity and the fact that LIDAR and B-ICI do not measure exactly the same volume of the cloud, differences may arise. Another uncertainty in comparing LIDAR with in-situ measurements arises from having to assume a LIDAR ratio (LR, ratio of backscatter and extinction coefficient) when deriving the extinction coefficient from LIDAR backscatter measurements. Nevertheless, for our measurements, the determined extinction profiles from LIDAR and B-ICI are in general similar, indicating relatively homogeneous clouds and an adequate choice of LR.

The LIDAR can also be used to measure the degree of depolarization of the backscattered light. Since depolarization depends on particle shape, it may be used to indicate predominant particle shape. Here, we are comparing LIDAR depolarization with our corresponding in-situ shape and extinction coefficient measurements to investigate relationships between depolarization, LR, and particle shape

As a case study, we study an Arctic cirrus cloud, which formed on 2018-02-28 in connection with a low-pressure system and orographic uplift. This cirrus cloud shows a strong vertical inhomogeneity. Overall, the cloud is geometrically thick with a vertical extension from 5.5 to 11 km altitude and has an average number concentration (NC) of about 20 / L. However, two thin layers, with a thickness of around 100 m, have a very high NC (~ 500 / L) and thus contain 72 % of all particles of the measured cloud profile. The particles in these two layers are all very small (< 50 µm) and mostly compact in shape. Another thin layer has a higher NC (~ 50 / L) of large (100 – 250 µm) particles with irregular and hexagonal-column shapes being most frequent.

These layers are reflected in the extinction profile with higher values. The extinction is strongest in the thin layer with large particles. By comparison with the LIDAR measurements we can infer possible values for LR in the different layers. The depolarization varies also somewhat in between these layers and the rest of the cloud. To better test if these variations are related to particle shape, we will compare this special case with measurements on other days that show certain similarities in particle shape, size, or NC.

[A-037]

ON THE RELATIONSHIP BETWEEN ENERGETIC ELECTRON PRECIPITATION AND MESOPAUSE TEMPERATURE

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Energetic Particle Precipitation (EPP) can potentially change the neutral atmospheric temperature at the mesopause region. Cresswell - Moorcock et al. used European Incoherent Scatter Scientific Association (EISCAT) radar data to identify the events. Here we use a similar approach and search for effects of EPPs on neutral temperature by studying the neutral temperature change in response to EPPs detected in the radar data. The temperature of the excited hydroxyl molecules is representative for the neutral air temperature at the height of the OH layer, assuming there is local thermodynamical equilibrium.

We use electron density datasets from the EISCAT Svalbard radar. They are collected in January and February 2019 and compared to a historical data set from the International Polar Year (IPY) in 2007-2008, when EISCAT Svalbard radar was run continuously. Following Cresswell – Moorcock et al. potential events are characterized by a rapid increase of the electron density by five times at an altitude range of 80-100 km.

To determine the neutral temperature, we use airglow data. The airglow data is available from the Kjell Henrik Observatory (KHO), only about 1 km away from the radar site. The neutral temperatures are averaged as hourly temperatures and are available since the IPY. The presentation reports on the results of the study, and discusses their significance.

[A-085]

PROJECT DAEDALUS, ROTOR CONTROLLED DESCENT AND LANDING ON REXUS 23

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Daedalus' goal is it to build and test an alternative form of descent mechanism for drops from very high altitudes. Since parachutes are not always the best option and sometimes hard to handle in space applications, there is a need for new and innovative ways to descend through an atmosphere without using any propellant at all.

Inspired by the bionic design of the maple seed which gently falls to the ground using its ingenious natural design, Daedalus is building a "SpaceSeed" applying the same idea of a gentle descent for Reentry missions. Such a mechanism can be more robust towards supersonic reentry then a parachute and can also be less affected by the space environment or heat compared to traditional options.

This can be especially useful when looking towards the challenges a future Mars mission would bring to the table, but applications of this are numerous, for example, could designs like this also have terrestrial usages like weather probes which would be able to withstand harsher winds than a parachute could. This is directly usable for a turbulent atmosphere like on Venus or even Jupiter. In addition, Payload Returns from LEO could be made with similar designs thereby removing some of the challenges one would face with a parachute or an actively propelled landing system. Daedalus wants to prove that this alternative is usable for real-life applications on earth and other planets.

Technology and Infrastructures for Balloons 2

Wednesday 19 June, Morning session – part 2

Room 3

Chair: S. Venel

[A-174]

MINIMIZING COST, TIME AND MANUAL LABOR: HOW TO SUCCESSFULLY FLY A SCIENTIFIC HIGH-ALTITUDE BALLOONING MISSION ALONE

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Student-interns at the United States National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) have successfully created a novel high-altitude ballooning (HAB) process that minimizes cost, time required, and manual labor from payload, to launch, to flight. Over the Summers of 2017 and 2018, student-interns under JPL's Innovation to Flight (i2F) program created the Zephyrus HAB platform; a modular, reusable, and reliable HAB payload system using commercial off the shelf (COTS) parts, as well as the Talos HAB auto-launching system. Talos is an automated HAB launcher that allows one person to launch a HAB (up to 3 m in diameter at launch) in under 15 minutes or less. Traditionally, 3 m diameter HABs require a team of 15+ people and at least one hour of setup (when launched in California's Mojave Desert). With Talos, a user can simply control the entire inflation and launch procedure electronically, without ever having to put a hand on the balloon. Similarly, the Zephyrus payload system allows a very rapid setup time and plug-and-play user-interface, allowing an individual or small team to attach a plethora of instruments and experiments to a single payload in only a matter of days. The Zephyrus system has now been flown 8 times, each iteration improving upon the previous, as well as carrying a new NASA JPL payload to near-space conditions (30 km in altitude). The 2017 i2F team created Zephyrus I-V on a materials budget of less than $10,000 in 10 weeks. Likewise, the 2018 i2F team created Talos Mk. 1 through Mk. 4 on a materials budget of less than $10,000 in 10 weeks.

[A-182]

NEUTRON EFFECTS ON MEMORY SYSTEMS

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The study of the effects of neutrons induced errors in Commercial Off The Shelf (COTS) components is becoming increasingly important for terrestrial and avionics applications as their potential impact in terms of reliability and safety could be catastrophic. This presentation describes the setup and the experimental analysis of neutron irradiation tests performed at the Rutherford Appleton Laboratories (ISIS) neutron accelerator on the NEMESYS (Neutron Effects on MEmory SYStems) platform, a project which has the goal of studying the effects of atmospheric neutrons on COTS components during the stratospheric flight of a balloon. The results of bit upsets on the COTS SRAM and COTS Camera obtained from the tests are discussed and correlated together with a discussion on the observed system Single Event Functional Interrupts (SEFIs) providing an overall characterization of the targeted COTS components as well as on the setup on NEMESYS and its further developments.

THE BALLOON LIDAR EXPERIMENT "BOLIDE"

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The Balloon Lidar Experiment BOLIDE was the first mesospheric lidar system carried by a long duration balloon. As part of NASA's PMC-Turbo balloon payload, the lidar was launched from Kiruna, Sweden in July 2018 on a six day mission to northern Canada. The BOLIDE instrument was primarily designed for high resolution profiling and altimetry of noctilucent clouds, but also provided temperature profiles from 45 km to about 85 km altitude. We discuss the technological challenges and constraints associated with the successful operation of a high-power lidar system on a balloon platform. Although the basic working principle is the same as of any ground-based mesospheric lidar system, BOLIDE faced several requirements unique to a balloon platform. Not only had the instrument to withstand the near-space environment which is characterized by low atmospheric pressure and dominating radiative heating and cooling, but it also had to meet the space, weight and power requirements imposed by the design of the PMC-Turbo gondola. Key features are a compact and robust laser design, a single-loop liquid cooling system involving a high-performance radiator for dumping of waste heat, a thermal protection system, integrated electronics, and a flight computer for command & data handling and data storage. Finally, we compare the in-flight performance of both the lidar and the thermal control system to pre-flight simulations. First scientific results based on BOLIDE measurements will be presented in a second paper.

[A-070]

PARAMETRIC WORST CASE THERMAL ENVIRONMENTAL CONDITIONS SELECTION FOR POLAR SUMMER LONG DURATION BALLOON MISSIONS

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When studying the thermal behaviour of an instrument on board of a stratospheric balloon, several parameters affecting its temperature should be taken into account. As in most space missions, the thermal design is carried out through the definition of two extreme operational cases, which in the case of balloons, are in steady-state conditions at float. Thus, it is necessary to define the thermal environment, albedo coefficient, Outgoing Longwave Radiation (OLR), solar irradiance and Sun Elevation Angle (SEA), to carry out the analyses. When selecting such conditions not only the thermo-optical properties should be considered, but also the relative position of the instrument studied has a huge influence. The thermal design follows an iterative process. First, thermal environmental conditions of the extreme operational cases are defined for a concept design. Then, once simulations are performed, critical elements can be identified. This allows to take actions in order to keep temperatures and gradients within their limits. The thermal design must evolve as the whole design does, and the extreme thermal conditions may change during this process. The methodology proposed aims at establishing a base to select dynamically the thermal environmental conditions based on real Earth observation data during the whole design process. In order to do so, data is selected considering the particularities of the mission and statistically treated to obtain an envelope of potential worst cases. A parametric model based analysis allows iterating through such envelopes taking into account the particularities of the considered system. The proposed methodology has already been implemented in the context of the SUNRISE III mission. Some of the parametric studies carried out for the electronics unit of the instrument IMaX+ are also presented.

SPACE-RELATED EDUCATION 1

THURSDAY 20 JUNE, MORNING SESSION – PART 1

ROOM 1

CHAIR: K. SCHÜTTAUF

[A-178]

EDUCATION: THE KEY TO REVEAL SPACE ENTHUSIASTS

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Enabling continuous research, development and innovation of the space domain could be performed only by preparing a new generation of space enthusiastic people. Some of us had the opportunity to discover space field, especially rocket and balloon science, thanks to their relatives. However, when you do not know anyone from a specific domain, it appears less likely to discover this passion by ourselves. Therefore, education programs exist: to promote space science to a wide spectrum of people and from the youngest.

Nowadays, in Europe, many opportunities are accessible. As an example, I discovered my passion for rocket science thanks to Planète Sciences, a French organisation carrying out scientific activities. I have participated several years in the C´Space, which is the French launch campaign for rocket amateurs. This event is a fantastic event to meet rocketry clubs from universities but also from schools; students and pupils leading the same kind of experiments through rockets, balloons and even CanSats. Such hands-on projects are an excellent way to try, to experiment, to succeed or even to fail. However, in any case, they enable us to get technical knowledge and improve our soft skills. Indeed, when you have discovered your passion, you want to live this passion. As a YGT, I had the chance to work for the ESA Education Office for the REXUS/BEXUS program (DLR/SNSA). This program enables European students to create, build, operate and analyse the results of their own experiment flying on a sounding rocket (REXUS) or a stratospheric balloon (BEXUS). It is a unique opportunity to live a full cycle of a space project (development, realisation, integration, testing, operations, post-analyses), sharing a launch vehicle with other teams (as satellites customers on a launcher) and learning from space professionals. It is a crossroads between space experts and the upcoming generation facing up to the reality.

Finally, after the studies, the goal is to live this passion every day. Thanks to all these activities (national and international programs) but also thanks to all the persons I have met and have transmitted their passion (volunteers, friends, colleagues…), I am now working for a start-up company, in Europe, building a sounding rocket and a microlauncher: PLD Space. A company that I met during the PAC symposium when I was working for REXUS/BEXUS. Again, life is made of cycles… Consequently, after receiving from the others and from the educational programs, we should also transmit our passion at personal level or even through volunteering activities to enable the growth of the rocket/balloon's community.

[A-132]

2ND CYCLE OF ESA PROGRAM FLY A ROCKET !

