INTERNATIONAL SPACE SCIENCE INSTITUTE

Annual Report 2023

Cover Page

The puzzle is composed of six images (from the upper left to the lower right):

1. The face-on spiral galaxy, NGC 1566, is split diagonally in this image: The James Webb Space Telescope's observations appear on bottom right, and the Hubble Space Telescope's at top left (Image Credit: NASA, ESA, CSA, STScI, Janice Lee (STScI), Thomas Williams (Oxford), Rupali Chandar (UToledo), Daniela Calzetti (UMass), PHANGS Team)

2. Infrared light particles (photons) from the poles of a pulsar are boosted to gamma-ray energies (blue) by fast electrons (Image Credit: Science Communication Lab for DESY)

3. Painting by Olga Panasenco

4. Image comes from the Polarimetric and Helioseismic Imager (PHI), and reveals the magnetic polarity of the solar surface (Image Credit: ESA & NASA/ Solar Orbiter, PHI team)

5. The Earth (Image Credit: ESA)

6. Chondrule from desert meteorite DaG 331 10 µm in diameter (Image Credit: J. Zipfel, SGN Frankfurt)

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The International Space Science Institute (ISSI) is an Institute of Advanced Studies where scientists from all over the world meet in a multi- and interdisciplinary setting to reach out for new scientific horizons. The main function is to contribute to the achievement of a deeper understanding of the results from different space missions, ground based observations and laboratory experiments, and adding value to those results through multidisciplinary research. The programme of ISSI covers a widespread spectrum of disciplines from the physics of the solar system and planetary sciences to astrophysics and cosmology, and from Earth sciences to astrobiology.

From the Chairs of the Board of Trustees

In 2023, ISSI returned to full capacity and set new records. A total of 104 events were organised and attended by over 1100 scientists worldwide, making it the busiest year in the history of ISSI. This shows that, after the COVID years, the community really wanted to get together again to discuss science and that ISSI is a unique platform to provide this opportunity through its workshops, fora, or international teams. In this report, you will find a summary of what ISSI was able to accomplish in 2023 and we are sure that you will be impressed by its breadth and uniqueness.

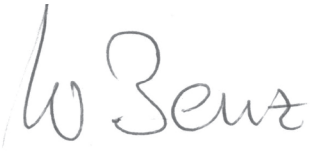
The Board of Trustees, which oversees the activities organized by ISSI, is pleased to note that the "raison d'être" of the Institute, namely to provide opportunities for free and open face-to-face scientific exchange, continues to meet a growing need in the scientific community, despite the many technological means of communication available. There is no doubt that face-to-face exchanges remain at the root of scientific creativity, not only promoting the dissemination of new ideas and best practices, but also allowing new questions to be raised.

This success, together with the ever-changing landscape in which science is conducted, brings new challenges for ISSI and requires action. Starting in 2023, the Board of Trustees, together with the Directorate, has begun a review of ISSI's strategy, with a focus on improving the way the Institute can fulfil its mission while maintaining the quality that is ISSI's hallmark. The possibility of expanding within the same building from 2024 not only makes such an exercise timely but also offers real new opportunities.

The significant change in key personnel at ISSI in recent years provides further motivation for this review of strategy, as new people bring new ideas. The Directorate has been completely renewed during this period, with Antonella Nota as the new Executive Director, supported by Maurizio Falanga, Thierry Dudok de Wit and Michael Rast as Directors. New members also joined the Board of Trustees in 2023. We had the great pleasure of welcoming Carole Mundell, who will represent ESA, and Linda Tacconi as a member at large. Furthermore, at the end of June, Georges Meylan, President of the Board of Trustees since 2015, was replaced by Willy Benz. Finally, ISSI would not be ISSI without its staff. Small in number but extremely dedicated, they are the ones who make the projects happen. We would like to take this opportunity to acknowledge their commitment and contribution.

Of course, none of this would be possible without the support of our funders, in particular the European Space Agency (ESA), the Swiss Federal Government, the Swiss Academy of Sciences (SCNAT), the University of Bern, and the Japan Aerospace Exploration Agency (JAXA). We hope that the activities taking place at ISSI, which you will read about in this report and which involve scientists from all over the world, will inspire also others to consider some form of active participation in this unique facility.

Georges Meylan
Chair of the ISSI Board of Trustees (until June 2023)
Ecole Polytechnique Fédérale de Lausanne (EPFL)
Lausanne



Willy Benz
Chair of the ISSI Board of Trustees (since July 2023)
University of Bern

From the Directors

In many respects, 2023 has been a transformational year.

The effects of the pandemic hiatus are finally behind us. By the end of 2023, ISSI had fully caught up the scheduling backlog, and could finally resume a steady state of activities, and start thinking about the future, and what the future could be for a unique organization like ISSI. During the pandemic, communication within the scientific community had totally changed: meeting on-line was the only way to do work and keep the communities connected. But as soon as in-person meetings could resume, the enthusiastic response of the scientific community was to be at ISSI again, in person, to discuss science.

Organisations such as ISSI have a unique role in society, as they are very much needed to provide a welcoming and neutral platform for scientific discourse, where scientists meet in person to discuss compelling scientific topics around the coffee machine or in the meeting rooms and in the hallways, and publish their results in the literature. As the Directors started in 2023 a process to develop a strategic plan for ISSI's future, and as we approach the 30th anniversary of the organisation, this core mission will remain valid, relevant, and unwavering.

We kicked off the process with a Science Strategy retreat that involved the Directors and staff in June 2023, and that retreat generated a number of actions and decisions that will shape the organisation future, with the resolve that ISSI's core mission will not change, but will adapt to the evolving nature of space science and of the needs of the scientific community we serve.

First, it was acknowledged that some of the lessons learned during the pandemic facilitated better operations for the future. For example, ISSI invested significantly in the technology necessary to enable online meetings. Now that technology investment is greatly paying off, and is allowing us to make our in-person meetings more efficient, and inclusive. ISSI frequently receives accolades from visitors for the ease of including their remote colleagues in their conversations.

Decisions were made that will further strengthen the organisation in the future. With an eye to our growing communities (mostly in-person but also on-line), it was recognised that ISSI's overall scientific communication could do with a refresh, starting with the website. The current website has served ISSI very well in the past, but it was time to think of a major redesign. This started in June 2023, and input was collected from all ISSI staff. ISSI's community will soon see the fruits of this hard work, as we will unveil the new site in May 2024. The new website will be faster, easy to navigate and aesthetically attractive, and we are very excited to be sharing it with the ISSI community soon. We also expect the new website will make it much easier to find and apply for the scientific opportunities that ISSI offers.

A second decision was a modest increase in our physical footprint. With the return of in-person meetings and the enthusiasm of the science community to be physically present at ISSI, we felt that the organisation could do with a little more breathing space. ISSI had effectively lost a few offices with the renovation of the J. Geiss Auditorium, so when the opportunity was presented to rent a new, beautiful, wing on the fourth floor, we felt that this was an opportunity not to be missed. The Board of Trustees was consulted, and with their strong support we moved to rent the new space. The contract was signed mid-2023, and at the moment of writing, the fourth floor is fully operational. It has been named the Space Science floor to reflect the presence of the ISSI post-docs, most of the ISSI Directors and the Discipline Scientists, and new and augmented modern meeting space. Already, the new Space Science floor conference room, equipped with state of the art technology, has acquired the reputation of offering the most beautiful mountain view in the entire building.

As we ramped up ISSI's meeting in-person capabilities, we also slowed down the pace of some on-line activities, like the very successful Game Changer seminar series, which has been extremely effective in keeping ISSI communities connected during the pandemic, and has grown a faithful constituency of attendees. In 2023, the cadence of the seminars became monthly, but the seminar contents are very much honest to the original idea: compelling topics, engaging speakers. Game Changer seminars continue to be archived on ISSI's fast growing YouTube Channel.

From the Directors

On the science side, we put emphasis on highlighting compelling and emerging science topics. In 2023, we hosted a wide variety of successful workshops and fora in the four disciplines that ISSI covers. Also in 2023, preparations started for the first Breakthrough WS. This would be a new format for ISSI and was considered an experiment. Breakthrough WS focus on a very specific question that is ripe for discussion, because of new observational data or theoretical or modelling developments. For this very first Breakthrough WS the chosen topic was the chronology of the very early Universe according to JWST: the first billion years. All successful PIs of Cycle 1 JWST proposals were invited (and agreed to come) to ISSI Bern to discuss the topic and write their conclusions in a high-visibility, high-impact paper to be published soon after the Breakthrough WS. The Breakthrough WS itself was held in 2024 and we anticipate that the experiment was very successful.

We very much enjoyed hosting the 2023 Johannes Geiss Fellow, Prof. Sandra Chapman, and the 2020 Johannes Geiss Fellow, Prof. Weiquing Han, who greatly enriched the ISSI science atmosphere during their stays in Bern. For that, and the numerous intellectually engaging lunch conversations, ISSI is very grateful. During 2023, ISSI also hosted a large number of individual visitors, who greatly contributed to the lively scientific life of the organisation.

We are also grateful to the ISSI Science Committee, whose commitment and hard work allows ISSI to maintain the level of excellence in the science program that our stakeholders have come to expect. We wish farewell to Prof. Louise Harra, who has selflessly chaired the committee in the past years and we wish great fortune to newly appointed Chair Prof. Emmanuelle Javaux, who took the helm in May 2023.

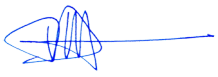
On the staff side, in 2023 we welcomed Planetary Discipline Scientist Geraint Jones, and we renewed our connection with Heliophysics Discipline Scientist Rumi Nakamura and Senior Scientist Alvaro Giménez. They all contributed community ideas in their areas of expertise. We also recognised that, in order to serve the community at the level of professionality and responsivity that is expected of ISSI, we needed to augment the secretarial staff, and we did that, recruiting two wonderful additions to the team: Dominique Fuchs and Xeila Monteagudo.

Finally, we also recognised that one of the services we offer to the ISSI community is to highlight the important science that is done at ISSI by the communities we serve, and at the end of December 2023, we recruited a new expert team member, Fabio Crameri, to help us with scientific communications, to the science community and to the public, in partnership with the Pro ISSI Association. We expect that the new website will provide a platform to routinely feature science news and ISSI events, as well as put a spotlight on the very diverse community that ISSI serves.

In conclusion, none of this could happen without the amazingly dedicated and welcoming ISSI staff, the strong support of our Board of Trustees (BoT), and the financial support of our funding agencies. ISSI expresses gratitude to Prof. Georges Meylan, who served as ISSI BoT Chair through mid-2023, and passed the baton to newly elected Chair Prof. Willy Benz. We wish Willy congratulations and offer our support, to him and the rest of the BoT, as we chart together ISSI's bright future.

As we approach the 30th anniversary of this unique organisation, we are confident that ISSI is thriving. Together with the ISSI community, and our stakeholders, we are excited to be shaping a future that is centred on important science, intense discussions and thousands of coffee cups, for many years to come.