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Fly a Rocket! was initiated as an ESA Education program in collaboration with the Norwegian Center for Space Related Education and the Norwegian Space Center as a pilot in 2017. The aim was to give students on lower levels of higher education an introduction to space physics and space engineering. The pilot cycle was a huge success hence a second cycle was initiated in the fall of 2018, and the launch campaign was in the spring of 2019. This paper will present the program of the second cycle, the improvements made from the first cycle and the educational results.

The Fly a Rocket! program includes an online pre-course with two assignments. The actual five-day long hands-on training is done at Andøya Space Center guided by instructors from NAROM. The students prepare and run their own student rocket mission. Students will have introductory lectures, build and launch a three-meter-long student rocket to 8.5 km of altitude, and will end the campaign by doing analysis of the actual rocket flight data. In the last phase, the students collaborate on writing a report of the project, what they have done during the second phase and the result they found during the flight analysis. By the time of the conference, the 2nd cycle of the program will be concluded.

[A-028]

FLY A ROCKET ! TEACHING EARLY UNIVERSITY STUDENTS HOW TO BUILD AND LAUNCH A ROCKET

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Being one of the twenty-four students selected to take part into the "Fly a Rocket! Campaign" promoted by European Space Agency Education Office and Norwegian Center for Space-related Education (NAROM), I am willing to give an insight into high latitude rocketry educational activities pursued by National Agencies in Europe, highlighting their strengths and importance.

My lecture would be based on my experience gained as it follows:"The Fly a Rocket! Campaign" is a hands-on programme which gives me the opportunity to launch my rocket as a student from the Andoya Space Center in Northern Norway. Throughout winter 2018 I participated in an online course to prepare me for the launch campaign at the Space centre scheduled for April 2019. During the campaign I will build, verify and launch my own rocket, as well as attending several lectures and tours and learning more about European and Norwegian efforts in space.

Being selected for the "Telemetry and Data Readout" team, my task will be to set up and operate the NAROM telemetry station, including tracking the rocket and downloading it's data. During this project, I will learn not only to how set up that station, but also how each component works (this will help if I need to do any troubleshooting later on). When the telemetry part is done, I will move on to set up NAROM's three decoders. After that, I will prepare a MATLAB script that read the data from the decoders and split them into variables.

During the Symposium, I would present a lecture based on my experience as a student involved in an unique program promoted by European Space Agency, bringing videos, interviews, and visual material regarding all the phases of the project, with a special attention to the launch campaign in Norway.

Having always given technical lectures to astronomy communities, this talk would give me the opportunity to speak of my experience as a participant, rather than a specialist. For this reason, I would focus on what I learnt and why this "Fly a Rocket! Campaign" had been such a relevant activity in my apprenticeship (as it would be for all students interested in space career), not only regarding the technical knowledge acquired, but also – not less important – the international frame of cooperation I worked in and I am interested to work in the future.

Campaign schedule:
- Day 1: Rocketry lectures, guided tours, MATLAB training, social gathering.
- Day 2: Visit to Spaceship Aurora, Ballooning lectures, release of PTU sondes, start of the work on the student rocket.
- Day 3: Continue working on the student rocket, highlight lectures.
- Day 4: Launch day.- Day 5: Post-flight analysis and tour of ALOMAR observatory.

[A-171]

LESSONS LEARNED FROM A STUDENT PAYLOAD ONBOARD THE G-CHASER STUDENT SOUNDING ROCKET

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The G-Chaser Student Rocket Program has provided an impactful opportunity for engineering and science students to participate in an international research campaign to study the cusp of the Earth's magnetic field. The broader campaign, dubbed "Grand Challenge Initiative" (GCI), consists of twelve rockets from Norway, USA, and Japan (see www.grandchallenge.no) that are being launched from Andøya, Norway in the years 2017–2020. Penn State's participation in G-Chaser provides its students and faculty with an excellent opportunity to work with renowned atmospheric scientists from around the world. The coordinators of the GCI felt it was vital to include a student rocket as part of the larger campaign.

The G-Chaser Student Rocket had student-built payloads from entities in Norway, USA, and Japan, administered by the Colorado Space Grant Consortium's RockSat-XN program. G-Chaser was a Terrier-Improved Malemute that launched from Andøya Space Center (ASC) at 09:13:00 UT on 13 January 2019, a two-stage rocket that reached an apogee altitude of 174 km. Penn State's payload was designed to investigate polar mesospheric winter echoes (PMWEs), and was designed and built by undergraduate students at Penn State. Students were responsible for the engineering as well as the science of their mission. Penn State coordinated a "science summit" for participating teams to maximize science return and to determine appropriate launch criteria. Students traveled to ASC for the mission and played key roles during all stages of the mission.

Student-built rocket payloads are extraordinarily effective pedagogical tools and represent an extremely engaging, innovative educational tool, as there is significant real-world application, problem-based learning, and hands-on nature to them. Additionally, students are exposed to a complete life-cycle—conceive, design, build, fly, analyze, report—and must employ systems engineering processes to ensure success. This paper reports on Penn State's contribution to G-Chaser, science results, and lessons learned. It is hoped that these lessons can be applied to future student sounding rocket missions.

[A-053]

QUEST ON BEXUS 27

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QUEST is the acronym for Quad-spectral Unaided Experimental Scanner of Topography. QUEST as part of the REXUS/BEXUS program was designed, developed, built, tested and operated by a team of 17 students from different German universities. It scanned the planet surface by analysing an array of four light sensors (RGB and IR) and two spectrometers. As a result, the system produced an overview image of the surface with marked areas depending on the type of the surface. QUEST distinguished between snow, water, plants, rocks and overlaying clouds. Not-recognizable areas were marked specially. The project has been a successful step to the designated target to build an autonomous system which could be used in interplanetary missions with demanding constraints on the bandwidth.

Therefore, a reusable cluster algorithm was developed for the categorisation of distinct areas on a surface. It allows adjustments with different parameters for varying planet surfaces. Furthermore, the algorithm's data base was generated and optimized before and during flight. Regarding to the hardware the system was built modular with standardized connectors, data lines and powering system to achieve an uncomplicated exchange of sensors for missions with distinct requirements. Also, a housekeeping system was integrated to get insight during flight. Furthermore, it was designed to safe all collected data for later analysis and parallel autonomous processing. The structure was designed for carrying all the environmentally sensible sensors and processing units in the harsh environment outside the balloon's gondola. Besides the flight system, infrastructure in form of a ground station was built to analyse and command the experiment.

The project was very successful in each objective. A lot of data from all sensors was taken and analysed on board. The autonomous differentiation of landscapes based on the collected data was also successful. The modular system worked without issues during flight and allowed a good flexibility on the selection of sensors.

Due to the success and the belonging to the REXUS/BEXUS program the preferred session or topic is space-related education.

[A-038]

PRIME: A REXUS26 PROJECT TO DEMONSTRATE A MINIATURE FREE FALLING UNIT FOR PLASMA MEASUREMENTS

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PRIME (Plasma Measurement with Micro Experiment) is a student experiment, to be launched from ESRANGE, Sweden on REXUS26 sounding rocket in March 2019 as part of the REXUS/BEXUS programme. The project aims to develop a miniature recoverable Free Falling Unit for plasma parameter measurements in the lower ionosphere. Two identical Free Falling Units are ejectable from the Rocket Mounted Unit. A Free-Falling Unit consists of an Experiment and a Recovery Unit, which share a common battery and an umbilical board. The Recovery Unit consists of a parachute and its deployment mechanism, a localization system and a data acquisition system to store the trajectory. The Experiment Unit includes four deployable, cylindrical Langmuir probes and four sunsensors, with its preamplification and control boards and a dedicated data acquisition system. After the flight, the Free-Falling Units will be recovered. This is done by using the obtained locations from the GPS, which are transmitted through the Globalstar satellite network and the VHF radiolink. For retrieving altitude profiles of the electron density and electron temperature, the Langmuir probes data and the trajectory reconstructed from the raw GPS data are used. The geometry of the Free-Falling Units is designed to be compatible with future 'DART' rockets, from the company T-Minus Engineering. The measurements will be validated against models and independent observations of the ionospheric parameters.

ATMOSPHERIC PHYSICS & CHEMISTRY 4

THURSDAY 20 JUNE, MORNING SESSION – PART 1

ROOM 2

CHAIR: B. STRELNIKOV

[A-006]

IN-SITU STUDY OF THE VARIOUS NATURES OF STRATSPHERIC AEROSOLS WITH THE LIGHT OPTICAL AEROSOLS COUNTER (LOAC) UNDER LIGHT DILATABLE BALLOONS

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While droplets with pure mixtures of water and sulfuric acid are the main component of stratospheric aerosols, field measurements performed for more than 30 years have shown that non-sulfate materials are also present. Such materials, mainly refractory, which are released both from the Earth through volcanic eruptions, pollution or biomass burning, and from space through cometary and interplanetary dust and meteorites, present a wide variety of composition, shape and sizes ranging from several nm to several hundreds of µ m.

We will present new field measurements performed since 2013 with the Light Optical Aerosol Counter (LOAC) during ~150 flights carried out under Light Dilatable Balloons (scientific weather balloons) up to 35 km in altitude. LOAC provides the concentrations of aerosols from 19 size classes in the 0.2-50 micrometers range, and an estimate of the typology of the particles. Most of the flights were conducted by the French Space Agency CNES from Aire sur l'Adour (South-west of France); other flights were conducted form the suburban area of Paris, from Ile du Levant (South of France), from Minorca (Spain), from Ile de la Réunion (Indian Ocean) and from Iceland.

LOAC observations have shown a relatively low content of liquid sulfate aerosols, as expected in this period of moderate volcano activity. Nevertheless, the measurements have also confirmed the presence of stratospheric layers presenting enhanced-concentrations of solid material, with a bimodal vertical repartition centered at 15 and 30 km altitude. Also, large particles are detected, for sizes up to several tens of micrometers, with decreasing concentrations with increasing altitudes. Such observations, which are uncorrelated with meteor shower events, could be due to the photophoretic effect lifting and sustaining light-absorbing particles mainly coming from the Earth in the stratosphere. When combining all the detections in the stratosphere from different methods of measurements, we may conclude that the chemical compositions, the concentrations and the vertical distributions of solid materials are highly variable because of their various origins. Strategies for frequent measurements will be necessary to better circumvent their impact on stratospheric chemistry and on the Earth's climate.

[A-014]

THE STRATEOLE-2 LONG-DURATION BALLOON PROJECT IN THE EQUATORIAL LOWER STRATOSPHERE

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Strateole 2 is a French-US project aimed at advancing our knowledge of dynamics and transport in the equatorial upper troposphere and lower stratosphere (UTLS). The tropical UTLS dynamically and chemically couples the troposphere with the global stratosphere, and therefore constitutes a key region of the climate system. The originality of Strateole-2 rests on the use of long-duration balloons able to perform 3-month flights at altitudes between 18 and 21 km.

During the course of the project (2019-2024), nearly 50 long-duration balloons will be launched from Seychelles Islands (4.7°S), and will provide information over the whole equatorial band (typically 10°S-10N), since they will be passively advected by the winds and circum-navigate the Earth. The balloons will carry in-situ sensors devoted to meteorology, greenhouse gases, and aerosols. Curtains of temperature, water vapor and backscatter ratio down to 2 km below the balloon will in addition be gathered by reeled instruments on some of the flights. Last, remote sensing instruments (backscatter lidar, GPS radio-occultation) will as well be carried, and provide information on the vertical structure of the Tropical Tropopause Layer.

Strateole 2 flights will hence provide a unique wealth of high-resolution, accurate observations of the global tropical UTLS, which will enable us to study wave generation by convection, forcing of the Quasi-Biennial Oscillation, wave-microphysics interaction, dehydration processes, and transport through the tropical tropopause.

Strateole 2 wind observations will be assimilated in numerical weather prediction models to improve the accuracy of operational analyses and foreacts in the equatorial UTLS. They will also contribute to the validation of the ESA Aeolus spaceborne wind measurements.

[A-172]

APPLICATION OF THE FLUORESCENT HYGROMETER ON BOARD LONG DURATION BALLOON AND STRATOSPHERIC AIRCRAFT M-55 GEOPHYSICA.

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Fluorescence Lyman-Alpha Stratospheric Hygrometer (FLASH) is an ultra-compact fast-response sensor capable of accurate measurements of water vapour in the lower and middle atmosphere (7 – 70 km). The instrument, initially conceived for rocket-borne soundings, was eventually redesigned for application onboard meteorological balloons as well as research aircrafts. The instrument is based on fluorescence method, which uses the photodissociation of H2O molecules exposed to Lyman-alpha radiation (121.6 nm) followed by the measurement of the fluorescence of excited OH radicals in the near-UV spectral range.

An advanced version of FLASH hygrometer was recently developed for the high-altitude M55-Geophysica aircraft, which was flown in Greece and Nepal within EU FP7 StratoClim project for study of the stratospheric impact of Asian Summer monsoon. FLASH-A performed flawlessly during the entire campaign and provided a wealth of high-quality measurements, some of which indicating a convective impact on stratospheric water up to 19 km. We present the measurement highlights along with assessment of instrument performance through intercomparison against two other airborne hygrometers.

The balloon version of hygrometer (FLASH-B) represents a compact lightweight sonde (0.7 kg) with measurement capacities rivaling those of frost-point hygrometers. Thanks to its compact optical design and fast-response Lyman-alpha technique, FLASH-B represents a perfect solution for measurements of water vapour onboard long-duration balloons. FLASH instrument makes part of the upcoming French-US Strateole2 super-pressure balloon experiment in the deep tropics. Strateole-2 is an ultimate balloon experiment aiming at covering the measurement gaps in the deep tropics using a large variety of instrumented payloads, including an innovative reeled device (hosting FLASH) which enables in situ sampling 2 km below the balloon flight level. We present and discuss the expected performance of FLASH instrument based on laboratory and field experiments.

[A-202]

DETERMINING SPACE-TIME VARIATIONS OF COSMIC RAY GEOMAGNETIC EFFECTIVE CUTOFF RIGIDITIES DURING 1950 – 2050 ON DIFFERENT ALTITUDES IN ATMOSPHERE AND MAGNETOSPHERE FOR BALLOONS, ROCKETS, AIRCRAFTS AND SPACECRAFTS WITH TAKING INTO ACCOUNT PENUMBRA AND MAGNETOSPHERIC / IONOSPHERIC CURRENT SYSTEMS

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The secular variations of the geomagnetic field lead to changes of geomagnetic cutoff rigidity, which in turn leads to secular variations of cosmic rays and radiation hazards. The problem is that space-time variations of magnetic field are very complicated: the amplitude of the 1-st harmonic (dipole part) decreased with time on about 10%/100years, but highest harmonics not decreased, but increased, and faster, on about 30%/100 years. When we calculate effective CR cutoff rigidities we need to take into account changes in penumbra (through each 0.001 GV in penumbra region about 1 GV with) and environments currents (according to modern models of N. Tsyganenko's group), so for each point and direction we calculate about thousand trajectories (through 0.001 GV and with of penumbra region about 1 GV); total much more than million trajectories.

It was found that for CR stations which are under the influence of North Atlantic Anomaly the negative magnetospheric effects are watched, anomaly drifts to the west with a speed of 0.14°/year. For the stations which are under the influence of the Southern Atlantic Anomaly the positive magnetosphere variations are observed, and amplitude of such variations reaches 10%, anomaly drifts to the west with a speed of 0.30°/year. Such effects need to be considered at an assessment of a spectrum of long-term cosmic ray variations and for experiments on different altitudes.

We made calculations in time through 5 years (1950, 1955,   2050) and through 5° in latitudes and 15° in longitudes, for different altitudes, useful for experiments on balloons, rockets, aircrafts, and spacecrafts.

[A-010]

LIDAR OBSERVATIONS OF THE STRATOSPHERIC AEROSOL LAYER ABOVE NORTHERN NORWAY

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The Stratospheric sulfate aerosol (SSA) layer is of fundamental importance for the radiative balance of the atmosphere. The layer is found in altitudes between the tropopause and 30 km. The radiative effect is due to scattering of solar and absorption of thermal infrared radiation by the aerosol particles. We use the state of the art Doppler Rayleigh/Mie/Raman lidar at the ALOMAR research station located in Northern Norway (69N, 16E) to observe the aerosol layer and derive microphysical properties. The aerosol and molecular signal is therefore derived by using a multi-wavelength approach and different scattering processes. The lidar is located at the edge of the polar vortex and allows the investigation of SSA from small spatial and temporal scales to decadal variations.

In this work results of the observations of the SSA layer above ALOMAR for the time span 2000 to 2018 are presented and discussed.

UTILISATION OF ROCKETS FOR RESEARCH APPLICATIONS 3

THURSDAY 20 JUNE, MORNING SESSION – PART 1

ROOM 3

CHAIR: W. JUNG

[A-061]

GRAND CHALLENGE INITIATIVE – CUSP AND MESOSPHERE PROJECTS

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The Grand Challenge Initiative (GCI) - CUSP project is major international rocket-based research project, with participation from NASA (six scientific projects), JAXA (1 scientific project) and UiO / ASC (1 scientific project). In addition, all three nations participated in a joint two-stage student rocket - "G-CHASER", launched from Andøya as part of GCI CUSP in January 2019.

GCI CUSP is a major project, with 12 rockets launched from Andøya and Ny-Ålesund, Svalbard in the period 2018-2020, often with both launch sites operated simultaneously. Probably the largest scientific rocket project NASA has ever participated in.

The project idea and ownership is Norwegian. Conceived in 2012 by Professor Jøran Moen (UiO) and Kolbjørn Blix (ASC). "Gathering scientists working on issues related to the gap in the Earth's magnetic field (CUSP) over Svalbard and for the first time launch from both Andøya and Ny-Ålesund in the same campaign". This way, Andøya launch NASA's largest scientific rockets – the Black Brant XII's, and fly them horizontally through the CUSP, high above Svalbard. While from Ny-Ålesund, we launch smaller rockets, straight up into the same area.

Doing this at different heights and with different instruments is important when trying to understand the processes going on in and close to the CUSP. Coordinating already planned CUSP related projects, and motivating the creation of new and complementary efforts was utterly important during the initial phase of the work with GCI CUSP. It was also important to ensure that necessary ground-based instruments and modelling communities were included in the team at an early stage.

Another important goal from the Norwegian side was to ensure that all data from rockets and ground-based instruments is available from a common database, where all active participants have equal access. After all, data is the most important part of a scientific campaign, and these must be easily available for potential users after quality control and necessary quarantine time. The GCI data-sharing agreement was signed by SIOS (The Svalbard Integrated Earth Observing System), NASA, JAXA and UiO in Tokyo in 2017.

So far, seven of the 12 rockets have been launched successfully out of Norway and Svalbard, and the next GCI project – GCI Mesosphere is already being planned. Preferably, it should include at least US, Norway, Germany, Sweden and Japan, but other nations are more than welcome to join in to the GCI Mesosphere. A project that due to working with lower altitude science than its CUSP cousin, have a potential for even more than the 12 CUSP rockets. Launching out of even more sites is also a possibility to be discussed, all based on the science topics raised during the planning phase.

VISIONS-2: IMAGING ION ENERGIZATION IN THE CUSP

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On December 7, 2018, NASA's VISIONS-2 (VISualizing Ion Outflow via Neutral atom Sensing – 2) sounding rocket mission was launched from Ny Ålesund, Svalbard into the geomagnetic cusp, to study processes that energize and eject ions from Earth's atmosphere. Part of the multinational "Grand Challenge Initiative – Cusp", VISIONS-2 was designed to image the heated ion populations that result when Earth's atmosphere is exposed to soft electron precipitation and strong plasma convection in the cusp. Imaging these populations is made possible by the MILENA (Miniaturized Low Energy Neutral Atom imager) instrument, developed at NASA GSFC, which can detect the energetic neutral atoms that are produced when accelerated ions charge exchange with the neutral atmosphere.

The VISIONS-2 mission was designed to fly two Black Brant X sounding rocket vehicles through the geomagnetic cusp, within two minutes of each other. These vehicles reached apogees near 600 and 800 km, and measured the accelerated ions and the processes that heat and energize them, both locally (with in situ sensors) and remotely (with the neutral atom imagers and a multispectral auroral camera onboard the rocket).

We present the initial results from the VISIONS-2 mission, including results from the rocket instruments and the ground-based observations (all sky imagers, EISCAT radar, and CUTLASS radar). Those results show that VISIONS-2 flew through an active cusp, with soft precipitation, and associated ion heating and upflow. We will show the relationship between the remotely sensed ion populations and those that were measured directly by the rocket instruments.

[A-054]

FIRST FLIGHT EXPERIENCE OF THE MINIATURIZED SUB-PAYLOAD FOR MULTI-POINT IN-SITU MEASUREMENTS ON THE G-CHASER STUDENT ROCKET

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With 1D sampling by rockets it is not possible to un-ambiguously discriminate between quasi-stationary wave and turbulent irregularity structures. Indeed, each measurement is made at a precise location in time and space, but due to the relative motion between the rocket and the plasma, a limited picture of the spatial-temporal evolution of the plasma structures is obtained. There is consequently a need to develop 4D Space measurement techniques (3D in space + Time). As part of the Grand Challenge Initiative (GCI) we have instrumented the G-Chaser student rocket with the 4D-Space module developed by Andøya Space Center. This module hosts 6 sub-payloads which are ejected from the rocket in flight. Each sub-payload is equipped with the miniaturized multi-needle Langmuir Probe instrument (m-NLP) in addition to an electron emitter to control the platform potential.

The G-CHASER student rocket was launched from Andøy Space Center on January 13th, 2019. We will report on the G-CHASER mission and first flight experience, focusing on the related technical solutions and results for the m-NLP instrument.

[A-092]

ELECTROSTATIC ADHESION MICRO ROVER "ROACH" ON REXUS24

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The experiment ROACH (Robotic in-Orbit Analysis of Cover Hulls) was part of cycle 10 of the German-Swedish student programme REXUS/BEXUS and was launched on the sounding rocket REXUS24 on the 12th March 2018. It was the first step to evaluate the feasibility of a rover to move on the outside of a spacecraft in reduced gravity and vacuum as well as having the ability to inspect the traversed surface. To achieve this, the concept of electrostatic adhesive pads on a vehicle was selected. The vehicle provides a platform to accommodate necessary sensor and command and control hardware. The mission aim was to manoeuvre a rover - smaller than one CubeSat unit (no larger than 10 x 10 x 10 cm^3) - on a floor panel inside a sounding rocket module, during the microgravity phase in almost vacuum.

ROACH consists of two systems, the experiment module and the rover itself. The rover's chassis is a 3D-printed integral component and locomotion mechanism, rover electronics and sensors, including a camera, are attached to it. The module bulkhead is used to mount the path, the Onboard Control Unit which is responsible for power and data handling, a camera observing the path, and the Rover Holding Mechanism (RHM). To avoid damage to the rover and sensitive electrostatic pads during launch, the rover is safely suspended within the RHM and a timer will release it during microgravity. Two additional cameras are placed on a strut above the path. Since the rover was intended to (partially) disintegrate after the ballistic experiment phase, the module has been sealed to contain the debris and protect the rocket.

Locomotion and Adhesion Mechanism: The rover's tracks are made of belts, with several electrostatic pads attached. These pads consist of 35 x 50 mm^2 copper-coated polyimide foils. A voltage of approximately 2 kV is applied between the module's bulkhead as one electrode and the copper of the pads as the other. The polyimide serves as electrical insulation between both electrodes, creating adhesion forces in normal direction of up to 2.2 N per pad. Because of the low-pressure environment and a resulting reduced breakdown voltage, the pads are extensively insulated on the top side.