Antonella Nota

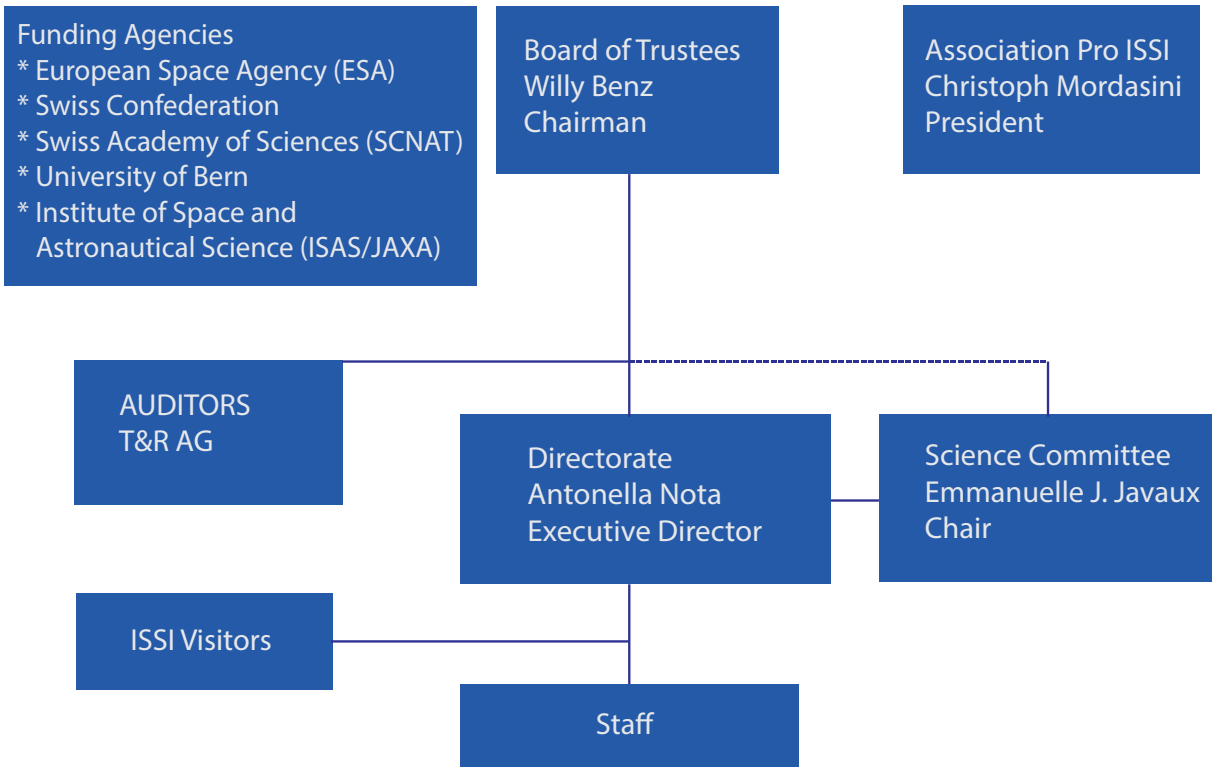


Thierry Dudok de Wit

Maurizio Falanga

Michael Rast

About the International Space Science Institute



The International Space Science Institute (ISSI) is a nonprofit organisation set up in Bern in 1995 as a foundation under Swiss law with an endowment by Contraves Space AG, later renamed Oerlikon Space AG and now part of RUAG. Three statutory bodies govern ISSI: the Board of Trustees, the Directorate, and the Science Committee. A fourth important body, the Association Pro ISSI, promotes the idea of ISSI, especially within Switzerland.

The European Space Agency (ESA), the Swiss Confederation, and the Swiss Academy of Sciences (SCNAT) provide the financial resources for ISSI's operation. The University of Bern contributes through a grant to a Director and in-kind facilities. The Institute of Space and Astronautical Science (ISAS/JAXA) is supporting ISSI with an annual financial contribution. The US Universities Space Research Association USRA supports the participation of US scientists in ISSI events. ISSI received tax-exempt status from the Canton of Bern in May 1995.

ISSI's **Board of Trustees** oversees the work accomplished at the Institute, exerts financial control, and appoints the Directors and members of the Science Committee. It consists of representatives of the Founder, and of the funding Institutions. In addition, the Board of Trustees may nominate up to five personalities representing the national and international scientific community, space industry and space politics for a term of three years. The Board of Trustees is presided over by Willy Benz.

The **Science Committee**, chaired by Emmanuelle J. Javaux, is made up of internationally renowned scientists active in the fields covered by ISSI. The Science Committee advises and supports the Directorate in the establishment of the scientific agenda providing a proper equilibrium among the activities and reviews and grades the Team proposals in response to the annual call. Science Committee members serve a three year term (with a possible extension of one year).

The **Directorate** is in charge of the scientific, operational, and administrative management of the Institute. It interacts with the Funding Agencies, the Swiss authorities, the Board of Trustees, the Science Committee and the Association Pro ISSI. The Directorate consists of Antonella Nota (Executive Director), Maurizio Falanga (University of Bern), Thierry Dudok de Wit and Michael Rast.

The **Association Pro ISSI** promotes the idea of ISSI by organising public lectures, when internationally known scientists introduce their results. Summaries of these talks are published in the journal SPATIUM. The Board of the Association Pro ISSI is presided over by Christoph Mordasini.

Scientific Activities in 2023: The 28th Year

The Programme and its Elements

ISSI's mode of operation is generally fivefold: multi- and interdisciplinary Workshops, Working Groups, International Teams, Forum, and Visiting Scientists. 1074 international scientists participated in ISSI's scientific activities in person in 2023, 677 of them from ESA member states and ESA. 438 visited ISSI for the first time.

Workshops consist of up to 50 invited scientists exchanging their views on a scientific theme, typically over one week. Workshops always lead to a volume of the Space Science Series of ISSI and in parallel as issues of Space Science Reviews or Surveys in Geophysics. In 2023, four Workshops were organised, summaries of which can be found on the following pages.

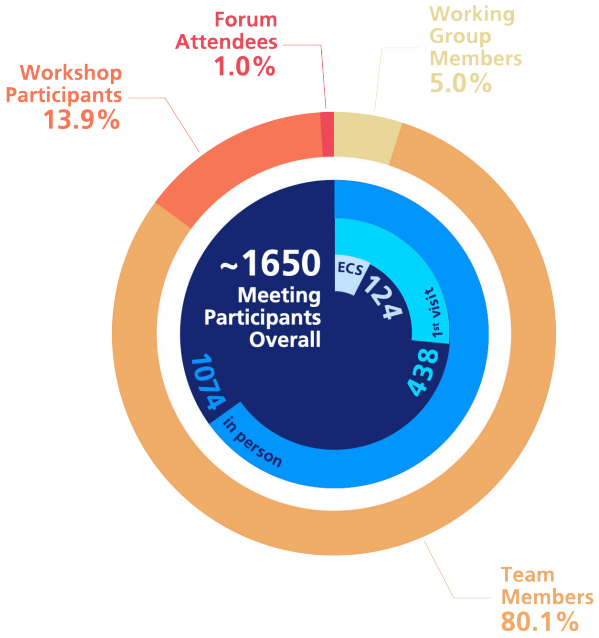
International Teams consist of about 15 external scientists, addressing a specific scientific topic in a self-organised fashion. The results of these activities are customarily reported in scientific journals. Details can be found starting on page 19.

A **Forum** is an informal and free-ranging debate consisting of some 25 high-level participants who discuss open questions of a scientific nature or science policy matters for about two days. A Forum does not necessarily lead to formal recommendations or decisions. One Forum was held during the reported period.

Working Groups have a smaller number of members and meet as often as necessary to achieve the assigned objective. Three new Working Groups started their projects in 2023. The results of the Working Groups are in general published as titles of ISSI Scientific Report Series or in the scientific literature.

Visiting Scientists spend between one week and two months at ISSI to work on a research project of their own, or to collaborate with ISSI's staff and/or with research institutes in Switzerland. In 2023, 18 individual visitors used the ISSI facilities.

The **Johannes Geiss Fellowship (JGF)** is established to attract to ISSI – for limited duration visits – international scientists of stature, who can make demonstrable contributions to the ISSI mission and increase ISSI's stature by their presence and by doing so will honour Johannes Geiss for his founding of ISSI and his contributions to ISSI, and for his many contributions to a broad range of space science disciplines.



The **Early Career Scientist (ECS)** Programme is designed to bring PhD students and postdocs into contact with their research community. These scientists are invited by the conveners of the different activities to complement the membership of Workshops, Working Groups, International Teams and Forums. 124 Early career scientists participated in ISSI activities in the course of the year.

How to use ISSI Tools

As a general rule, any member of the community can submit a proposal for any of the ISSI tools. Once an activity is approved, the financial support for invited scientists covers the local accommodation expenses and a per diem while in Bern.

International Teams: A call for proposals is released every year in mid January for a deadline in mid March. These proposals are evaluated by the ISSI Science Committee and approved by the Directorate. Over the past years the number of accepted Teams is about 30 per year.

Workshops, Working Groups, and Forums: The scientific community may suggest at any time Workshops, Working Groups, and Forums. Proposal templates can be found at www.issibern.ch. Interested applicants should always liaise with an ISSI staff member when preparing a proposal. The ISSI Science Committee will evaluate these suggestions and the ISSI Directorate will take a final decision.

Game Changers Online Seminars

Starting in the summer of 2020, the International Space Science Institute has organised the weekly on-line seminar series called "Game Changers". After six series of weekly talks on the themes of "Missions that Changed the Game in Solar System, Astrophysics and Earth Sciences", "Ideas and Findings about the Solar System, the Universe and our Terrestrial Environment","Habitability – From Cosmic to Microbial Scales", "Viewing Earth from Space – the Changing Environment and Climate of our Planet", and "Captivating Cosmology: From the Big Bang to Tomorrow" and the topic "Space Environmental Hazards: Mitigation and Prediction", the webinar series continues on a monthly basis.

ISSI has continued its series of webinar talks that have become known as the Game Changers Online Seminars with speakers from all over the world. The webinars were recorded and are available at www.issibern.ch where upcoming talks are also advertised. Between roughly 100 and 400 participants have attended the live webinars, many as loyal participants throughout the series.

Space Environmental Hazards: Mitigation and Prediction

The Shining Earth: The Polar Lights with Jean Lilensten (Institut de Planétologie et d'Astrophysique de Grenoble, France) – 12 January 2023

Satellite Drag Effects on Satellite Operations and Debris in Low Earth Orbit with Eelco Doornos (Royal Netherlands Meteorological Office, NL) – 19 January 2023

Planetary Space Weather Science and Solar System Exploration with Christina Plainaki (Italian Space Agency (ASI), Italy) – 26 January 2023

Space Weather Impact on Radio Wave Propagation with Norbert Jakowski (DLR, Germany)– 2 February 2023

Using AI to Predict the State of the Space Environment with Enrico Camporeale (NOAA, USA) – 9 February 2023

Environmental Risks in Space – An Insurer View with Denis Bousquet – 16 February 2023

A Clock for the Solar Cycle Variation of Extreme Space Weather Activity with Sandra Chapman (University of Warwick, UK) – 23 February 2023

Further Game Changers Online Seminars
(on a monthly basis)

The Habitable Zone Around Supermassive Black Holes with Jeremy D. Schnittmann (NASA, GSFC, USA)– 30 March 2023

Climate Change from Space with Gavin A. Schmidt (Goddard Institute for Space Studies, NASA, USA) – 27 April 2023

Asteroid Deflection and Exploration: Successes and Challenges with Patrick Michel (CNRS, France) – 1 June 2023

Sun, Climate and Ozone: 1850-2100 with Judith Lean (University of Colorado, USA) – 29 June 2023

Combining Exoplanet Measurement Techniques to Discover, Weigh and Characterize Cold Gas Giants with Emily Rickman (Space Telescope Science Institute, Baltimore, USA) – 31 August 2023

Essential Climate Variable (ECV) Products from Satellite Gravimetry: Terrestrial Water Storage and Groundwater with Adrian Jäggi (University of Bern, Switzerland) – 28 September 2023

Telescopes on the Moon: The Next Decades with Joseph Silk (IAP, Paris, France) – 26 October 2023

Genetically Modified Galaxies with Andrew Pontzen (UCL, UK) – 30 November 2023

Forums are informal and free-ranging debates among some twenty-five high-level participants on open questions of a scientific nature or science policy matters.

International Cooperation in Space Science

25–27 October 2023

The Forum consists of two parts: the first was on 25–27 October 2023, with a follow-up session planned for June 2024. A group of active scientists with diverse backgrounds and with extensive experience in space science gathered at ISSI to discuss the advantages and disadvantages of international cooperation in space science. The goal of this Forum was to inform scientists interested in establishing space missions in cooperation among different agencies and funding bodies, and to better inform them of some of the challenges related to international cooperation. Ultimately, the goal is to develop a common understanding that could lead to broader, more effective cooperation. The second part of the Forum is planned in June and the goal will be to complete the discussion and agree on a number of key points.

The reasons for cooperation in space science missions are many, ranging from the idea being born within a pre-existing scientific collaboration, to the desire to build a better performing mission by pooling resources, to the wish to cover a broader set of science topics by involving different communities, etc. Elements discussed during the meeting included international cooperation in a rapidly changing world, with new actors, evolving relations, tensions, and increasing ambitions.

The Forum participants felt that the lessons learned from international scientific collaborations can be used to overcome the challenges brought about by differences in cultural background. This opens opportunities for the growth of personal relations, fundamental for originating and strengthening cooperation, particularly within a fragile international system. In the end, this would be a benefit to humanity as a whole, not only to science.