Results and lessons learned: Unfortunately, the REXUS24 rocket suffered a non-nominal flight, which prevented the experiment execution. The module and rover suffered extensive damage, when the rocket failed to perform its intended trajectory and crashed before the timer started the operation of the experiment. Therefore, none of the mission objectives could be met and no scientific data was collected. Due to this, the focus of the post-flight analysis discussed in this paper will focus on pre-flight tests, lessons learned and further improvements.

[A-139]

PROGRESS OF MINI-IRENE PROJECT: THE FIRST EUROPEAN FLIGHT EXPERIMENT OF A DEPLOYABLE HEAT SHIELD

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The Paper describes the progress in the MINI-IRENE FLIGHT EXPERIMENT (MIFE) project, funded by ASI and ESA. MINI-IRENE is the Flight Demonstrator of IRENE: a capsule with a variable geometry, "umbrella-like" deployable heat shield that reduces the capsule ballistic coefficient, leading to acceptable heat fluxes, mechanical loads, stability and final descent velocity.

The feasibility study of the IRENE has been carried out in 2011. The TPS materials have been tested in the SPES hypersonic wind tunnel at the University of Naples, and in the SCIROCCO Plasma Wind Tunnel at CIRA.

European Space Agency is now funding the current phase of the program. The aim is to achieve TRL-7 by means of a suborbital flight, after ejection from sounding rocket, and Plasma Wind Tunnel (PWT) testing of the deployable heat shield.

The Critical Design Review of the project has been considered successfully closed in May 2018.

PWT test has been executed in June with positive results for both the flexible TPS and the mechanical elements of the deployable heat shield.

Dynamic stability of the capsule has been investigated by means of numerical simulations and analogies with other similar systems.

For the low subsonic regime, the dynamic stability has been verified by means of a scaled model of the capsule, dropped from 50m altitude by means of a radio-controlled drone.

A full-scale ground demonstrator of the patented deployment mechanism has been realized and testes with the actual TPS flexible materials and cinematics.

Avionic systems and software design is concluded and most of the parts have been already procured integrated and tested.

The main structure parts and mechanisms for the flight demonstrator have been procured and the integration is proceeding along with the flexible TPS.

The dummy model, representative of mass, CoM location and interfaces of the flight demonstrator have been realized. Fit checks and separation tests have been carried out by SSC and mechanical tests are carried out in early spring 2019.

The project is in good health and the first flight opportunity is scheduled in December 2019 on Texus 56. A backup flight opportunity is scheduled in 2020 on Maser 15.

SPACE-RELATED EDUCATION 2

THURSDAY 20 JUNE, MORNING SESSION – PART 2

ROOM 1

CHAIR: S. MAWN

[A-164]

[REXUS23] SPACE NAVIGATION USING SIGNALS OF OPPORTUNITY

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One of the many problems in the aerospace domain is assisted navigation. GPS receivers used in LEO satellites are very expensive and a big part of the total budget is used to buy these components. The main objective of the SPAN experiment is to use signals of opportunity to navigate, integrating timing information extracted from the signals to obtain the relative position from a known starting point. Signals of opportunity are signals which are used for other purposes that are not their primary ones. In this specific case, we will use DTTV, GSM and LTE signals. These signals are naturally slaved to a precise atomic clock, have significant power and bandwidth and are transmitted continuously or are never too long without being transmitted. Using a SDR and an on-board Rubidium Atomic Clock in a rocket module, will allow the team to receive the signal and couple it with the synchronized signal given by a timing signal generator that will be calibrated with the clock. Extracting the delay between a received symbol and the timing marker generated by the SPAN experiment, it is possible to calculate the relative distance between the transmitter and the receiver. Knowing the start position, the evolution of this delay gives the trajectory done by REXUS rocket. The ultimate goal of SPAN is to develop a compact methodology for future LEO satellites navigation, possibly integrated with communications.

[A-062]

ROCKSTAR: ENHANCING STEM EDUCATION

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Space sciences and astrophysics are the most popular scientific disciplines, especially among young students. Educational projects based on these subjects are very valuable to increase interest towards science and technology in general. "RockStar: Enhacing STEM education" (acronym "RockStar") is an Erasmus+ project that uses some of the best educational resources in Europe related to space sciences and astrophysics. RockStar, from "rocket" and "star", establish a collaboration program between students from Spain, Norway and Denmark, through a coordinated project between high schools from the different countries, and three institutions dedicated to research, education and dissemination: the Museum of Science and the Cosmos (MCC), the Institute of Astrophysics of the Canary Islands (IAC), both in Tenerife, and the National Center for Space related Education (NAROM), located in Andøya, Norway. This program focus on astrophysics, space science and technology, and priories practical activities. The program uses the fantastic educational infrastructures located Tenerife (MCC and Teide Observatory) and Andøya. These complements very well offering a unique frame for developing educational projects based on active-inquiry learning by using the attractive astrophysics and space science fields as hook to get attention into STEM disciplines. In this case, the activities planned for Tenerife concentrate on astrophysics and technology (the Sun as star), and for Andøya on space physics, atmosphere physics, in particular aurora borealis, and technology (the active Sun and its relation with the Earth). RockStar also focus in developing methodologies for using space sciences and astrophysics in the frame of 21st century skills, including learning and innovation skills (critical thinking and problem solving, collaboration, and innovation), digital literacy skills, and career and life skills (including cross-cultural interaction).

[A-089]

ALTERNATIVE TO AIRCORE FOR ATMOSPHERIC GREENHOUSE GAS SAMPLING BY TEAM TUBULAR ON BEXUS FLIGHT 26

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Carbon dioxide (CO_2) and methane (CH_4) are two main greenhouse gases emitted by human activities. Developing a better understanding of their contribution to greenhouse effects requires more accessible, flexible, and scalable air sampling mechanisms. A balloon flight is the most cost-effective mechanism to obtain a vertical air profile through continuous sampling between the upper troposphere and the lower stratosphere. The TUBULAR BEXUS experiment is a technology demonstrator for atmospheric research, supporting an air sampling mechanism that consists of two sampling methods on the same balloon payload. The first method is using a long tube for constant gas sampling throughout the atmospheric profile, while the complementary sampling method collects air at fixed flight altitudes. The benefit of the complementary method is that each sampling altitude is known and can be chosen and that more air can be sampled at each altitude. Running both sampling methods enabled a mutual validation of the end-results. By analysing CO, CO_2 and CH_4 concentrations in the samples a vertical profile of the atmosphere has been obtained for these gases.

The Team behind this project designed and launched this project as part of their Masters level university education at Luleå University of Technology in Sweden. After several design iterations and expert reviews, development of the experiment began in June 2018 and was completed by September 2018. Rigorous test plans were carried out until the launch campaign in October 2018. The TUBULAR experiment launched from Esrange on the 17th October 2018 onboard the BEXUS 26 flight.

The experiment was a partial success with the first sampling mechanism performing nominally and a failure with the complementary sampling mechanism. However, data from the first mechanism was of a good quality and a partial atmospheric profile was produced. The team has learnt a great deal from partaking in the REXUS/BEXUS programme, obtaining a deeper understanding of how to apply their interdisciplinary science and engineering backgrounds into practical experiments that support climate change research.

[A-184]

INVESTIGATION OF COSMIC RAY INDUCED DEFECTS IN CIGS SOLAR CELLS

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As an exercise in teamwork and project management 16 engineering students from Uppsala, Linköping and Lund have executed a project as part of the REXUS/BEXUS programme with the goal to study microscopic cosmic ray induced defects in CIGS solar cells. Over the course of a year, the students planned and constructed an experimental setup that was mounted on an aluminum cage which also held a number of experiments from other student teams across Europe. The cage was launched by balloon from Esrange in Kiruna, Sweden to an altitude of 28km where it stayed for 2 hours exposed to cosmic rays. By measuring the CIGS solar cells pre-flight, during flight and post-flight vast amounts of data was collected.

The setup consisted of a box which was designed to withstand the stratospheric environment and two solar cell modules. The box held CIGS solar cells as well as sensors and electronics, and the solar cell modules held CIGS, amorphous silicon, and silicon solar cells. The electronics were used for data collection and communication. Temperature, radiation counts, and IV-measurements were collected and send to the ground station during flight. The data collected during the flight indicates that all solar cells except one were functional during the entire flight. However, no anomalies due to cosmic radiation could be detected from the in-flight measurements. To study the microscopic induced defects, high precision measurements were performed with the hypothesis that the CIGS would be largely unaffected by the cosmic radiation. Measurements of the quantum efficiency confirm that this is the case, the CIGS efficiency was unaffected by the flight. However, when cooling the cells with liquid nitrogen some potential temperature-dependent defects were discovered, these could have been induced by cosmic radiation. Further analysis is required to pinpoint the exact source of these differences.

[A-127]

BESPIN – BALLOON EJECTION STUDENT PROTOTYPE INVESTIGATION

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The aim of the BESPIN project is to design and test an engineering solution for deploying a two-stage parachute and develop an aerodynamic sufficient shape for re-entry of the atmosphere. This will act as a first part for a mission with the objective of deploying a balloon from a rocket during atmospheric descent.

The mission will be carried in the nosecone of the rocket from which it will be separated before apogee. The experiment will free fall until a drogue parachute is deployed at 3000 m altitude. A few seconds later at a height of 2000 m a main parachute will be deployed. The experiment will then reach the ground within 15 minutes after lift off.

At the parachute deployment, the experiment will start to measure and send the position of the experiment to a ground station. The experiment will also measure pressure, temperature, acceleration, spinning rate and feature three cameras for scientific data collection.

The mission can be categorised as a technology demonstrator in re-entry system and in deployment systems.

[A-075]

NAROM 2018 CANSAT KIT – A NEW UNIQUE HARDWARE DESIGN WITH COMPREHENSIVE ONLINE DOCUMENTATION FOR UNDERGRADUATE HANDS-ON STUDENT SATELLITE TRAINING

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NAROM has since 2009 developed and offered hands-on CanSat (Satellite in a Can) teacher training courses based on an Arduino Uno and a CanSat sensor shield design from the University of Aalborg, Denmark.

The new NAROM 2018 CanSat kit is a new unique hardware design based on a Teensy 3.5 microprocessor and an all-in-one printed circuit board.

The new NAROM 2018 CanSat kit was developed to deal with some of the less attractive sides of using an Arduino Uno based CanSat kit. Even though Arduino Uno is familiar to most Arduino experiences people and has a physical size/pin-out that many sensor shields are using, there are however a number of drawbacks using the Arduino Uno as the base for a CanSat sensor kit. The Teensy 3.5 based NAROM 2018 kit tries to solve some of these issues. Technical details and the printed circuit board will be presented in the paper.

In the new NAROM 2018 CanSat we use a new radio compared to most previous CanSats. The RFM96 is a radio for 433 MHz ISM band, which is free to use and perfect for CanSat use. The radio uses a proprietary protocol called LoRa (short for long range), that is perfect for low data rate, but long range and relatively low transmission power.

One of the advantages of this radio compared to the radio used in most previous CanSat kits is the availability to check when the radio is ready to send more data. This will improve the effective transmission time since you can send a new data packet directly after the previous one has been sent and thereby avoid dead time. Another advantage is that the radio module setup including transmission frequency is programmed directly in the same Arduino programme as used for sensor readings and can if wanted be changed during flight.

The new NAROM 2018 CanSat kit has so far been used with success in two hands-on teacher training courses, university student fieldwork activities at UNIS (the University Centre of Svalbard) and as a basis for a secondary school student competition in remote sensing in marine environment at AMOS/NTNU (The Norwegian University of Science and Technology, Trondheim).

The comprehensive online documentation for building the CanSat also includes the older Arduino Uno based versions “3.2” and “6.2”. The contents and links will be presented in the paper.

Utilisation of Balloons for Research Applications 2

Thursday 20 June, Morning session – part 2

Room 2

Chair: M. Snåll

[A-090]

PLANETARY SCIENCE FROM BALLOON-BORNE TELESCOPES: HOW IMPORTANT IS DIFFRACTION-LIMITED PERFORMANCE ?

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Balloon-borne telescopes are expected to be competitive in providing high acuity images in UV and visible wavelengths, where ground-based adaptive optics systems struggle to achieve high Strehl ratios and comparable space-based telescopes are orders of magnitude more expensive. The tolerances are unforgiving, however: a one-meter aperture diffraction-limited telescope operating at 500 nm needs to have RMS wavefront errors less than 26.6 nm (if we allocate half of the wavefront error budget to the telescope, half to the instrument and optical bench). Catanzaro et al. (2018) performed a STOP analysis of a hypothetical one-meter balloon-borne telescope and showed how easy it is to exceed the wavefront error budget (e.g., with thermal gradients, gravitational sag at different elevation angles, etc.).

Given the challenges of achieving diffraction-limited performance, we now examine what planetary science observations could be obtained from a balloon-borne telescope when the wavefront errors are worse than the diffraction-limited case. We look at three design reference missions (DRMs) as examples: (a) imaging faint companions of asteroids or Kuiper belt objects, (b) tracking clouds on extended objects (like Neptune or Jupiter) to monitor atmospheric dynamics and (c) discovery of faint objects. We quantify how each DRM is affected by wavefront errors and compare a balloon-borne telescope's expected performance to ground-based adaptive optics systems that are under development.

References

B. Catanzaro et al. 2018. Proc. SPIE 10705, Modeling, Systems Engineering, and Project Management for Astronomy VIII, 1070515 (10 July 2018); doi: 10.1117/12.2312312

[A-097]

MOTION COMPENSATION, THERMAL CONTROL AND WAVEFRONT SENSING ON THE THAI-SPICE PAYLOAD

***M. Skrutskie*[1], E. Young[2], G. Ebelke[1], J. Fox[2], V. Klein[2], M. Nelson[1], J. Wilson[1], R. Woodruff[2]**

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THAI-SPICE (Testbed for High Acuity Imaging – Stable Photometry, Image-motion Compensation Experiment) is a NASA-sponsored balloon program that will address two factors that can degrade diffraction-limited image acuity in the stratosphere: thermal gradients across the telescope and stability of the focal plane. To study thermal gradients, THAI-SPICE will model the effectiveness of sun-shields, earth-shields and OTA enclosures. Preliminary modeling suggests that passive shielding can reduce a telescope's thermal excursions over day/night cycles from more than 50 K to less than 2 K and achieve steady-state temperatures as low as 180 K. Given the prospects for 100-day super-pressure balloon missions, the ability to passively cool a telescope is critical for infrared observations, and the reduction of gradients eliminates one of the most significant obstacles to maintaining telescope alignment and mirror figure. THAI-SPICE will fly an instrumented OTA enclosure to test thermal models in the stratosphere.

To address image stability, THAI-SPICE will fly a 50-cm aperture telescope with pointing stabilized at the few arc-second level. Image motion on the focal plane will be characterized with a combination of inertial and optical sensors. To stabilize the focal plane at the 50-mas level, THAI-SPICE will use an orthogonal transfer CCD (OTCCD). This detector can shift the image in four directions (left-right-up-down) during an exposure, and thereby serves as a fast motion compensation device with no moving parts. The THAI-SPICE experiment will characterize the performance of the OTCCD in the stratosphere, focusing on charge transfer efficiency (CTE) and the effects of cosmic ray strikes on long integrations.

THAI-SPICE will also include a wavefront sensor to monitor aberrations in the balloon-borne telescope in flight. The immediate goal is to quantify alignment errors and mirror aberrations as a function of the elevation angle, temperature field and other factors. THAI-SPICE will include a secondary capable of focus and tip-tilt motion that can be actuated in flight to reduce aberrations. THAI-SPICE is expected to have a quarter-scale demonstration flight in September 2019 concentrating on validating thermal models and a full-scale flight in September 2020.

THE FAINT INTERGALACTIC MEDIUM REDSHIFTED EMISSION BALLOON 2: THE DEBUT SPACE FLIGHT OF A BALLOON-BORNE MULTI-OBJECT SPECTROGRAPH

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FIREBall-2 (PI: C. Martin, CALTECH, French Co-PI: B. Milliard, LAM), the circumgalactic medium (CGM) emission path finder and technology demonstrator, was launched on the 22nd of September, 2018 from the CSBF NASA facility in Fort Sumner, NM.

This NASA/CNES co-funded instrument is a balloon-borne 1-m telescope coupled to a UV (200 nm) multi-object slit spectrograph (MOS) designed to image z~0.7 galaxies and quasars via resonant emission lines (Lya, OVI, CIV) from the stratosphere (~40km, 3mB).

MOS are, by their very nature, at the limit of complexity for instruments that can be launched with a typical stratospheric payload budget. They provide the possibility to image and obtain spectra from ~100 sources simultaneously, which allows interesting analysis (constrain statistical features, stacking, etc.).

This comes at a price; it requires both a high precision pointing control/stability and a rigorously accurate (X,Y) pre-flight calibration to ensure that the light of the 80 galaxies, ~7 billion light years away from us, will enter their ~80 microns slit while guiding on stars with a separate off-axis visible guider. Despite these challenges, and thanks to NASA/CNES support, we managed to fly the first balloon borne MOS. Flight data shows that FIREBall-2 overcame these obstacles and that every subsystem worked as expected.

FIREBall-2 demonstrates a wide field of view (FOV) of 20.5x37 arcmin2, a high-speed beam (f/2.5) and a spatial and spectral resolution of ~5 arcsec FWHM, and ~2000 (λ/dλ) respectively. This flight was equipped with four multi-object science masks, each with a total of ~80 preselected targets, as well as 5 calibration masks. A guider camera in the visible uses the full pupil flux at field locations not used for UV targets.

Among the new technologies demonstrated during this flight, the use of a high-QE UV electron multiplying CCD, δ-doped and AR-coated by JPL must be emphasized, as well as the first flight of a low cost aspherized grating and the use of the state of the art CNES pointing system for stratospheric gondolas (<0.5" rms/sec/axis).

FIREBall-2 and its first flight will be presented, focussing on the instrument performance derived during its pre-flight calibration as well as the verified performances that can be accessed from flight data (XY alignment, image quality, FOV, sensitivity - end-to-end throughput, etc.).

[A-051]

DREX: A SPRING DRIVEN DEPLOYABLE REFLECTOR ON BEXUS24

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Solid dish antennas are a widespread technology nowadays, employed in many communication systems. Despite this, the mass and volume of this type of antenna are sometimes not compatible with the characteristics of space systems and their operating environment. This feature prevents their use in many more applications in which, actually, solid dish antennas could be very useful. Deployable antenna structures seem to offer a promising solution to this problem by combining an optimized structure with the same features of a solid dish.

This paper presents a new design for a parabolic reflector that extends its surface through a radial opening, umbrella-like mechanism. The light structure and the compact initial configuration of the reflector make this device a great option for those applications in which the physical constraints are a particular issue. The deployment is initiated by a single actuation system which releases the arms, allowing the reflector to expand its surface by nine times, compared to the stowed configuration. Furthermore, this design is characterized by an innovative system that exploits a central fixed parabola on the launch configuration. This feature guarantees the antenna operation also in the event of unexpected behaviour of the deployment system, overcoming the need for redundancy, otherwise required to assure that the correct functionality of the system is not compromised.

This kind of technology could be used, for instance, to implement an aerial stratospheric telecommunication system composed of high-data-rate microwave radio link, for interception of communications and radar signals, for military and intelligence, Earth observation in low and midrange-frequency radar, deep space observation and remote sensing.

DREX flew on BEXUS24 platform, in the framework of the REXUS-BEXUS programme. The flight took place from the ESRANGE Space Center on October 18th, 2017. This paper presents a detailed 3D prototype design, deployment simulation and experimental test results obtained during the flight. Moreover, this paper presents the lessons learned acquired from this educational experience.

[A-047]

SPECIES: A BALLOONBORNE AND AIRBORNE MULTICHANNEL INFRARED LASER SPECTROMETER USING OPTICAL-FEEDBACK CAVITY-ENHANCED ABSORPTION FOR TRACE GASES MEASUREMENTS

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A new infrared laser spectrometer, SPECIES (SPECtromètre Infrarouge à lasErs in Situ), has been developed for rapid (> 0.5 Hz) simultaneous on-line measurements of several trace gases, e.g. O3, N2O, HNO3, NH3, H2O2, CH4, CH2O, CO2, CO, HCl. It is usable both on board balloon and aircraft, from the ground to the middle stratosphere. In addition to the use of a near-infrared DFB (Distributed FeedBack) laser, the coupling of DFB QCLs or ICLs (Quantum or Interband Cascade Lasers) in the mid infrared domain with optical resonant cavities (OF-CEAS: Optical-Feedback Cavity-Enhanced Absorption Spectroscopy) has been adopted to increase the variety of species to be measured and the detection limits. In the mid infrared spectral region, these lasers operating in continuous wave mode at regulated temperature have excellent reliability, spectral purity, and negligible linewidth with respect to the molecular absorption lines, which enables to reach excellent precision of the measurements. In the OF-CEAS technique, the laser beam enters the optical cavity formed by three highly reflective dielectric mirrors. Following detection of a sufficient cavity output level as the laser frequency is tuned through cavity resonance, the laser emission is interrupted and the exponential decay of the cavity output signal is recorded. As in CRDS, a decay time of some tens of microseconds can be achieved, and with a cavity base length of 0.5 m, this corresponds to an effective optical interaction path length of several kilometers. The main advantage of the OF-CEAS with respect to other CRDS techniques lies in its intrinsically highly linear frequency scale and efficient coupling (exploiting the optical-feedback effect) of the cavity to the laser. This limits in-situ absolute concentration calibration by means of reference gases during flights and allows high signal-to-noise levels, leading to sub-ppb detection limits.

One paradigm leading the instrument development was modularity. As such it consists of several 19" standard racks, each dedicated to the measurement to one or more species, which can be interchanged in order to adapt to the scientific objectives. Particular care has been taken to ensure that the instruments maintain their performance in the harsh environmental conditions encountered in the stratosphere or in aircraft, and to ensure a long-term stability. Moreover, in order to minimize the effects of adsorption, desorption and chemical reactions on the tube walls, a high speed sampling system has been developed, giving a transit time to the pressure-regulated measurement cavity of less than a few tenths of seconds. Within the frame of the StratoScience campaign organized by CNES and CSA agencies, SPECIES has been flown for the first time on August 16, 2018 from Timmins airport, Canada (48.57°N – 81.369°W), under stratospheric balloon up to 33 km altitude. The preliminary results are presented.

[A-115]

BEXUS26 – IMUFUSION: DEVELOPMENT AND EXPERIMENTAL TESTING OF THE FAULT-TOLERANT INERTIAL NAVIGATION SYSTEM

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The IMUFUSION project was one of seven BEXUS experiments carried in two BEXUS balloons launched in 2018. BEXUS balloons are lifted to a maximum altitude of 30 km, depending on total payload, with a flight duration of about five hours. The idea was to calculate the trajectory of the balloon within the BEXUS campaign with the help of an Inertial Measurement Unit (IMU)-based System. A typical application of an IMU is the sensor part of a mechatronic stabilization system of Unmanned Aerial Vehicles. The project was focused on designing, the prototyping, and practical testing of the fault-tolerant inertial navigation system. Two Micro Controller Units (MCUs) with redundant memory modules, 3-axis gyroscopes, 3-axis acceleration sensors, and 3-axis magnetic field sensors are the central parts of the IMUFUSION system. The measurements of two Global Positioning System (GPS) modules are used as a reference for the evaluation of the computed results based on the core sensor data. During the experiment, the system recorded inertial data in a near space vehicle with a specially designed, robust and miniaturized system and computed the time-dependent pose of the gondola. The experiment objectives were: (1) record inertial measurement data in a near space vehicle with a specially designed, robust and miniaturized system, (2) estimate the flight trajectory including orientation by the recorded inertial measurement data, and (3) integrate a redundancy concept for higher reliability, diagnosis capability, and accuracy. This contribution describes the practitioner experiences and lessons learned after the test of the aforementioned embedded fault-tolerant inertial navigation system that incorporates redundant inertial measurement units, microcontroller units, and memory modules.