Elements of a successful international cooperation were discussed in three sessions: ownership and governance of missions, possible approaches to cooperation, and costs and benefits of cooperation. Participants described the approach to space science missions in different institutional contexts, which showed interesting differences: top-down vs bottom-up approach to decision making, how a mission comes to be proposed and then accepted, who owns the mission vs. who manages it, funding allocations, or collaboration with PIs. Common elements were identified, like external and internal reviews, that cooperation should not just be out of necessity, even though it does cover that role, but also as an opportunity for 'more science', and that trust is fundamental, together with clear communication and clear interfaces.

Among the topics discussed, the importance of starting cooperation as early as possible, and carefully evaluating partnerships, because by nature space missions are very long and an unstable relationship may be detrimental to the mission. Other elements of cooperative missions were also considered: for example, citizens' appreciation may be important for growing space economies to maintain support for public spending.

It quickly emerged that key elements of cooperation are trust (at all levels, not just at the top), respect, clear interfaces, genuine science goals, diversity, advantages for all partners, transparency, communication, and persistence. It was felt that cooperation plays a role not just during the mission implementation but afterwards as well, both in sharing and even jointly analysing the data.

Cooperation adds to the mission cost and usually entails an increased overhead for the bigger partners. Additionally, cooperation requires compromise which may not always be the most efficient approach to decision-making. Cooperation implies higher risk of overruns. Efficiency is possibly higher in missions implemented by a single agency, but cooperation brings additional advantages. Budget overruns can have a more limited impact on the mission as countries have a greater responsibility to bring the mission to completion and can help and support each other.

It was broadly felt that it is not a question of whether to cooperate, but how to make it easier for the scientists involved to make cooperation most effective.

Alvaro Giménez and Antonella Nota

Workshops are selected by the Directorate in consultation with the Science Committee. Proposals or suggestions for Workshops may originate from the external community. The programme and speakers are defined by a group of experts serving as conveners. The Workshops can be attended by up to 50 invited scientists. Workshops always lead to a volume of the Space Sciences Series of ISSI (SSSI) published by Springer and in parallel as a Topical Collection in Space Science Reviews or an issue of Surveys in Geophysics.

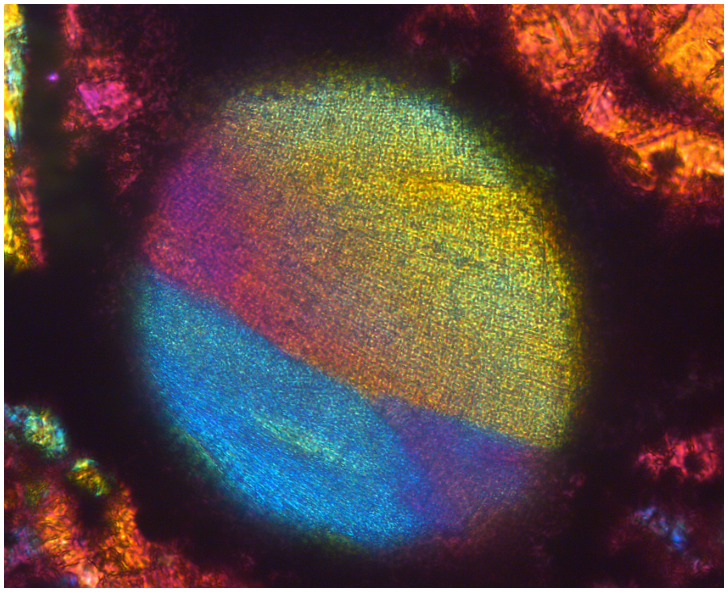
Evolution of the Solar System: Constraints from Meteorites

5–9 June 2023

The Workshop was held at ISSI with the aim of reviewing the present status of meteorite research and to discussing new developments in cosmochemistry and their significance in understanding the formation and early evolution of the solar system. The time for such a workshop seemed appropriate, because of two recent major advances. (1) Material from asteroids has been brought to Earth. The relationship of this material to meteorites gives new insights into the formation of solid bodies in the solar system. (2) Recent improvements in techniques for precise stable isotope analysis have provided new constraints on the origin of meteorites and their components.

The Workshop was organised along eleven themes: (1) What do meteorites tell us about solar system evolution? (2) How close are CI chondrite chemical compositions to the Sun? (3) How chemically and isotopically homogeneous was the early solar system and when was it isolated from the ISM? (4) What are we learning from meteorite ages for the evolution of our solar system? (5) Why are meteorites and planets depleted in volatile elements? (6) Which are the (currently) most likely chondrule formation processes? (7) Was there an initially homogeneous reservoir of matrix material? (8) Is there a genetic relationship between matrix and chondrules? (9) What are meteorites telling us about nucleosynthesis? (10) When, how and to which extent were meteorites altered? (11) How do returned asteroid samples compare with meteorites?

Scientific sessions with talks and extensive discussion time started on Monday morning and lasted until Thursday evening. Friday morning was entirely devoted to reviewing and discussing insights from the previous days. There were lively discussions on controversial issues.



Chondrule from desert meteorite DaG 331 10 µm in diameter. Image taken with crossed nicols and lambda plate (Image Credit: J. Zipfel, SGN Frankfurt)

One highlight was a report by Professor Tomoki Nakamura from Tohoku University, Sendai. Prof. Nakamura is a leading expert in the recent successful sample return missions to the asteroids Itokawa and Ryugu. He gave a first-hand account of the samples that had been returned from Ryugu and many other aspects of this mission.

Most participants were impressed by and pleased with the meeting. One person, in particular, claimed that this meeting was the best that he had ever attended in his professional career.

The Workshop had 47 participants with 30% being female and 70% male. Participants were mostly professional scientists, but also several students (5) attended the meeting. Participants came from seven countries, USA (15), Germany (15), France (6), Switzerland (4), United Kingdom (3), Denmark (2) and Japan (2).

The meeting was organised by Herbert Palme, Jutta Zipfel (both Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt), Dominik Hezel (Goethe-University Frankfurt), Klaus Mezger (Unversity Bern) and Alessandro Morbidelli (Observatory Cote d'Azur), who also act as associate editors of papers of the forthcoming volume in the Space Science Series of ISSI.

Herbert Palme and Jutta Zipfel

Magnetic Switchbacks in the Young Solar Wind

18–22 September 2023

Workshop poster drawn by Olga Panasenco

The observation by NASA's Parker Solar Probe mission of very strong magnetic field fluctuations in the inner heliosphere, leading to strong deflections locally reversing the direction of the field itself, called switchbacks, has attracted considerable attention from the heliophysics and space physics communities.

Today we know that switchbacks behave as Alfvénic structures and are a natural process accompanying solar wind acceleration. The fact that they appear to come in groups, or patches, has been associated with the spatial/temporal properties of their sources at the Sun, which are connected to super-granular structures. However, many aspects are still not understood, such as their connection to solar transients like, for instance, jets or the nature of the instabilities (e.g. interchange) that can give rise to such folds of the magnetic field. Because of their ubiquity, switchbacks are expected to hold one of the keys to our understanding of solar wind generation and acceleration. One of the main obstacles to a better understanding of these structures is the need to link in situ observations of the solar wind (where they are observed) with remote sensing observations of the solar corona and surface (where they are thought to be generated).

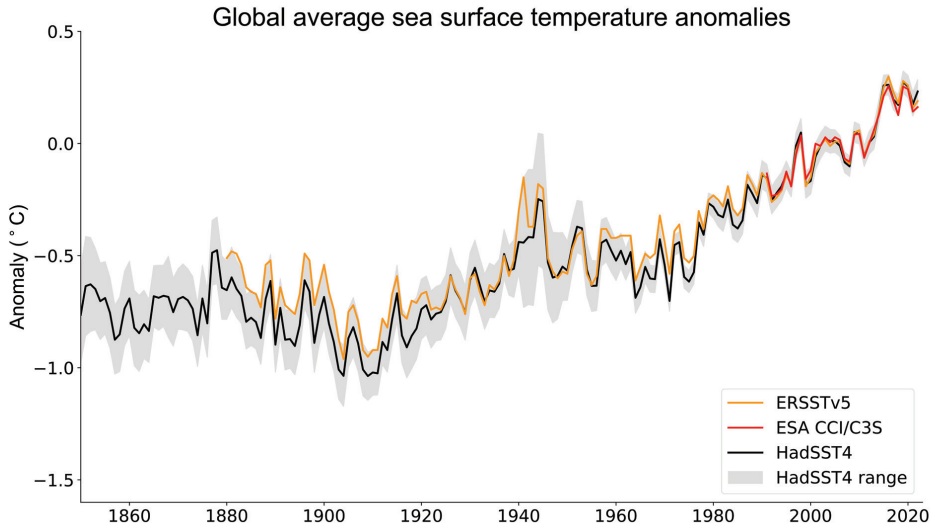
The Workshop aimed to bring together solar and solar wind scientists to better understand how these structures are formed and how they contribute to the heating, acceleration and scattering of energetic particles in the solar wind. Although there are still competing theories for the formation and evolution of switchbacks, a major outcome of the workshop was the recognition of the role played by small-scale energetic magnetic field annihilation (or reconnection) events that exchange plasma between open and closed fields in the lower corona, leading to the development of small-scale jets of hot plasma. There is general agreement that these may provide the necessary conditions for the formation of switchbacks in the corona and inner heliosphere. A series of review papers describing the current state of our understanding of switchbacks and the results of the workshop will be published in a dedicated book and in Space Science Reviews.

The Workshop was convened by Marco Velli (UCLA, Los Angeles, USA), Maria S. Madjarska (MPI, Göttingen, Germany and SRTI, BAS, Sofia, Bulgaria), Stuart D. Bale (University of California, Berkeley, USA), Olga Panasenco (Advanced Heliophysics, Los Angeles, USA), Etienne Pariat (LPP/CNRS, Paris, France), Anna Tenerani (University of Texas, Austin, USA), Tim Horbury (Imperial College, London, United Kingdom), Thierry Dudok de Wit (ISSI, Bern and University of Orléans, France).

Thierry Dudok de Wit

Remote Sensing In Climatology – Essential Climate Variables (ECVs) and their Uncertainties

13–17 November 2023



Annual global average sea surface temperature (°C), relative to the average for the 1991–2020 reference period. Data sources: HadSST4.0.1.0 (1850–2022, black; grey shading indicates the uncertainty, ERSSTv5 (1880–2022, orange), and ESA CCI/C3S SST Climate Data Record v3.0 (1991–2022, red). Image Credit: C3S/ECMWF/UK Met Office.

The Workshop tackled recent developments in and challenges to of quantifying uncertainties in Essential Climate Variables (ECVs) observed from space. This gathering of experts underscored the crucial role of remote sensing in climate science, particularly in refining the accuracy of ECV measurements crucial for climate change assessment and modeling. As example, Emma Woolliams' (National Physics Laboratory, UK) discussion on the metrological approach to satellite data highlighted the necessity for a rigorous application of metrological principles in satellite uncertainty analysis. This approach aims at ensuring that ECV data products are provided with detailed metadata and associated quality indicators, traceable to reference standards, to ensure the reliability of climate research and policy-making. Andreas Güntner (GFZ Potsdam) and Adrian Jäggi's (Astronomical Institute of the University of Bern) presentation on the challenges faced in satellite gravimetry analysis for terrestrial water storage underscored the importance of accurately capturing smallest variations in Earth's gravity field. They stressed the integration of various satellite-based observations to derive accurate estimates of ground water storage changes, an important component for understanding global water cycle dynamics. Adam Povey's (University of Leicester) insights into aerosol and cloud ECV uncertainties highlighted the complexity of aerosol-cloud interactions and their significant uncertainty in climate feedback mechanisms. Alejandro Blazquez (LEGOS, Toulouse) focused on the global ocean heat content and Earth Energy Imbalance (EEI), demonstrating the critical need for precise measurements of ocean heat content as a proxy for assessing EEI and the impacts of anthropogenic climate change. This highlights the role of advanced satellite altimetry and gravimetry in improving the accuracy and reliability of these essential measurements.

The discussions and presentations at the Workshop recognised the significant progress in ECV uncertainty quantification through remote sensing. They stressed the critical need for greater efforts in harmonizing and communicating approaches across related communities, notably incorporating the climate modeling community, to drive more robust advancements and ensure consistent application and understanding. These efforts are aimed not only at overcoming current limitations in our understanding and management of ECV uncertainties but also at equipping the scientific community and policymakers with the tools and information needed for more effective climate action and adaptation strategies.

Roland Hohensinn

Workshops

Megavolt Sky Astronomy

11–15 December 2023

The Workshop gathered more than 40 researchers from all over the world. It was devoted to a broad discussion of MeV band gamma-ray astronomy in the context of the multi-wavelength and multi-messenger studies of high-energy astrophysical sources. Gamma-ray astronomy has experienced a period of very impressive scientific advances and successes during the last decade. In the high-energy range, studied with space instruments above 100 MeV, the AGILE and Fermi missions led to important discoveries. In particular, the Fermi's Large Area Telescope has established an inventory of active sources of various kinds (blazars, pulsars, supernova remnants, high-mass binaries, gamma-ray bursts, etc.) showing a variety of gamma-ray emission processes. Recently important new development concerns the role of gamma-ray astronomy in the multi-messenger studies of the energetic astrophysical objects as mergers of relativistic compact objects – neutron stars and black holes – detected as gravitational wave sources by the LIGO and VIRGO observatories. Gamma-ray observations are crucial for studies of the origin of dark matter particles and of the sources of astrophysical neutrinos detected by the Ice Cube observatory. The operating atmospheric Cherenkov telescopes, H.E.S.S., MAGIC and VERITAS, the water Cherenkov telescope HAWC, the high-altitude air shower observatory LHAASO, and the future Cherenkov Telescope Array, CTA, extend the gamma-ray observations to very high (>100 GeV) and ultra-high (>100 TeV) photon energies.

Many of the most spectacular objects in the Universe, including sources showing fast variability and/or a transient nature, have their peak emissivity at photon energies between 0.2 and 100 MeV (e.g., gamma-ray burst sources, blazars, pulsars, etc.), so it is in this energy band that essential physical properties of these objects can be studied most directly. This energy range is also known to feature spectral characteristics associated with gamma-ray emission from pion decay, the primary signature of hadronic acceleration. This fact makes the MeV energy region of paramount importance for the study of radiating non-thermal particles and for distinguishing leptonic processes from hadronic ones, a needed step to unveil the long standing mystery about the origin of Cosmic Rays. Moreover, this energy domain covers the crucial range of nuclear gamma-ray lines produced by radioactive decays, nuclear collisions, positron annihilations, or neutron captures, which makes it as special for high-energy astronomy as optical spectroscopy is for manifold phenomena

Participants of the "Megavolt Sky Astronomy" Workshop

of atomic physics. In particular, measuring the redshifts of MeV-regime nuclear lines in the close vicinity of relativistic objects – neutron stars and black holes – provides unique information on the inner radii of the accretion regions and allows to constrain the equation of state of neutron stars. In addition, the highest magnetic fields in the Universe, up to 1015 G, well exceeding the critical characteristic fields of quantum electrodynamics, were revealed in magnetars. In such high fields, cyclotron lines have to be in the MeV range. This opens up the possibility of using the unique power of MeV spectroscopy to study fundamental physical processes.

All these phenomena were reviewed and discussed in depth in the Workshop, highlighting the power of discovery that MeV astronomy holds. The book containing the collective reviews of the main topics is in preparation to be published as ISSI series in Springer.

Maurizio Falanga

Scientific Performance of ESA Space Missions

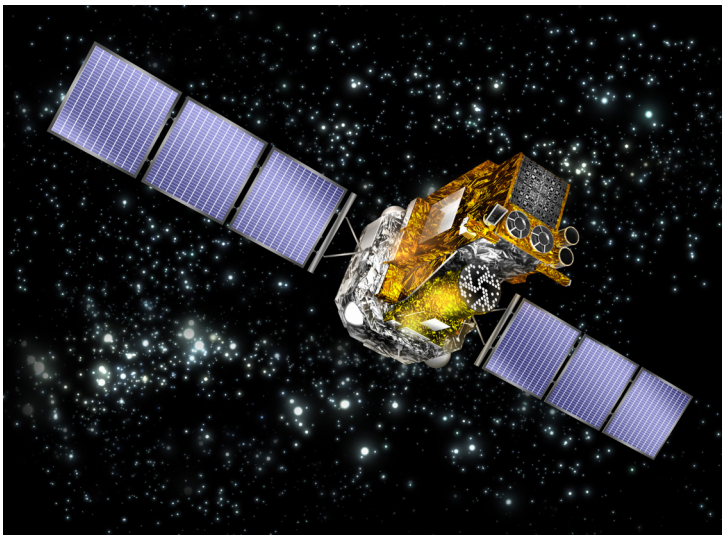
Working Groups are set up by the ISSI Directorate for specific tasks, often also of a technical nature. The results of the Working Groups' activities are published as volumes of the ISSI Scientific Report Series (SR) or in the scientific literature.

The purpose of this Working Group is to examine the scientific performance of the *ESA Science Programme's* missions. The outcome of this study will be published in a volume of the ISSI Scientific Reports series. The Working Group met twice in 2023 in April and in November in order to progress with the writing of the draft chapters. These are now close to finalisation and we expect to be ready to submit to the publishers in early 2024. The Working Group identified three ways in which to examine the scientific performance:

1. The >68,000 refereed publications that directly use the scientific data from each of the Science Programme's missions covering astronomy, planetary science and heliophysics. As well as the number of such publications and the yearly publication rates, the number of these that are highly cited, the total number of citations, various statistical metrics and the number of unique author names were examined to provide insights into mission successes and the communities exploiting the data provided by the Science Programme's missions. We highlight the importance of "archival papers" – those written by scientists not directly involved in the provision of payloads or the definitions of the scientific projects.

2. The outcomes of the regular announcements of observing opportunities for ESA's observatory missions, INTEGRAL, Herschel and XMM- Newton. In particular, INTEGRAL and XMM-Newton have been operating for over 20 years allowing the evolution of their user communities to be investigated. We examined the gender of the proposers requesting observing time and the members of the Time Allocation Committees and how these have evolved with time. We determined the "academic age" of many of the proposers using the date they were awarded their PhD to examine how success rates vary with age, and hence experience. We have also examined how the chance of having a proposal accepted depends on the country where a proposer's institute is located and on the proposer's gender.

3. Examining the provision of payload elements for the ESA Science Directorate's missions. Generally, such contributions are directly funded by entities in ESA Member States and so ESA does not have details of costs; these are anyway difficult to compare between countries. Instead the numbers of principal and co-principal investigators from each of the ESA Member States are used as proxies for the costs in order to investigate the provision of payload elements. A comparison of publications and payload contributions provides insights into how different countries are exploiting the results and opportunities coming from ESA's missions compared to their direct contributions to payloads.



Integral, ESA's International Gamma-Ray Astrophysics Laboratory, is gathering some of the most energetic radiation that comes from space. The spacecraft was launched in October 2002. (Image Credit: ESA)

The Working Group is composed of the following members: Arvind Parmar (MSSL, UK), Roger-Maurice Bonnet (IAP, FR), Guido De Marchi (ESA, NL), Pedro García-Lario (ESA, ES), Erik Kuulkers (ESA, NL), Göran Pilbratt (SE), Celia Sánchez-Fernández (ESA, ES), Maria Santo-Lleó (ESA, ES), Norbert Schartel (ESA, ES) and John Zarnecki (OU, UK).

Arvind Parmar

Working Groups

Global Assessment of Limnological, Estuarine and Neritic Ecosystems (GALENE)

Participants of the first Working Group meeting "GALENE" at ISSI in July 2023

Inland and coastal water ecosystems provide essential services to humans (i.e. drinking water, fisheries). As important and biodiverse habitats they play a crucial role in global carbon and water cycles. Water is essential for the blue economy by facilitating diverse activities in industry, commerce, and recreation. Despite the importance of these ecosystems, they are severely under threat. Consequences of anthropogenic activities and global environmental change (e.g. water overexploitation, pollution, weather extremes, water level changes) particularly affect water oxygen regimes, columnar stratification, productivity and food chains, and the health of aquatic life. The increasing vulnerability of aquatic ecosystems severely compromises their capacity and increases the risks to providing ecosystem services.

Detailed understanding and knowledge of globally distributed and highly dynamic aquatic ecosystems are urgently needed to implement sustainable protection and management of these ecosystems. Systematic observations are essential for this purpose and must include detailed in situ monitoring together with satellite remote sensing for harmonised global water information. While a multitude of available remote sensing missions particularly focuses on ocean biology and biogeochemistry and terrestrial environments, satellite missions specifically designed to study critical coastal and inland aquatic ecosystems at a global scale are non-existent. This observational gap is determined by the high dynamic and optical complexity of water ecosystems, combined with technological challenges to optimise the relevant radiometric, spatial, spectral, and temporal sampling.

The object of this Working Group is to define requirements and main components for future satellite missions, that will dynamically measure coastal and inland aquatic ecosystems and allow advancing science of these ecosystems. A particular focus is on the consolidation of the scientific goals (related to Grand Challenges). The setting provided by ISSI was considered unique for gathering the required diverse expertise and discussing relevant questions including:
(i) the distribution and dynamic of phytoplankton stocks, diversity, productivity, and carbon fluxes in coastal and inland aquatic ecosystems
(ii) the state and expected trajectory of water quality on Earth and which types and concentrations of contaminants exist in coastal and inland waters and their aggregation zones
(iii) the requirements for a water mission to best serve aquatic science and contribute to addressing upcoming societal challenges, including biodiversity loss, water scarcity, and carbon and water cycling.

Complementing the scientific activities and achievements of earlier ISSI-WG's addressing the scientific aspects of physical Oceanography also in the coastal zone, this WG would specifically address biological and biochemical conditions of coastal and inland aquatic ecosystems.

From the 10th to the 12th of July 2023 the Working Group met for the first time with 16 participants, being convened by Astrid Bracher (Alfred Wegener Institute, Germany), Malik Chami (Sorbonne Université, France), Alexander Damm-Reiser (University of Zurich, Switzerland), Claudia Giardino (National Research Council -IREA, Italy), Daniel Odermatt (Eawag, Switzerland), Nicole Pinnel (DLR, Germany) and Michael Rast (ISSI, Switzerland).

During its first meeting the Working Group specifically addressed biogenic and carbon cycle related variables of coastal and inland waters, shallow habitats, benthic substrate and floating algae, but also atmospheric correction and aerosol optical properties, as well as multi-angular and polarimetric capabilities, on-board calibration concepts and validation strategies. The second and third meetings of the Working Group are planned to take place in 2024 and early 2025 respectively.

Michael Rast

Why Do We Still Have a "Coronal Heating Problem" 8 Decades After Edlen's 1943 Article?

Why, 80 years after Bengt Edlén's proof that the Sun's corona is hundreds of times hotter than the surface, do we still seek a clear solution to the coronal heating problem? Given the many potential explanations, the first goal of this ISSI Working Group of instrument builders, observers, spectroscopists, MHD and plasma physicists, numericists and theoretical physicists is to explore the nature of the problem, and to examine the strengths and weaknesses of the methods used to-date in attempts to solve it.

Exploring the anatomy of claimed solutions, the Working Group will consider aspects ranging from epistemology to MHD turbulence theory, instrument building to non-linear dynamics and emergent phenomena, and global topological constraints versus local equations of motion, as well as the usual host of more specific studies of coronal plasmas and their behaviour in relation to evolving magnetic fields, observationally and theoretically. Faced with a plethora of solar phenomena ("spicules", "loops", "flares", "nanojets", "prominences", ...), WG members will return to the observational and theoretical foundations of the behaviour of hydromagnetic and kinetic systems, in an attempt to see a mature, unsolved problem from the perspectives of scientists in multiple but related disciplines within physics. Refutation of hypotheses is seen as being of pressing importance, to attempt to clear the research landscape for progress to be made. Bayesian inference, which demands prior assumptions to be challenged with information-rich data, may help to avoid confirmation bias, and inconclusive or highly contingent results.

The coronal heating problem has three essential components: the modes of generation, propagation and irreversible dissipation of magnetic free energy. Of the 7 decades of scales between driving and dissipation, observations currently access just 3 (~100 - 0.2 Mm, the highest resolution coronal data come from instruments such as HiC and EUI on Solar Orbiter). The smaller scales (150 km to 10 m) span magneto-hydrodynamic scales to kinetic scales. Computationally, these regimes are being actively researched, although no convincing calculation spans the entire range. The journey from large scale driving to dissipation is not currently possible using direct numerical situations.