Ranges facilities 2

Thursday 20 June, Morning session – part 2

Room 3

Chair: M. Viertotak

[A-177]

R&D SERVICES AT ANDØYA SPACE CENTER

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Andøya Space Center in 2016 has established a new department "Research & Development" as point of contact for scientific cooperation and science related developments.

The R&D department now contributes to a number of international and national projects with focus on technology development and atmosphere research.

The overall goal for all R&D activities is to acquire forward-looking projects, offering the opportunity for new activities and services at ASC or contribute to achieve the required expertise for a sustainable long-term development of ASC. All activities are based on expertise in remote sensing, telemetry and aerospace engineering.

Present projects partners are e.g. the National Institute for Aerospace Research in Romania, the universities in Wroclaw and New Hampshire and H2020 initiatives. The R&D project portfolio also comprises Cal/Val projects with financing through the Norwegian Space Center and ESA.

Bi-lateral funding between Norway and Romania is the trigger for the building of a flight certified version of a balloon borne-holographic cloud sensor from ETH Zürich [1] and for the new development of an alert system of icing conditions for commercial drone operators.

R&D is point of contact for scientific projects, which use ASC operated instruments and R&D provides the PI of those instruments.

The present talk presents the R&D department, its present project portfolio to the EASP community and invites co-operations.

[1] Lohmann, U., J. Henneberger, O. Henneberg, J. P. Fugal, J. Bühl, and Z. A. Kanji (2016), Persistence of orographic mixed-phase clouds, Geophys. Res. Lett., 43, 10,512–10,519, doi:10.1002/2016GL071036.

EXPANSION OF ESRANGE SPACE CENTER – A EUROPEAN SATELLITE LAUNCH FACILITY

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SSC is currently expanding Esrange Space Center with new capabilities and services to support the emerging small satellite market. The SmallSat Express orbital launch service will provide regular launches of small satellites to 600 km sun synchronous orbit and to polar low Earth orbits.

The SmallSat Express development has now reached a critical design phase in which existing facilities at Esrange Space Center have been analyzed and new ground infrastructure, equipment and instrumentation has been designed and specified to provide a basis for the upcoming procurement phase. As part of the work, new processes have been developed to enable rapid launch preparation.

An analysis of the global launch vehicle market has been performed resulting in a shortlist of launch vehicles. Risk analysis in accordance with FAA standards has been performed and verified by independent third parties and the results show that launch of satellites from Esrange is far below existing limits defined by the FAA.

SSC has procured the required land for the new site and finished the tender process for the ground works.

As part of SSC strategy for the small satellite and launcher market, Testbed Esrange has been inaugurated, a new test facility at Esrange Space Center focused on low TRL engine validation to support researchers and companies develop the necessary rocket technology. This intermediate step towards launching satellites adds several new capabilities to Esrange that allow handling of liquid propellants and oxidizers. Testbed Esrange shall support test of rocket engines, sub-orbital test flights, reusability tests and validation of subsystems onboard free flying exploration platforms.

SmallSat Express is co-financed by the county of Norrbotten and the Kiruna municipality. The Swedish government provide funding for Testbed Esrange as part of the national space strategy.

Esrange Space Center is located above the Arctic Circle (68N, 21E), in the very north of Sweden. Up to date, over 550 sounding rockets and over 630 balloons have been launched on behalf of the international scientific community, space agencies and commercial customers. This paper will present the latest results of the SmallSat Express phase C study, and the steps taken towards establishing a European mainland launch facility for small satellites at Esrange.

[A-102]

THE ALOMAR FACILITY – UPDATE AND PRESENT PROJECTS

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The Arctic Lidar Observatory for Middle Atmosphere Research (ALOMAR) at Andøya Space Center (ASC) was opened in 1994 and hosts a wide range of instruments for atmospheric research. The current instrumentation covers the height range from ground to over 100 km. Instrumentation includes active instrumentation such as radars and lidars, and passive instrumentation with radiometers, photometers, Imaging Rometer and more.

ALOMAR is a well-equipped atmospheric observatory, which offers infrastructure like closed cooling water circuit with high temperature stabilisation, power back up and fiber connection suitable for high data rates. Its location in the vicinity of ASC's rocket and balloon launch facilities ALOMAR allows for combined experiments using ground-based and in-situ instrumentation. The instrumentation is a combination of equipment providing long-term time series of up to almost three decades, and campaign-based instrumentation placed at ALOMAR for shorter periods during projects or campaigns.

ALOMAR takes responsibility, operates and maintains the hosted instrumentation.

Through ASC's participation in EU-projects and networks for monitoring and research of atmospheric parameters ensures both the sustainable operation and development of the observatory and its staff.

ASC is currently is contributing to calibration and validation of ESA satellites. The validation from Andøya of polar-orbiting satellites has obvious advantages due to the increase number of nearby overpasses at high latitudes.

[A-152]

COMPLETED AND ON-GOING SOUNDING ROCKET PAYLOAD PROJECTS BY ANDØYA SPACE CENTER

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The Hotel Payload is a complete sounding rocket service. The concept is shaped to give scientists predictability and assurance on configuration, costs and time frame for their projects. The scientists are offered one sounding rocket partner from planning till launch – so they can focus on their instruments.

Nucleus is the most resent flight in the Hotel Payload series, launched from Andøya in September 2018. The Nucleus payload was launched on a new type one-stage hybrid motor developed by NAMMO. The main goal of the project was to flight test the sounding rocket propulsion system itself, and a number of sensors was included to evaluate the performance of the motor. A small, tactical grade, low weight, high performance non-GPS aided Inertial Measurement Unit was tested on the flight. In addition, a new improved version of the 4DSPACE experiment was flown on the payload.

The Hotel Payload team contributed with one experiment module on the G-Chaser student rocket mission. The 4DSPACE experiment was a collaboration between the University of Oslo and Andøya Space Center and it was the first time a standardized Hotel Payload module have been launched with another payload. For us the flight was a used as a technical test to evaluate the performance of the 4DSPACE system.

A new payload is currently under development, the ICI-5 mission. The ICI-5 payload is one of the Norwegian contributions to "the Grand Challenge Initiative – Cusp project", which is a multinational collaboration consisting of 9 projects with 12 sounding rockets. The ICI-5 payload will be housing instruments from the University of Oslo, the University of Bergen and the University of Iowa. The Hotel Payload team will contribute on two 4DSPACE experiments on the payload as well as being in charge of the overall payload works. The current talk will discuss results and lessons learned from completed flights and modifications and suggestions of improvements for future launches.

[A-107]

VAHCOLI: A NEW LIDAR CONCEPT FOR 4D-OBSERVATIONS OF THE MIDDLE ATMOSPHERE

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Doppler resonance lidar, observing temperature, wind and metal densities in the mesosphere are complex and expensive systems. For this reason, only a few systems worldwide have been built in the past, observing a limited altitude range of the atmosphere in the mesosphere at a single location and often only at darkness.

The institute of atmospheric physics has developed in recent years a complete new approach for Doppler measurements of Rayleigh-, Mie- and Resonance scattering, allowing for the first-time simultaneous Doppler measurements from the troposphere to the lower thermosphere with a single system day and night. By reducing the size, cost and complexity, it becomes now possible building such a lidar in a few months only as compact, automatic and largely maintenance free system for a fraction of the cost of former systems. The patent pending technology allows unattended operation for long periods with minimum infrastructure requirements and without operator.

The heart of such a system is a novel, single crystal diode pumped alexandrite ring laser without amplification stage or non-linear conversion. The whole daylight capable lidar fits into a cube of 1x1x1 m and is movable to any place around the world in short times. Because of its small size and lightweight construction with weather proofed housing only Ethernet and a standard wall plug is required for operation.

Within the project VAHCOLI (Vertical And Horizontal COverage by Lidar) we currently assemble 4 identical systems within one year which can operate as single units or as a network. As network, it will be possible to regular probe the atmosphere over large horizontal distances of several hundred or thousand km, observing gravity waves, tides, or tracers such as stratospheric aerosols, NLC or metals over a large altitude range with high altitude and time resolution. VAHCOLI can therefore additionally address horizontal scales required for a detail understanding of the atmosphere about the complete middle atmosphere.

[A-023]

ROCKET CAPABILITIES UPGRADES – CURRENT AND PLANNED, AT ESRANGE SPACE CENTER

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Esrange Space Centre, located in the North of Sweden and run by SSC, - Swedish Space Corporation, is one of the launching facilities from which industry and the science community may launch their systems and experiments. As a consequence, SSC shall uphold and improve such capabilities, both in the frame of sounding rocketry as well as high altitude ballooning. During the last half decade, SSC have invested in the upgrade of both rocket and balloon capabilities, where the scope of this presentation targets the rocket launch capability. Presently, the rocket launch site area is undergoing a rigorous overhaul concerning cabling trunking both above and below ground. The area will be opened up to better accommodate maintenance work with refurbished or new roads and passages. Currently communication hard lines between Blockhouse and all the launchers are in place trunked through a culvert system. Firing and control lines on both the MRL and the MAN2 launchers have been replaced. The MRL facility is upgraded with heaters and in close proximity been equipped with a heated cabinet for fibre, communication and control systems. Communication over fibre is improved and modernised over the entire launching complex to meet the requirements future mission is expected to have. Presently launch desks and other old systems are targeted for modernisation, an activity that will be initialised this year and finished by the end of 2020. Lastly SSC have invested in a new capability of static rocket motor test that will be part of another presentation.

[A-043]

INCREASED CAPABILITIES AT ESRANGE SPACE CENTER – TESTS OF REUSABLE MOTORS AND STAGES

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SSC (Swedish Space Corporation) is investing alongside funding decided by the Swedish Government, in a new test bed facility at SSC's Esrange Space Center. Esrange is since a couple of years undergoing a major upgrade in order to meet the increasing demand of access to space and test facilities for motors and reusable stages. The test bed facility will enable validation of new liquid, hybrid and solid engines as well as of new sounding rockets and reusable first stages through tethered tests, jump tests and controlled landings. A test facility for static firing of solid rocket motors is already in operation, facilities for liquid rocket motors are expected to be operational by Q3 2019. The plan is to carry out validation of new sounding rocket motors by 2019 and reusable stages by 2020. Esrange Space Center, owned and operated by SSC since 1972, has an ideal location in the very north of Sweden, above the Arctic Circle (68°N, 21°E) with access to a vast, unpopulated recovery area, 5200 km2. It has a well-equipped infrastructure and proven experience of operations, range and launch safety, handling of large rocket motors and launching of guided rockets. The facility is presently used by the international scientific community, space agencies and commercial customers for launching sounding rockets for microgravity and atmospheric research as well as high altitude balloons for astronomy, atmospheric research and drop tests. This paper will develop the test bed services and facilities in more detail.

Utilisation of Rockets for Research Applications 4

Thursday 20 June, Afternoon session – part 1

Room 1

Chair: M. Kohberg

[A-045]

MIURA1 – THE REUSABLE EUROPEAN SOUDING ROCKET GETTING READY FOR ITS MAIDEN FLIGHT

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PLD Space is a European company with the goal to provide easy and frequent access to space. The company aims to provide launch services for suborbital applications such as scientific research or technology development as well as orbital launches for small satellites. For this, PLD Space is currently developing and manufacturing two dedicated, reusable launch vehicles named MIURA 1 and MIURA 5.