There is thus a need to identify and catalogue robust observational signatures of the response of coronal plasmas to evolving magnetic fields. This raises a multitude of questions: Is there definite evidence showing that resolved, measurable signatures of dynamic evolution (at scales >150 km) are related to the bulk of coronal heating? Flares can occur and yet vast volumes of the corona in the same active region usually show little change in heating. Is the corona instead heated steadily via unobservable small processes such as ion viscosity or wave-particle interactions? If irreversible processes occur on unobservable scales, how can we probe such mechanisms observationally? What is the role of waves, turbulence, and mode conversion in redistributing energy? How do we understand wave modalities in a heterogeneous plasma environment? Are obvious observed phenomena (e.g. spicules, jets, jetlets, etc.) important for coronal heating, or are these often subsonic, field-aligned flows which, like acoustic waves, carry too little energy to heat the plasma?

A similar need exists for robust signatures of theoretical mechanisms leading to irreversible heating. For example, are there elementary scales associated with dissipative structures? Do they carry characteristic magnetic and or dynamical signatures, such as line profile asymmetries and polarisation properties of instability-induced plasmoids? Are there direct signatures of kinetic processes? What kind of spectral line profiles are expected from MHD waves and turbulence under representative conditions of locally open and closed magnetic fields?

The first meeting was held on 6–10 November 2023 and was convened by Pallavi Bhat (ICTS Bangaluru, India), Philip Judge (HAO NCAR (*Working Group Chair*)); Charles Kankelborg (Montana State University), Rony Keppens (Katholic University Leuven) and Lucia Kleint (Universit Bern).

Philip Judge

Working Groups

Solar Forcings for CMIP 7

In preparation for the IPCC's 7th Assessment Report, climate modellers are performing global climate simulations coordinated by the Coupled Model Intercomparison Project (CMIP). Several of these climate models now require inputs that describe both the solar radiative forcing and the precipitation of energetic particles in the upper atmosphere.

In 2015, for the first time, an ISSI team produced a comprehensive dataset containing such radiative and particle forcings with different scenarios, allowing climate modelers to run their models from 1850 to 2300. This dataset was fed into CMIP6, which formed the basis of the IPCC first Working Group's 6th Assessment Report.

The CMIP7 Working Group aims to coordinate the preparation of these forcing datasets for the next CMIP7 project, starting in 2024. The 12-person team met for the first time in March 2024 to discuss existing datasets, find the best way to combine them, design future scenarios, agree on the methodology for prescribing ozone variability in a self-consistent way in climate models without interactive chemistry, and prepare meetings to gather community feedback. A first article has just been published (Funke et al., GMD (2023) doi:10.5194/gmd-2023-100) proposing a roadmap for the making of these forcing datasets. The team will meet again in 2024 to actually produce and validate these datasets.

The Working Group is convened by Bernd Funke (Instituto de Astrofísica de Andalucía, Granada, Spain), Dan Marsh (NCAR, Boulder, USA / University of Leeds, UK), Margit Haberreiter (PMOD-WRC, Davos, Switzerland) and Thierry Dudok de Wit (ISSI & Univ. of Orléans, France). The first meeting was held on 27–31 March 2023.

Thierry Dudok de Wit

Further Working Groups met in 2023

Their purposes are described in previous Annual Reports

Observing Photons in Space

Session at ISSI: 23–24 February 2023 (Editorial Meeting)

The Variability of the Airglow for the Detection of Atmospheric Dynamics

Sessions at ISSI: 8–11 May 2023 and 28 November – 1 December 2023

International Teams

International Teams consist of about 8–15 external scientists, addressing a specific scientific topic in a self-organised fashion, under the responsibility of a leader in a series of two to three one-week meetings over a period of 18 to 24 months. The results of these activities are customarily reported in scientific journals. The selection of International Teams results from an annual call issued in January and from the subsequent review and prioritisation done by the Science Committee.

Listed are Teams that had a meeting at ISSI in the period of the 28th business year. A rationale is given only for the Teams selected in 2022; for the others see the previous Annual Reports.

Teams selected in 2019

The Role of Partial Ionization in the Formation, Dynamics and Stability of Solar Prominences

Team leaders: José Luis Ballester and Manuel Luna, Universitat de les Illes Balears, Palma de Mallorca, Spain
Session: 12–16 June 2023

Tropical Width Impacts on the Stratosphere (TWIST)

Team leader: Sean Davis, NOAA, Boulder CO, USA
Session: 18–22 September 2023

Provenances of our Solar System's Relics

Team leaders: Maria Drozdovskaya, University of Bern, Switzerland, and Cyrienne Opitom, ESO, Santiago, Chile
Session: 16–20 January 2023

Exploring the Solar Wind in Regions Closer than ever Observed before

Team leader: Louise Harra, World Radiation Center, Davos Dorf, Switzerland
Session: 17–21 April 2023

What Determines the Dynamo Effectivity of Solar Active Regions?

Team leader: Kristof Petrovay, Eötvös Loránd University, Budapest, Hungary
Session: 10–14 July 2023

Cluster Physics from Space to Reveal Dark Matter: Current and Future Challenges

Team leader: Johan Richard, Université de Lyon, Saint Genis Laval, France
Session: 2–6 October 2023

Radiation Belt Physics from Top to Bottom: Combining Multipoint Satellite Observations and Data Assimilative Models to Determine the Interplay between Sources and Losses

Team leaders: Jean-François Ripoll, CEA/DAM/DIF, Arpajon, France, and Geoffrey Reeves, Los Alamos National Laboratory, USA
Session: 23–26 January 2023

A New Non-Equilibrium Model of "Iron Snow" in Planetary Cores

Team leaders: Tina Rückriemen-Bez, DLR, Berlin, Germany, and Chris Davies, University of Leeds, United Kingdom
Session: 8–12 May 2023

Understanding our Capabilities in Observing and Modeling Coronal Mass Ejections

Team leaders: Christine Verbeke, KU Leuven, Belgium, and Marilena Mierla, Royal Observatory of Belgium, Brussels, Belgium
Session: 30 January – 3 February 2023

The Identification and Classification of 3D Alfvén Resonances

Team leader: Andrew Wright, University of St Andrews, United Kingdom
Session: 14–18 August 2023

Deciphering Compositional Processes in Inner Airless Bodies of our Solar System

Team leader: Francesco Zambon, INAF, Rome, Italy
Session: 28 February – 3 March 2023

Teams selected in 2020

Effects of Solar Wind High-Speed Streams on the Ionosphere-Thermosphere System

Team Leaders: Anita Aikio, University of Oulu, Finland, and Aurélie Marchaudon, Université de Paul Sabatier, France
Session: 28 August – 1 September 2023

Langmuir Probes, a 100 Year Workhorse: Easy to Fly but Difficult to Interpret

Team Leader: Laila Andersson, University of Colorado, USA
Session: 15–19 May 2023

International Teams

Use of Geostationary Satellites to Improve Air Quality Characterization and Forecasts (ISSI – ISSI Beijing Team)
Team Leaders: Guy Brasseur, Max Planck Institute for Meteorology, Hamburg, Germany, and Claire Granier, NOAA, Toulouse, France
Session: 20–24 March 2023

SHoT: The Stellar Path to the Ho Tension in the Gaia, TESS, LSST and JWST Era
Team Leader: Gisella Clementini, INAF, Bologna, Italy
Sessions: 12–16 June and 4–7 December 2023

Data-driven 3D Modeling of Evolving and Eruptive Solar Active Region Coronae
Team Leaders: Georgios Chintzoglou, Lockheed Martin Solar and Astronphysics Lab, Palo Alto, USA, and Michael Wheatland, The University of Sydney, Australia
Session: 26–30 June 2023

The Earth's Exosphere and its Response to Space Weather
Team Leaders: Hyunju Kim Connor, University of Alaska, Fairbanks, USA, and Jochen Zoennchen, University of Bonn, Germany
Session: 9–13 October 2023

Feeding the Spinning Top – Spin Evolution of Accretion-Powered Pulsars in High-Mass X-Ray Binaries
Team Leader: Ilek El Mellah, KU Leuven, Belgium
Session: 3–7 July 2023

Time-Variable Gravity Field Modeling and Simulation from Present and Future Gravity Satellite Missions (ISSI – ISSI Beijing Team)
Team Leader: Wei Feng, Chinese Academy of Sciences, Hubei, China
Session: 26–29 June 2023

Advanced Three-Dimensional Modeling of the Magnetic Field in Active Regions on the Sun
Team Leader: Gregory D. Fleishman, New Jersey Institute of Technology, Newark, USA
Sessions: 17–21 April and 30 October – 3 November 2023

Stratospheric Age-of-Air: Reconciling Observations and Models
Team Leader: Hella Garny, DLR, Wessling, Germany
Session: 5–9 June 2023

Similarities and Differences in the Plasma at Comets and Mars
Team Leader: Charlotte Goetz, ESTEC, Noordwijk, The Netherlands
Session: 30 January – 3 February 2023

Towards Determining the Earth Energy Imbalance from Space
Team Leader: Margrit Haberreiter, World Radiation Center, Davos, Switzerland
Sessions: 2–4 May and 6–8 December 2023

Multi-Sensor Observations of Antarctic Sea Ice and its Snow Cover
Team Leaders: Petra Heil, University of Tasmania, Australia and Rachel Tilling, NASA Goddard Space Flight Center, Greenbelt, USA
Session: 19–23 June 2023

WaLSA: Waves in the Lower Solar Atmosphere at High Resolution
Team Leader: Peter Keys, Queen's University Belfast, United Kingdom
Session: 9–13 January 2023

Resolving the Generation Mechanisms and Electrodynamical Effects of Medium Scale Traveling Ionospheric Disturbances (MSTIDs)
Team Leaders: Jeffrey Klenzing, NASA Goddard Space Flight Center, Greenbelt, and Katherine Zawdie, US Naval Research Laboratory, Washington, USA
Session: 17–21 July 2023

The Life Cycle of Comets
Team Leader: Rosita Kokotanekova, European Southern Observatory (ESO), Garching, Germany
Sessions: 11–15 September and 18–22 December 2023

The Metal-THINGS Survey of Nearby Galaxies
Team Leader: Maritza Lara-Lopez, Universidad Complutense de Madrid, Spain
Session: 7–11 August 2023

Understanding Mesoscale Ionospheric Electrodynamics Using Regional Data Assimilation
Team Leader: Karl Magnus Laundal, University of Bergen, Norway
Sessions: 1–5 May and 2–6 October 2023

Strong Gravitational Lensing Studies with CSS-OS and EUCLID (ISSI – ISSI Beijing Team)
Team Leader: Ran Li, National Astronomical Observatories of China, Chinese Academy of Science, Beijing, China
Session at ISSI: *tbd*

Understanding Satellite, Aircraft, Balloon, and Ground-Based Composition Trends: Using Dynamical Coordinates for Consistent Analysis of UTLS Composition
Team Leader: Luis Millan, NASA Jet Propulsion Laboratory, Pasadena, USA
Session: 28 February – 3 March 2023

Multiwavelength View on Massive Stars in the Era of Multimessanger Astronomy
Team Leader: Lida Oskinova, University of Potsdam, Germany
Session: 17–21 November 2023

Unravelling Solar Wind Microphysics in the Inner Heliosphere
Team Leaders: Denise Perrone, Italian Space Agency, Rome, Italy, and Sergio Toledo-Redondo, Universidad de Murcia, Spain
Session: 15–19 May 2023

Mass Loss from Io's Unique Atmosphere: Do Volcanoes Really Control Jupiter's Magnetosphere?
Team Leader: Lorenz Roth, KTH Royal Institute of Technology, Stockholm, Sweden
Session: 11–15 September 2023

Coronal Dimmings and Their Relevance to the Physics of Solar and Stellar Coronal Mass Ejections
Team Leaders: Astrid Veronig, University of Graz, Austria and Karin Dissauer, NorthWest Res. Ass., Boulder, USA
Session: 1–5 May 2023

Towards a Unifying Model for Magnetic Depressions in Space Plasmas
Team Leader: Martin Volwerk, SRI, Austrian Academy of Sciences, Graz, Austria
Session: 24–28 July 2023

Molecular and Metallic Ions in the Magnetosphere
Team Leader: Masatoshi Yamauchi, Swedish Institute of Space Physics, Kiruna, Sweden
Session: 25–27 September 2023

Teams selected in 2021

Star Formation Within Evolving Galaxies: The Revolution of Upcoming Space Missions
Team Leader: Angela Adamo, Stockholm University, Sweden
Session: 28 August – 1 September 2023

Energy Partition Across Collisionless Shocks
Team Leader: Takanobu Amano, The University of Tokyo, Japan
Session: 19–23 June 2023

Revisiting Star Formation in the Era of Big Data
Team Leaders: Marc Audard, Université de Genève, Switerland and Odysseas Dionatos, University of Vienna, Austria
Sessions: 23–27 January 2023 and 16–19 October 2023

Geomagnetic Activity and Solar Cycle Dependence of Electromagnetic Ion Cyclotron (EMIC) Wave Activity and Wave Parameter in the Earth's Magnetosphere
Team Leaders: Remya Bhanu and Alexa J. Halford, NASA Goddard Space Flight Center, USA
Session: 24–28 July 2023

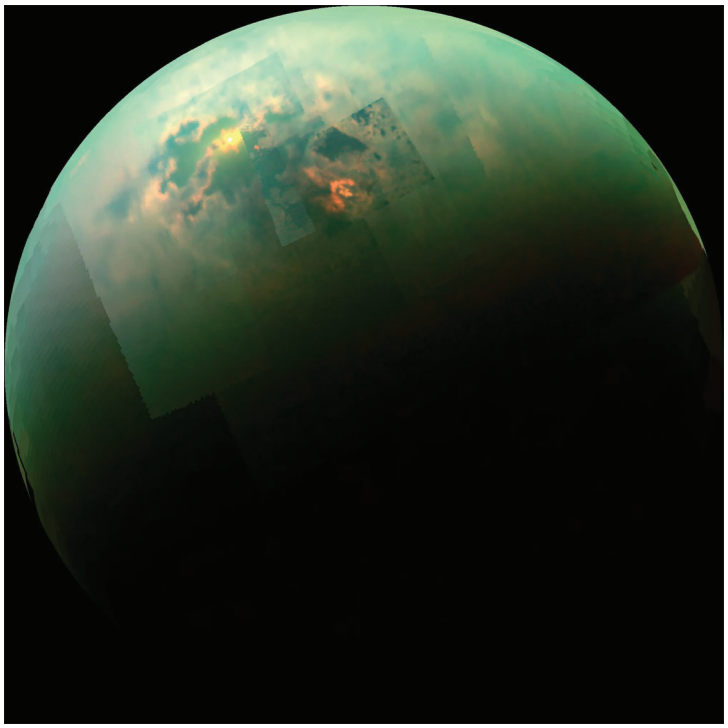
Imaging the Invisible: Unveiling the Global Structure of Earth's Dynamic Magnetosphere
Team Leader: Natalia Buzulukova, NASA Goddard Space Flight Center, USA
Session: 22–26 May 2023

Understanding the Connection Between Coastal Sea Level and Open Ocean Variability Through Space Observations
Team Leaders: Francisco Mir Calafat and Svetlana Jevrejeva, National Oceanography Centre, Liverpool, United Kingdom
Session: 13–16 March 2023

Thermophysical Characterization of Ice-Rich Areas on the Surface of Specific Planetary Bodies: Conditions for the Formation of a Transient Exosphere
Team Leader: Michelangelo Formisano, INAF, Rome, Italy
Session: *19–21 March 2024*

Bridging New X-ray Observations and Advanced Models of Flare Variability: A Key to Understanding the Fundamentals of Flare Energy Release
Team Leaders: Laura Hayes, Trinity College Dublin, Ireland and Andrew Inglis, NASA Goddard Space Flight Center, USA
Session: 6–10 March 2023

International Teams



This near-infrared, colour mosaic from the Cassini spacecraft shows the Sun glinting off of Titan's north polar seas. (Image Credit: NASA/JPL-Caltech/University of Arizona/University of Idaho)

How Heavy Elements Escape the Earth: Past, Present, and Implications to Habitability
Team Leaders: Raluca Ilie, University of Illinois at Urbana-Champaign, USA and Rona Oran, Massachusetts Institute of Technology, USA
Session: 3–7 July 2023

Heliospheric Energy Budget: From Kinetic Scales to Global Solar Wind Dynamics
Team Leaders: Maria Elena Innocenti, Ruhr Universität Bochum, Germany and Anna Tenerani, The University of Texas at Austin, USA
Session: 27–31 March 2023

Toward A 3-D Observation of the Ocean Color: Benefit of Lidar Technique (ISSI – ISSI Beijing Team)
Team Leaders: Cédric Jamet, Université du Littoral-Côte d'Opale, France and Davide Dionisi, CNR, Italy
Session: 26–28 September 2023

Understanding Interhemispheric Asymmetry in MIT Coupling
Team Leader: Hyomin Kim, New Jersey Institute of Technology, USA
Session: *7–10 October 2024*

Space Observations of Dwarf Galaxies from Deep Large Scale Surveys: The MATLAS Experience
Team Leader: Oliver Müller, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland
Session: 20–24 November 2023

Unraveling Surges: A Joint Perspective from Numerical Models, Observations, and Machine Learning
Team Leader: Daniel Nobrega-Siverio, Instituto de Astrofisica de Canaries (IAC), Spain
Session: 19–23 June 2023

Magnetotail Dipolarizations: Archimedes Force or Ideal Collapse?
Team Leader: Evgeny Panov, Austrian Academy of Sciences, Graz, Austria
Session: 22–26 May 2023

Ice Beyond Earth: Laboratory Investigations of Planetary Ices
Team Leader: Ganna Portyankina, University of Colorado in Boulder, USA
Session: 12–16 August 2023

The Habitability of Titan's Subsurface Water Ocean
Team Leaders: Christophe Sotin, Laboratoire de Planétologie et Géodynamique, France and Rosaly Lopes, NASA Jet Propulsion Laboratory, USA
Session: 16–20 January 2023

Distribution of Interstellar Neutral Hydrogen in the Sun's Neighborhood
Team Leader: Pawel Swaczyna, Princeton University, USA
Session: 9–13 October 2023

AsteroCatS – A Legacy Catalogue for Spectroscopic Surveys
Team Leaders: Marica Valentini and Guillaume Guiglion, Leibniz-Institut für Astrophysik Potsdam (AIP), Germany
Session: 6-10 February 2023

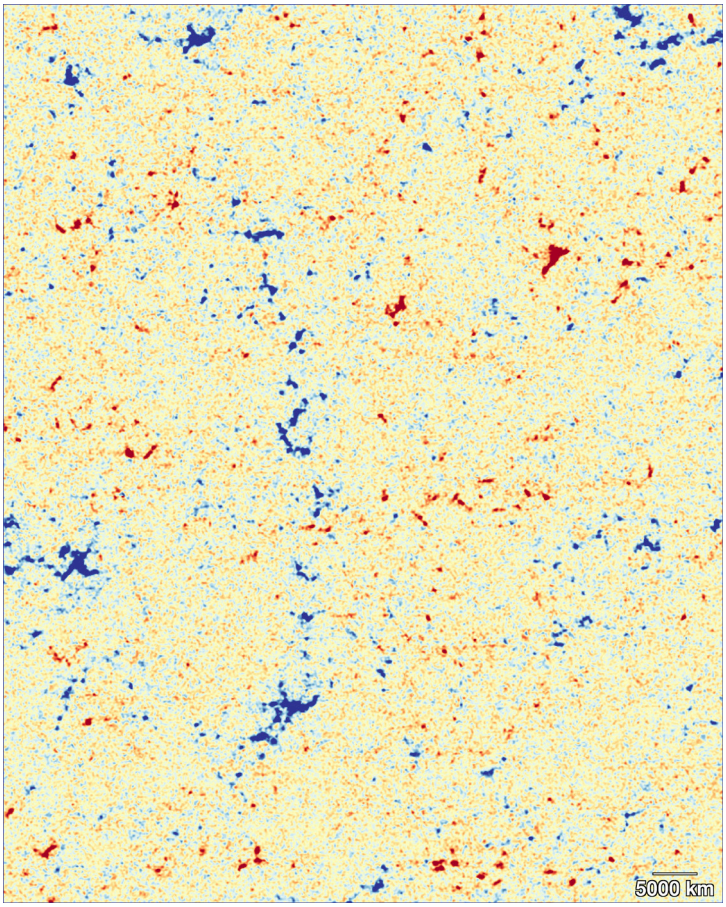
Teams selected in 2022

Impacts of Climate Change on the Middle and Upper Atmosphere and Atmospheric Drag of Space Objects

Team Leaders: Juan A. Añel, Universidade de Vigo, Spain and Ingrid Cnossen, British Antarctic Survey, United Kingdom

Session: January 9–13, 2023

Scientific Rationale: Evidence for the impacts of climate change on the middle and upper atmosphere is increasing, making clear the critical need for observational data to monitor and understand trends. For example, a contraction of the stratosphere has been quantified, but we still face significant limitations on the data available to assess it. Past efforts to study trends have focused mainly on the atmospheric levels separately (mesosphere, thermosphere, ionosphere), where cooling and contraction have also been observed. Monitoring these trends and their impacts on satellites and space debris needs a continued effort that provides better data and improved insight into the consequences that increased CO_2 has on the middle and upper atmosphere. Therefore, the goals are to evaluate the existing data gaps to monitor trends in the middle and upper atmosphere, improve the situation regarding data availability, make recommendations on existing needs to study such trends and assess their impact on the drag of space objects. The Team brings together scientists in different stages of their research careers, representing thirteen institutions and the private sector from seven countries, and multidisciplinary expertise.



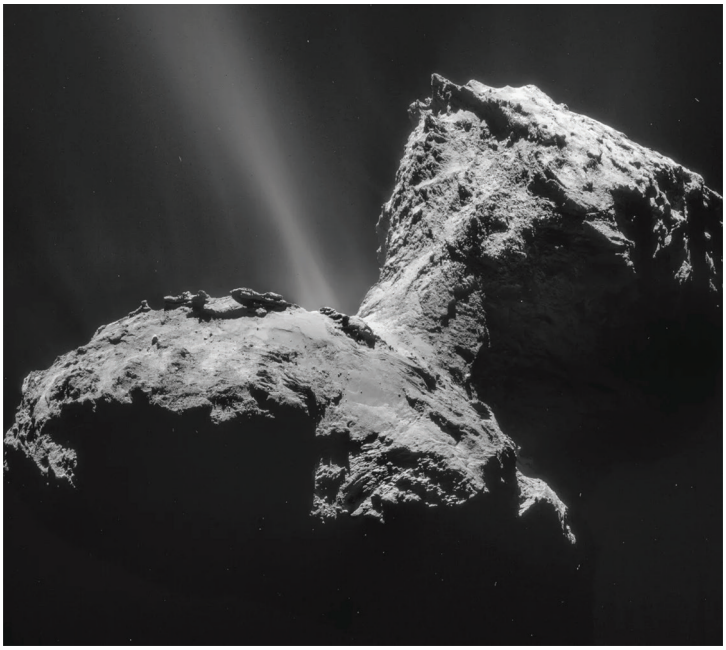
The image comes from the Polarimetric and Helioseismic Imager (PHI), and reveals the magnetic polarity of the solar surface. The red and blue shaded regions represent patches of north and south magnetic polarities. (Image Credit: ESA & NASA/ Solar Orbiter, PHI team)

Observe Local Think Global: What Solar Observations can teach us about Multiphase Plasmas across Astrophysical Scales

Team Leaders: Patrick Antolin, Northumbria University, United Kingdom and Clara Froment, CNRS, Univ. Orléans, France