MIURA 1 is conceived as a one-staged suborbital sounding rocket using a liquid propulsion system designed and built by PLD Space as well. MIURA 5 – using five units of the engine propelling MIURA 1 – is a two-staged launch vehicle for small satellites.

The first flight model of MIURA 1 is currently integrated in PLD Space's rocket factory in their headquarters in Elche, Spain. With a total length of 12.5 m, a diameter of 0.7 m and a lift-off mass of 2550 kg, MIURA 1 can lift a nominal net payload mass of 100 kg to an apogee of 150 km.

The maiden flight of MIURA 1 is set to take place in the fourth quarter of 2019. The vehicle will be launched from the historical Spanish launch site "El Arenosillo" in the south-west of Spain. From there the rocket will fly into south-westerly direction and after a flight time of about 12.5 minutes splash down about 40 km off the coast in the Gulf of Cadiz in the Atlantic Ocean.

In this first test flight, MIURA 1 will already carry several payloads. Half of the total available payload capacity will be used by PLD Space. A variety of sensors will be integrated into the rocket with the intention to quantify the flight environment. These sensors will for example measure flight loads and temperatures in the payload compartments, pressure profiles along the rocket to qualify the aerodynamic model and many more.

The other half of the available payload mass has been made available for the scientific community and will house several experiments.

During the symposium PLD Space aims to present the MIURA 1 suborbital rocket, the current status of the integration and testing of the first flight vehicle and the payloads on board the maiden flight.

[A-104]

ILR-44 AMBER ROCKET – QUICK, LOW COST AND DEDICATED ACCESS TO SUBORBITAL FLIGHTS FOR SMALL EXPERIMENTS

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This paper presents the development process and capabilities of the ILR-33 AMBER rocket that is being developed by Warsaw Institute of Aviation since late 2014. The main goal of this project is to design a suborbital rocket that could serve as a platform for small microgravity experiments and rocket-related technology validation. ILR-33 was already tested once during a low-altitude successful flight. The apogee was limited to 15 km due to law restrictions that were in force in 2017. In 2018, high-apogee flights were made possible in Poland. The maximum ceiling is now limited only by safety restrictions based on on-ground limited area.

ILR-33 AMBER is a two-staged rocket in a parallel configuration. It makes use of two solid rocket boosters and a hybrid rocket motor that utilizes High Test Peroxide (98% concentration) as an oxidizer and polyethylene as a fuel. Use of hybrid propulsion allows easy adjustment of ceiling and thus makes it possible to conduct tests at both Polish and foreign test ranges. The approach based on focusing on relatively small experiments enables to provide quick and dedicated access to microgravity for such payloads, in line with NewSpace trends. In general, the AMBER rocket allows testing of 10 kg experiments at apogees up to 100 km. The possibility of significant cost reduction by conducting experimental flights for altitudes inaccessible to stratospheric balloons and high-altitude platform stations from a Polish test range is being analysed. Such apogees can be sufficient for specific payloads.

This paper presents results from on-ground and in-flight tests. It also focuses on rocket's performance and shows capabilities of ILR-33 in terms of payload (mass, microgravity time, dimensions). Follow-up actions and technology maturation plans are presented. An outline of an orientation control system based on Hydrogen Peroxide that is planned to be flight-tested is shown. The first high-altitude launch of the rocket is scheduled for 2019.

[A-121]

THE DLR REUSABILITY FLIGHT EXPERIMENT (REFLEX) – CHALLENGES OF FLYING AN AERODYNAMICALLY GUIDED EXPERIMENT ON AN UNGUIDED SOUNDING ROCKET

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The Reusability Flight Experiment (ReFEx) is being developed by DLR (German Aerospace Center) to provide flight and design data on, as well as operational experience with, a winged first stage of a reusable launch vehicle (RLV). As such ReFEx will be a small technology demonstrator and is slated for launch in 2021. The experiment will be launched on a VSB-30 sounding rocket to altitudes and velocities similar to a first staging event and will then attempt a return flight along a trajectory comparable to a returning winged first stage RLV, transitioning from hypersonic speeds down to subsonic flight.

ReFEx is about 2.7 m in length, has a wingspan of about 1.1 m and has a mass of approx. 450kg. It is controlled by a cold gas reaction system (RCS) while outside the atmosphere and transitions to aerodynamic control surfaces (canards and rudder) when atmospheric effects come into play. The maximum Mach number reached during the re-entry manoeuvre is about Mach 5. Besides being able to fly an optimised trajectory to reduce the thermal and mechanical loads, ReFEx shall demonstrate manoeuvrability by flying a turn of at least 30° with respect to the original heading measured from entry interface.

One of the main challenges of the flight experiment is flying ReFEx on top of a VSB-30. The vehicle is not symmetric and possesses various aerodynamic control surfaces, which protrude the fairing covering the main foldable wings. As such there is a strong coupling between the experiment itself (i.e. the payload) and the launcher during all phases of design. Especially in the early phases, various iteration loops between aerodynamic design, structure, mission design and subsystems where necessary to close the design.

This paper details some of the challenges faced and how a solution could be found that satisfies both the capabilities of the launch vehicle and the ambitious mission goals.

[A-031]

A MICRO-SIZED GLIDER FOR ATMOSPHERIC EXPERIMENTS – A PROOF OF CONCEPT USING A SOUNDING ROCKET (REXUS 25 TEAM GAME)

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The experiment is part of the REXUS/BEXUS programme, which provides students with the opportunities to develop and build their own experiment to fly on a sounding rocket. The team consists of 15 students from the University of Applied Sciences Jena.

The objective of project GAME – short for Glider for Atmospheric Measurements and Experiments – is to investigate whether a micro-sized glider, which is released into near-space conditions and free fall, can transition into stable fight without any active control. Thus, stabilisation is solely achieved by the glider's aerodynamic characteristics. The glider is to be released at the apogee of the rocket's trajectory.

The glider has a delta-shaped wing with a 26 cm span width. It weighs approximately 60 grams, comprising wing, electronics and battery. Within the rocket the glider is mounted on an ejection mechanism below the nose cone. It is connected to the rocket's service module via the Rocket-mounted Control Unit (RCU). The ejection mechanism is spring loaded and will be activated by pyro cutters severing the tensioning wires. A small camera inside the rocket will monitor the glider's ejection and the subsequent descent of the payload stage of the rocket.

To make the glider as lightweight as possible the wing base material (depron) is reinforced by aramid fibres, which are stitched onto the structure, resulting in a unique composite. This process is called tailored fibre placement (TFP) and was developed by the Leibniz Institute of Polymer Research Dresden.

The glider carries a Glider-mounted Control Unit (GCU) to gather data on the position and attitude as well as some environmental data during the glider's descend. During the flight this data is continuously streamed to a ground station for subsequent evaluation.

With the gathered data, we are going to evaluate the use of our glider as a micro-sized experiment platform for upper atmosphere research, providing substantially longer residence time than parachute based platforms. The data will also be used to develop an autonomously navigating glider for future missions.

The launch of the REXUS 25 sounding rocket is planned for March 2019.

[A-191]

SPIDER-2, MAKING USE OF A NATIONAL PROGRAM FOR BALLOONS AND SOUNDING ROCKETS FROM ESRANGE

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From the 1960's to the end of the last millennium, one or two Swedish national sounding rockets were launched each year from Esrange, not accounting for all the numerous metrology rockets in the same era. In 2012, after the successful flight of the PHOCUS mission, the Swedish National Space Agency (SNSA) budgeted and initiated a new national programme for balloons and rockets from Esrange.

The programme is mainly directed towards Swedish principal investigators but international cooperations and collaborations are possible and have been a big part in the mission history.

Three rocket-missions have so far been successfully launched within the programme. The forth, SPIDER-2, is planned for the winter of 2019/2020.

SPIDER-2 (Small Payloads for Investigation of Disturbances in Electrojet by Rockets 2) is a mission with the principal investigator from the Space and Plasma physics department of KTH, Royal Institute of Technology. This scientific mission is also a collaboration both nationally with the Institute of Space Physics, Kiruna and Department of Meteorology, Stockholm University as well as internationally with the Institute of Atmospheric Physics, Germany.

This paper reports on the possibilities within this programme. I also reports on the upcoming SPIDER-2 mission, focusing on the related technical solutions and results.

LIFE AND PHYSICAL SCIENCES 3

THURSDAY 20 JUNE, AFTERNOON SESSION – PART 1

ROOM 2

CHAIR: M. EGLI

[A-185]

BEXUS27 TEAM WHB SAMPLING OF MICROBES FROM THE STRATOSPHERE

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The biosphere and ecology of the stratosphere is a generally unexplored and a little understood topic in Biology. There is currently minimal information regarding the diversity of the microbial fauna that resides in the stratosphere. The limited number of previous studies have sampled the stratospheric biosphere using normally one method of collection. This experiment combines the depositional pump suction method and the filter method. The environment of the stratosphere at the far northern latitudes is unique relative to rest of the stratosphere. The temperatures are warmer, ionising radiation is higher, and UV radiation is higher. In this experiment, we will build a safe, sturdy, and clean microbial collection device to sample the microbial life forms at several altitudes in the arctic stratosphere. The samples collected were examined with a SEM. The composition was also examined. Some of the samples found are organic and appeared at least visually to correspond with previous studies. The flow rate of the collecter was higher than previous studies and the laboratory contamination was also similar to previous studies despite a budget that was considerably smaller.

[A-124]

THE INFLUENCE OF MICROGRAVITY ON HUMAN CELLS

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Microgravity offers a unique cell culture environment, enabling the scaffold-free formation of three-dimensional (3D) multicellular spheroids (MCS) by exposing cells to an unusual stress and forcing them to react and adapt. These MCS are invaluable models for searching new drug targets for cancer treatment. Consequently, it is important to investigate the mechanism of 3D structure formation.

Over the past years, we have used simulated microgravity, achieved on a random positioning machine (RPM), as an altered gravity stimulus on different human cells. Human MCF-7 breast cancer cells, FTC-133 thyroid cancer cells and EA.hy 926 were cultured on the RPM for different time periods. The results indicated alterations in expression of genes known to be involved in MCS formation. Additionally, the exposure to real microgravity seemed to shift thyroid cancer cells towards a less-aggressive phenotype. Comparable results were obtained from the SIMBOX/Shenzhou-8 mission and the ESA experiment SHEROIDS, where FTC-133 cells (SIMBOX) and EA.hy 926 cells (SPHEROIDS) were cultured on board of the ISS.

However, the underlying molecular mechanisms responsible for the initial sensing of and adaptation to microgravity in human cells are still unknown. Therefore, we plan to investigate the different cell types in upcoming sounding rocket flight missions (TEXUS) with a focus on alterations of the cytoskeleton and the extracellular matrix. Furthermore, we intend to examine the activation and expression patterns of selected relevant genes found to be regulated by real microgravity. During the sounding rocket flight, the cells will be fixed at pre-determined time points during the different g-phases. These experiments will help us to detect very early effects of microgravity on signalling pathways related to ECM proteins, cell adhesion molecules, growth factors, cytokines and apoptotic factors in human cells, to further elucidate the formation of spheroids and to get a step closer to new drug targets.

[A-098]

MOLECULAR CHANGES IN HUMAN CELLS EXPOSED TO MICROGRAVITY

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Human cancer cells were investigated in real and simulated microgravity (µg) to evaluate the effects of short-term and long-term µg on the cytoskeleton, extracellular matrix, focal adhesion, growth and on factors of apoptosis.