Session: March 13–17, 2023

Scientific Rationale: Cool plasmas (mostly at ~10^4 K) embedded in a larger, much hotter (generally >10^6 K) medium are ubiquitous in different astrophysical systems such as solar and stellar coronae, the circumgalactic (CGM), interstellar (ISM) and intra-cluster (ICM) media. The role of these multiphase plasmas has been highlighted in mass and energy cycles at all such scales, from thermal non-equilibrium (TNE) cycles in the solar atmosphere to precipitation-regulated feedback cycles that drive star and galaxy formation. The properties of the cool plasmas across these multiple scales are strikingly similar, intimately linked to the yet unclear but fundamental mechanisms of coronal and ICM heating and instabilities of thermal or other nature. Being so close and governed by small timescales, the solar corona constitutes a formidable astrophysics laboratory where we can spatially and temporally resolve the physics of producing and removing such multiphase plasma. The multi-faceted response of the solar atmosphere to the heating, best exemplified by TNE cycles that manifest through puzzlingly week-long EUV intensity pulsations despite the stochastic nature of the solar atmosphere, are now recognised as a major solar conundrum. At small (~100 km) scales, the solar atmospheric response comes through the generation of cool coronal rain, the seed of prominences, whose mysterious properties are similar to those of multiphase filamentary structure in the ISM and ICM or to molecular loops in the Galactic centre. Coronal rain also occurs across a wide energetic scale extending to flares. However, flare-driven rain, whose features seem recurrent in active stars, is often ignored and is not understood despite its signifi-



Comet 67P/Churyumov-Gerasimenko (Image Credit: ESA/Rosetta/NAVCAM – CC BY-SA IGO 3.0)

cant energy budget. The formation and destruction of coronal rain and prominences have recently received further attention in stellar evolution, owing to their potentially significant contribution and diagnostic capabilities to the otherwise unknown wind mass-loss rate. While the quantity and morphology of the cool plasma in the solar atmosphere are now known to be closely linked to the properties of coronal heating, the theoretical investigation of multiphase gas is far ahead in the ISM/ICM. These results therefore provide a new perspective and strong new constraints on the mass and energy transfer in the solar corona. Furthermore, they provide unique cross-disciplinary opportunities for knowledge transfer offered by the multi-scale and multi-energetic manifestation of cool plasma across the Universe. With the help of the advanced theoretical knowledge from the ISM and ICM fields, this Team will use the models from the extragalactic community and test them on the high-resolution solar observations to investigate the role of multiphase plasma in the establishment of the solar atmospheric mass and energy cycle. In turn, the understanding achieved will be applied to the larger unresolved scales.

Magnetohydrodynamic Surface Waves at Earth's Magnetosphere (and Beyond)

Team Leaders: Martin Archer, Imperial College London, United Kingdom and Katariina Nykyri, Embry-Riddle Aeronautical University, USA

Session: March 27–31, 2023

Scientific Rationale: Surface waves act as an efficient mechanism for filtering, accumulating, and guiding turbulent disturbances in space plasmas, controlling the global dynamics of Earth's magnetosphere and other systems. They can affect plasma transport and dynamics of both thermal plasma and high-energy particles, thus having a major impact on the magnetospheric mass and energy budget. Despite several recent high-impact discoveries of magnetopause and plasmapause surface modes, these have been limited case studies and the work of disparate groups. The Team brings together researchers with expertise spanning theory, simulations, and observations to address key challenges to understanding how surface wave physics mediates the solar-wind–magnetosphere–ionosphere dynamical coupling. This Team will:

1. Consolidate current surface wave theory, simulations, and observations into a comprehensive review.
2. Simulate the global dynamics due to surface waves and predict potential observational signatures.
3. Test these predictions for a variety of driving events to assess occurrence rates, properties and impacts.
4. Identify missing links and technology gaps needed for future missions to address unresolved questions.

This work significantly advances our fundamental understanding of surface waves in complex space plasma systems and their importance in the global mass, energy, and momentum transfer.

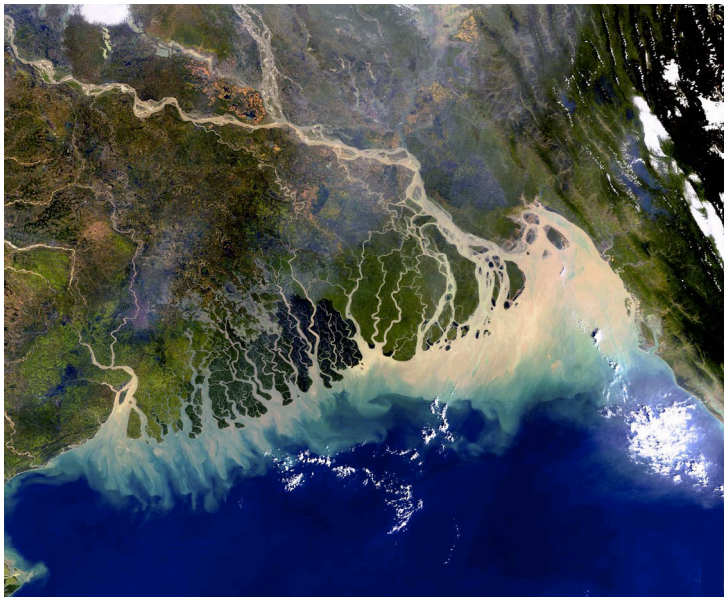
Understanding the Activity of Comets Through 67P's Dynamics

Team Leader: Nicolas Attree, Technische Universität Braunschweig, Germany

Session: February 6–10, 2023

Scientific Rationale: Comets, thought to be amongst the most primordial of Solar System objects, are distinguished by their activity, i.e. the insolation-driven ejection of gas and dust from their surfaces. The exact mechanisms of the outgassing and dust ejection remain as an important open question in planetary science, relating as they do to the structure, composition, and thermophysical properties of the surface material. A directly observable effect of the activity is the resultant non-gravitational force and torque on the cometary nucleus, which can alter its trajectory and rotation state. Understanding the effect of non-gravitational forces on the dynamics of a particular comet therefore gives us a powerful tool to investigate its activity and surface properties.

In this context, the detailed measurements made by ESA's Rosetta mission at comet 67P/Churyumov-Gerasimenko provide a unique opportunity to discern a ground-truth for models of both non-gravitational acceleration (NGA) and torque (NGT), and outgassing activity. Rosetta collected data at 67P from 2014 to 2016, whilst spacecraft radio tracking combined with optical navigation allowed the comet's position to be measured with unprecedented precision. Initially, the comet's trajectory was reconstructed without taking the NGA into account, resulting in discontinuities in the reconstruction and hampering the extraction of the acceleration. Recent work, however, has improved the situation, and it is now possible to extract time-varying curves of the outgassing induced NGA directly from the trajectory. Alongside this, tracking of the nucleus orientation allows a measurement of the outgassing-induced torque, while Rosetta's in-situ instruments have measured the total outgassing rate itself. Together, these data provide significant constraints on both the distribution of activity over 67P's surface, and the activity mechanism itself.
This Team brings together international experts in spacecraft trajectory analysis with those in modelling and observations of cometary activity, in order to better understand the non-gravitational forces present at 67P and their implications for its activity pattern. The use of the Rosetta data will result in the output of new scientific knowledge regarding cometary activity in general, which will be relevant for the next generation of missions such as Comet Interceptor.



A colourful view of the Bangladesh coastline seen by Envisat's Medium Resolution Imaging Spectrometer (MERIS) (Image Credit: ESA).

Past, Present and Future of the Asian Mega-Deltas: The Role of Space Observations

Team Leaders: Mélanie Becker, CNRS - Université de La Rochelle, France and Marta Marcos, University of the Balearic Islands, Spain
Sessions: January 17–20 and October 17–20, 2023
Scientific Rationale: More than 250 million people live in Asian deltas, a region recognised as highly vulnerable to the impacts of climate change. The situation of South and Southeast Asian deltas is especially uncertain, regarding the rates of sea level rise, subsidence, shoreline recession, sediment starvation and extreme meteorological events, combined with rapidly growing populations. There are many obstacles to understanding the dynamics of these complex systems: i) a lack of traditional in-situ measurements and difficulty accessing the Asian deltas for managing and instrumenting them; ii) a low level of cross-disciplinary scientific production, which does not allow an integrated approach to these systems; and iii) a complex interplay of different processes over extremely broad spatial and temporal scales. Consequently, in face of ongoing climate changes, there are urgent needs for additional observations, in particular from space, and interdisciplinary researches in order to better understand the deltas' dynamics and to provide reliable information to improve their sustainability.
This project aims to: 1) provide the state of the art on the processes governing the Asian deltas dynamics, to clarify observational and modelling requirements necessary for addressing key scientific questions and elaborate a framework for integrated analysis of the delta evolution; 2) gather and assess existing and available datasets from different Earth observing systems (both in-situ and from remote sensing) as well as modelling results and projections, considering the main components in Asian delta dynamics (i.e. sea level changes, land vertical movements, extreme of sea level, sediment dynamics, exposure); and 3) understand and try to reduce the wide range of component uncertainties and express the integrated impacts on the Asian deltas in terms of flooded area changes and exposed populations.

Planetary Acoustics: A Brand New Sense with which to Explore Atmospheres in our Solar System (ISSI – ISSI Beijing Team)

Team Leader: Baptiste Chide, Los Alamos National Laboratory (LANL), USA
Session: February 20–23, 2023
Scientific Rationale: After more than 60 years of planetary exploration, the very first sounds from Mars were recorded very recently by the two microphones onboard the NASA Perseverance rover. A few months later, the

CNSA Zhurong rover also landed with a microphone, showing the rising interest in acoustics for the exploration of Mars. Besides Mars, the use of acoustic is even more favourable on denser atmospheres like Venus and Titan, as will be experienced by the Dragonfly's microphones heading to Titan in the 2030's and the acoustic projects under study for Venus. Indeed, acoustic can provide key insights to understand interactions planetary surfaces and atmosphere.

This growing interest by planetary scientists complements a decade of increasing interest by terrestrial acousticians, who have been conducting theoretical studies on what might be gained from planetary acoustics and how this might be achieved. Unless these two communities are brought together to strategize, opportunities will be wasted through sub-optimally-designed planetary experiments, and the ambitions of both communities will not be realised. The Team here is to bring them together and build a planetary acoustic community, which does not exist so far. The Team will therefore dedicate its efforts to adapting acoustic methods commonly used on Earth to extraterrestrial atmospheres, and thus to promote the potential of acoustics for the exploration of the Solar System. This Team gathers planetary scientists, acousticians and instrument scientists with the ambition to draw the roadmap of planetary acoustics for the coming decades.

Solar Sources and Evolution of the Alfvénic Slow Wind

Team Leaders: Raffaella D'Amicis, National Institute for Astrophysics (INAF), Italy and Marco Velli, University of California, USA

Session: February 13–17, 2023

Scientific Rationale: The goal is to advance our current understanding of the origin and evolution of different solar wind stream types, with particular reference to Alfvénic slow wind streams. Such streams are characterised by a state of turbulence that, though well described by an inertial range power law, shows the correlated magnetic and velocity field fluctuations typical of Alfvén waves propagating away from the Sun. Such Alfvénic turbulence is usually seen in high-speed solar wind streams. Alfvénic slow streams, first seen by Helios at a heliocentric distance of 0.29 AU, were considered to be rare peculiar flows until measurements at Lagrangian point L1 during solar maximum revealed a statistically significant occurrence of such streams. Alfvénic slow wind shares several other properties with high speed streams, such as pronounced differential speeds between proton and alpha particles and large proton temperature anisotropies. Recent studies reveal that Alfvénic slow wind arises, as its fast counterpart, from open field regions, or coronal holes. Alfvénic slow wind, however, appears to undergo strong super-radial expansion in the corona, originating from very narrow equatorial extensions of polar coronal holes and/or isolated low latitude coronal holes with very small area at the Sun. Recent observations by Parker Solar Probe (PSP), carried out just as we exit the last solar minimum, have shown persistent Alfvénic slow wind streams throughout all perihelion passages, suggesting that Alfvénic fluctuations might dominate the nascent solar winds quite generally except for the immediate surroundings of the heliospheric current sheet. However, if both fast and slow wind originate from open field regions, then something must account for the difference in speed. The study of this solar wind regime may thus provide a better understanding of the origin and acceleration of the solar wind in general.