Follicular thyroid cancer cells (FTC-133) were cultured in Space for 10d or 12d during the Sino-German Shenzhou-8, CellBox-1 and CellBox-2 space missions. FTC-133 cells and breast cancer cells (MCF-7) had been exposed to short-term µg, obtained during parabolic flight campaigns and TEXUS sounding rocket missions (TX52, TX53). µg was additionally simulated by a random positioning machine (RPM).

Real µg influenced the gene expression of various biological processes. We measured a large number of differentially expressed genes (proliferation, cytoskeleton, adhesion/extracellular matrix, proliferation, apoptosis, stress response, migration, angiogenesis, and signal transduction). The effect of real µg in space was antiproliferative. The gene expression during the parabolic flight maneuvers was often regulated in the opposite direction. A common finding are cytoskeletal alterations appearing early in µg, which was proven by life-cell imaging during the TX52 mission. The FLUMIAS microscope revealed significant alterations of the cytoskeleton related to microgravity.

Changes in the growth factors VEGFA, EGF, CGTF, the cytokines IL-6 and IL-8, E-cadherin, NFkB and VCAM are reported, indicating their involvement in the formation of three-dimensional aggregates, so-called multicellular spheroids (MCS). The structure of these MCS is depending on the cell type. MCF-7 form glandular MCS after a five-day exposure to the RPM, whereas FTC-133 grow in compact MCS after five days. Both cancer cell lines form compact MCS after 24h. Targeting of NFkB with dexamethasone and E-cadherin with PP2 revealed a reduction of MCS formation. These experiments are first attempt to use gravitational biology in cancer research.

In summary, we use microgravity as a new approach for target search in cancer. One objective is to find suitable drugs for therapy. Ground-based facilities are useful to support the data obtained from space missions.

[A-095]

CELLS OF THE IMMUNE SYSTEM RAPIDLY ADAPT TO ALTERED GRAVITY

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The hostile environment of microgravity during human spaceflight bears multiple limiting factors for human health and performance especially with respect to immune system weakening. Integrated risk assessment and development and validation of potential preventions and countermeasures require the investigation of the biology and homeostasis of immune modulation under spaceflight conditions. We therefore analyzed the cellular metabolism, functional parameters, gene expression responses and cellular dynamics in human lymphocytes and macrophages in different gravity environments through multi-platform approaches (parabolic flights, suborbital ballistic rockets, International Space Station and 2D clinostat and centrifuge experiments), including rigorous control experiments. A multi-platform approach not only allows for cross-validation of findings in independent experiment platforms, but also for understanding the time-course of mechanisms. Primary human macrophages exhibited fast and dynamic cellular changes within minutes on a suborbital ballistic rocket experiment. Furthermore, the ISS experiment TRIPLE LUX A provided direct evidence of cellular sensitivity within seconds and a subsequent ultrafast adaptation in only 42s to microgravity, through real-time on orbit measurements. However, exposure to long term microgravity of 11 days during the CELLBOX experiment on board the ISS neither showed quantitative nor structural changes of the cytoskeleton and only minor alterations in the metabolite spectrum. We addressed the question, if gene expression homeostasis is constantly shaped by the gravitational force on Earth, determined the time frame of initial gravitational force-transduction to the transcriptome, identified gravity-responsive genes, and assessed the role of cation channels in the transduction process. We detected profound alterations in the transcriptome after 20s of microgravity or hypergravity and found that nearly all initially altered transcripts adapted after 5min. Only 2.4% of all microgravity-regulated transcripts were sensitive to the cation channel inhibitor SKF-96365. Additionally, we revealed an overall high stability of gene expression in microgravity and identified olfactory gene expression in the chromosomal region 11p15.4 as particularly robust to altered gravity. We also conclude that microgravity alters gene expression homeostasis not stronger than other environmental factors in the investigated cell types and probably does not impose an unacceptable risk during long-term space missions at the cellular level.

[A-108]

SEMANTIC EVALUATION OF DATA OBTAINED FROM EXPERIMENTS ON CELLS EXPOSED TO MICROGRAVITY

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Microgravity as generated during sounding rocket or parabolic flights affect the molecular systems of single cells and whole organisms. Right now, it is of great interest to understand the mechanisms how cells sense lacking gravity and transduce the induced signals to the cell interior. Although there are possibilities to simulate microgravity and study its effects on cells, additional exposure to real microgravity appears necessary to draw reliable conclusions in regard of the health of human beings travelling into space.

Unfortunately, sounding rocket flights, providing the situation of real microgravity are rare and very expensive. Furthermore, the payload, i.e. the number of experimental units, which can be taken along is limited. Therefore, it is our aim to draw as much information as possible from the experiments performed.

Most information from our spaceflight experiments was drawn by investigating morphology and molecular biology of fixed cells returned from rocket flights. The technologies applied for this purpose were Multianalyte Profiling (MAP) and gene array technology, quantitative rtPCR, mass spectrometry, and Western blotting. All these methods revealed quantitative alterations of gene expression and of protein accumulation and secretion.

In order to find a relationship between the results obtained from the cell biological experiments and the influence, which an alteration of distinct mRNA or protein production has, we applied semantic methods. This means that we compared the experimental results with knowledge archived about interesting proteins. Emphasis was put on genes and proteins, which are interwoven with each other and according to the literature activate or inhibit each other. In this way, we detected gravi-sensitive proteins, which are involved in different types of space sickness observed when astronauts/cosmonauts return from spaceflights. In addition, gene and protein alterations were observed that influence apoptosis. But most interesting were those proteins and genes that favor or prevent the transition of growth of cells in a monolayer to growth within three-dimensional aggregates. The latter could be developed to a model to study metastasis of cancer cells.

[A-120]

FORAMINIFERA ROCKET EXPERIMENT – LIFE-SUPPORT SYSTEM FOR STUDYING MICROGRAVITATIONAL INFLUENCE ON CELL PHYSIOLOGY AND MOTILITY

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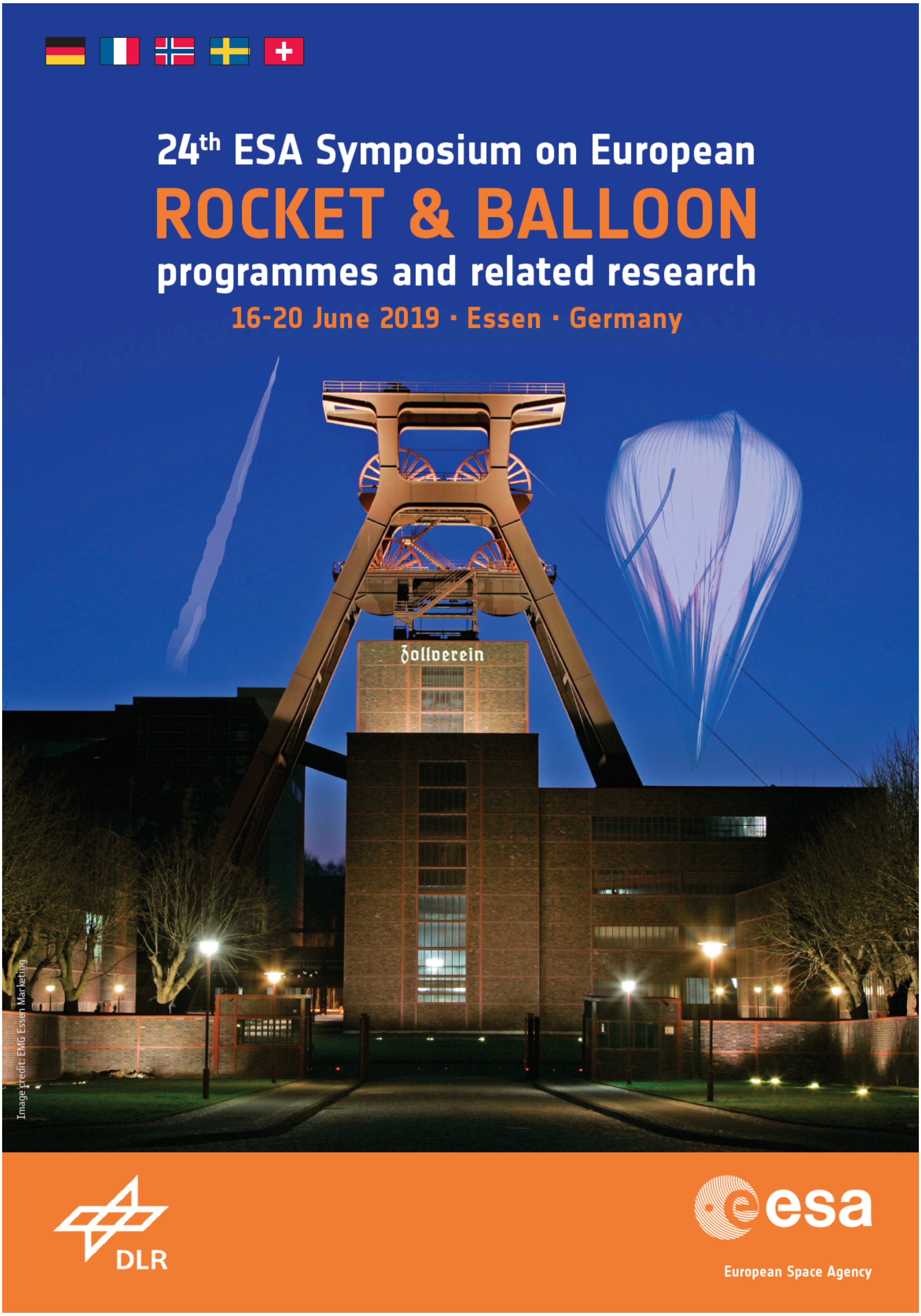
Gravity is the most constant environmental parameter for all life on Earth. As all known life forms have developed and adapted under the same gravitational conditions, the possibility of eliminating this factor artificially has been the focus of many space based biological studies. Small animals, plants and microorganisms exhibit a very distinct behaviour and growth pattern when exposed to microgravity. Under microgravity conditions, human cells show an immediate reaction of the cytoskeleton and even abiotic processes such as the formation of crystals are distinctively different. However, the formation of crystallised shells from living microorganisms has not yet been in the focus of microgravity studies. The formation of calcareous shells of shell-bearing organisms such as Foraminifera under such conditions is especially interesting, as the shells are important subjects for material sciences and biomedical applications, e.g. in bone restoration and controlled drug delivery. Modifications of the shell formation process also carry potential for applications in biotechnology, chemistry, bionics and space industry.

Under normal conditions, Foraminifera typically develop pseudopodia around the living cell, which serve important purposes such as movement and other ways to interact with their surroundings. Afterwards, a new part of the shell is formed in correlation with the pseudopodia, which is then inhabited by the cell, leaving the previously built cavities empty. To study this phenomenon under microgravity conditions, the FORAminifera Rocket EXperiment (FORAREX) was conducted in the course of the REXUS/BEXUS programme - an opportunity for university students to carry out scientific and technological experiments on board of sounding rockets or stratosphere balloons. Under the limited microgravity duration provided by the REXUS rockets, we focused on testing the purpose-built equipment and the behaviour of the Foraminifera Amphistegina lobifera examining changes in cell motility and movement during the flight in comparison to a control group. Additionally, the shell building capability and behaviour was investigated by optical means, REM and Nano-SIMS after the flight. To serve this purpose, we designed and constructed a life-support system for real-time observations of Foraminifera and tested it successfully under real mission conditions. Investigations during the flight were conducted using a miniaturised container with a flow cell examination chamber and a closed-circuit life support system with integrated LED-based illumination. Foraminifera were recorded with an integrated and automated camera. High-performance miniaturised sensors continuously measured oxygen, pH and temperature. For comparison, we performed additional experiments using a clinostat for simulating microgravity, centrifugation for simulating hypergravity and vibration. With these comprehensive experiments and results, we intend to set up a long-term experiment on board of the International Space Station (ISS), where we would like to investigate Foraminifera shell formation under extended microgravity influence.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