Future Missions to Uranus and Neptune: Prospects for Non-Planetary Science

Team Leaders: Daniel D'Orazio, Niels Bohr International Academy, Denmark and Prasenjit Saha, University of Zurich, Switzerland

Session: May 8–12, 2023

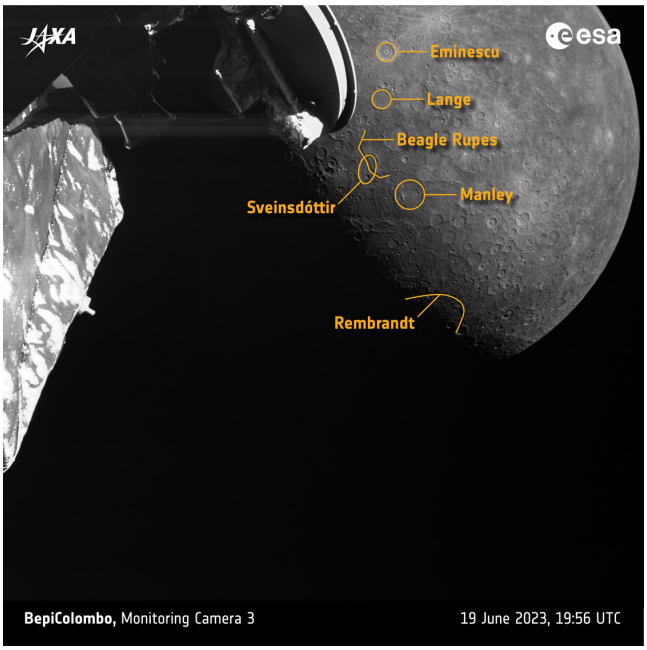
Scientific Rationale: The giant planets within our Solar System present an exceptional opportunity for studying the physics of high-pressure, rotating convective systems with density and compositional variations. Among them, Jupiter and Saturn have been relatively well studied compared to the more distant Uranus and Neptune, which remain the least explored Solar System planets to this day, having been visited only once by the Voyager II spacecraft in late 1980s. These missions are not only significant for planetary science, but also an exceptional opportunity for exploiting the non-planetary science potential of the spacecraft, thanks to long spacecraft cruise periods and travel distances. Radio communication between Earth and two distant spacecraft presents a unique case for investigating various phenomena via Doppler tracking, with which we can measure variations in the light travel time between Earth and the spacecraft and deviations in the spacecraft trajectory as it travels to the outer planets. Measurements of the Doppler signal can allow us to utilise the ~10 year travel time of these missions to constrain the dark matter content in the Solar System, discover exoplanets around compact binaries in the Milky way, and detect low-frequency gravitational waves from supermassive black hole systems at cosmological distances.

The Team explores the full non-planetary science potential of prospective Uranus and Neptune missions that will be launched in the upcoming decade. It will set a benchmark for the technology required for detections of various astrophysical observables. To this end the Team will (i)

develop an extensive black hole binary population model to estimate the number of expected detections, (ii) focus on the engineering challenges in regard to both spacecraft and antenna technology, as well as noise modeling, and (iii) investigate the capability of the missions to detect long-period exoplanets and to constrain the local dark matter abundance.

Wide-Ranging Characterization of Explosive Volcanism on Mercury: Origin, Properties, and Modifications of Pyroclastic Deposits

Team Leader: Anna Galiano, INAF-IAPS Institute for Space Astrophysics and Planetology, Italy
Session: no meetings in 2023
Scientific Rationale: The detection of pyroclastic deposits on Mercury provides unexpected evidence for the existence of volatiles in the planet, as these volatiles were required to drive the explosive paroxysm of magma particles. Pyroclastic deposits on Mercury have a higher albedo and a redder spectral slope than the surrounding terrains, with a drop in reflectance in the UV spectral range. More than 200 pyroclastic deposits were found on Mercury and our recent approach allowed the identification of potential new candidates. Despite their importance for understanding the interior evolution of Mercury, many open questions still remain, including their mineralogical composition, granulometry, age, evolution and the nature of the volcanic gases responsible for the eruptions. The investigation of pyroclastic deposits is a critical tool for determining the magma's composition, and to understand the thermal evolution of Mercury. This Team will execute an in-depth analysis of pyroclastic deposits by combining morphological, topographical, spectral, and elemental examinations using data from several instruments onboard the MESSENGER spacecraft, i.e. images from MDIS, spectra from MASCS, and topographical data from MLA. The remote-sensing data analysis will be applied both to pyroclastic deposits identified in the literature and to the new potential candidates and will be supported by laboratory experiments and spectral modelling in order to assess the mineralogical composition, physical properties, origin and evolution of the explosive eruptions on Mercury. Such an effort will be addressed by the Team's interdisciplinary expertise in remote-sensing imaging spectroscopy, volcanism, laboratory spectroscopy and modelling, morphology and topography. The results of the analysis proposed in this project will reveal potential targets for a detailed examination by the future ESA/JAXA BepiColombo mission. Indeed, the synergistic approach will be an important input for the implementation of high-quality observations performed by the instruments on board BepiColombo, that will study Mercury beginning in 2026. The

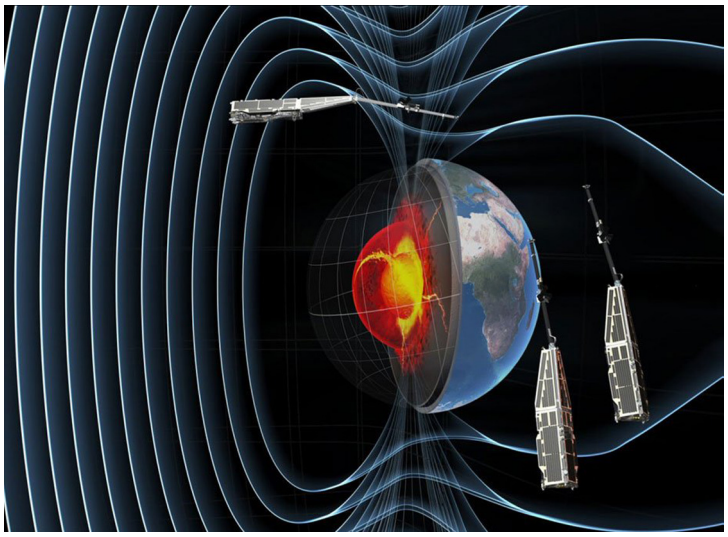


A bounty of geological features, including the newly named Manley impact crater, are visible in this image of Mercury taken by the ESA/JAXA BepiColombo mission on 19 June 2023 as the spacecraft sped by for its third of three gravity assist manoeuvres at the planet. (Image Credit: ESA/BepiColombo/MTM)

Team involves members with a broad knowledge of Mercury and the MESSENGER dataset, who are part of the BepiColombo team, and some of whom have direct access to laboratory facilities.

CSES and Swarm Investigation of the Generation Mechanisms of Low Latitude Pi2 Waves

Team Leaders: Essam Ghamry, National Research Institute of Astronomy and Geophysics, Arab Republic of Egypt and Zeren Zhima, National Institute of Natural Hazards, MEMC, China
Session: September 4–8, 2023
Scientific Rationale: It is known that Ultra Low Frequency (ULF) waves are common phenomena observed in Earth's magnetosphere and transmitted from the magnetosphere to the top-side ionosphere. ULF waves have been recognised to play an important role in magnetospheric plasma energisation/loss and energy transfer from the solar wind to Earth's magnetosphere and ionosphere. Among them, Pi2 ULF waves, with periods of 40–150 s can be observed at different radial distances from Earth's surface by ground stations and satellite missions.
High-sampling-rate magnetic measurements by low Earth orbit (LEO) satellites enable scientists to detect Pi2 ULF waves in the top-side ionosphere region, which



In November 2023, Swarm celebrated ten years in orbit. The three-satellite constellation has been a game changer for scientists, providing measurements of Earth's magnetic field with unprecedented accuracy. (Image Credit: ESA/ AOES Medialab SA)

remains extensively unexplored. The accuracy and high resolution of magnetic field measurements from the China Seismo-Electromagnetic Satellite (CSES) potentially allow us to clearly detect Pi2 pulsations in the ionosphere. These kinds of pulsations are commonly observed during the onset phase of a substorm expansion, when the configuration of the magnetosphere is changed and the substorm current wedge (SCW) is formed. Since Pi2 pulsations serve as an important ingredient in understanding the complicated electrodynamic techniques within the magnetosphere and the magnetosphere-ionosphere coupling, an investigation of Pi2 generation and propagation during substorms requires a comprehensive study.

The spatial structure and propagation characteristics are important for understanding the generation mechanisms of Pi2 ULF waves. This project aims to understand the spatial features of low-latitude Pi2 pulsations with a comprehensive study that will be carried out for the first time using magnetic field measurements from the newly launched CSES satellite, operating since February 2018, integrated with the three-satellite Swarm constellation launched in November 2013. Both missions, operating simultaneously at four different orbits and three altitudes, will provide a good opportunity to investigate for distinctive Pi2 signatures in the ionosphere, combined with solar wind data and geomagnetic activity indices (Dst, AE, SML and Kp) as well as the ground-based observations (INTERMAGNET, SuperMAG networks, and SuperDARN coherent scatter radars).

A Framework for Improving All-Weather Visible and Near-Infrared Satellite Data Assimilation

Team Leaders: Benjamin Johnson, UCAR/JCSDA, USA and Angela Benedetti, ECMWF, United Kingdom

Session: April 25–27, 2023

Scientific Rationale: Successful weather forecasts start from accurate estimates of the current state of the Earth system. Cloud-affected satellite radiance observations have been at the forefront of recent advances in data assimilation (DA) at many operational centres. Prior efforts in cloud-affected (or all-sky) DA have focused primarily on microwave (MW) satellite observations and on surface properties such as soil moisture, sea surface salinity, wind speed, snow cover, and sea-ice extent. As computational capabilities have increased, so has the capability to incorporate additional shorter wavelengths in DA systems, such as infrared (IR) and visible satellite radiances. Cloudy radiances in the visible and near-IR contain a wealth of information on clouds at much higher spatial and temporal resolution than microwave observations, but have never been assimilated in global operational numerical weather prediction (NWP) models as they pose many challenges. The reason lies in the fact that solar radiation originates from a single source in the sky, rather than purely thermal emission as is the case for IR and MW. This makes visible radiances much more sensitive to the solar source and the details of the optical properties of atmospheric constituents. Also, scattering, including multiple scattering, is much more important at visible frequencies. These effects significantly add to the computational cost of radiative transfer models used to convert model profiles of atmospheric and surface properties into radiances for comparing with the observed values. At present, there are three primary operational radiative transfer models (aka "forward and adjoint satellite operators"): The RTTOV model, used widely among European operational centres and their international partners; The CRTM model, which is mostly employed at operational and research centres within the United States; and the more recent ARMS model, closely related to CRTM, used within China. While each of these models are capable of simulating visible radiances, these calculations are computationally expensive compared to MW and IR. Furthermore, very few studies to date have fully exercised these models within a visible radiance assimilation context. The Team members seek to answer the following question: given recent advances in computational availability and improved visible radiance solvers, can the extant challenges now be solved or reduced, enabling the user community to benefit from the high spatial-temporal resolution of information available from visible sensors?

Impact of Upstream Mesoscale Transients on the Near-Earth Environment (ISSI – ISSI Beijing Team)

Team Leaders: Primoz Kajdic, Universidad Nacional Autónoma de México (UNAM), Mexico and Xochitl Blanco-Cano, Ciudad Universitaria, Mexico

Session: February 20-24, 2023

Scientific Rationale: One of the outstanding questions in the field of solar-terrestrial relations concerns how the solar wind transfers energy, momentum and mass into our planet's magnetosphere. This transfer leads to magnetospheric and ionospheric disturbances that form part of the phenomena known as space weather. Some of them may interrupt the proper functioning of our technological systems, such as electric grids, GPS signals and artificial satellites.

One transfer mechanism involves the formation of transient upstream mesoscale phenomena. These are magnetic and plasma structures with sizes up to a few tens of Earth Radi and with durations of up to several tens of minutes in the spacecraft data. It has been shown in the past that these structures may cause displacements of the magnetopause and are a source of certain magnetospheric waves. They have been shown to interact with the bow-shock, modify the magnetosheath, distort the magnetopause, trigger magnetopause reconnection and contribute to radiation belt diffusion, but the details about how this occurs are still largely unknown.

The Team consists of scientists who specialise in processes in the near-Earth environment (foreshock, bow-shock, magnetosheath, magnetosphere, ionosphere). It aims to quantify how the upstream mesoscale structures get transmitted across the bow-shock into the magnetosheath and how they impact the magnetosphere. The Team uses spacecraft in-situ measurements, ground-based data and global and local hybrid numerical models in order to answer some of the open questions, such as: How do the upstream transients interact with the bow-shock and what are the consequences of these interactions for the magnetosheath? What and how significant are the impacts of the various mesoscale structures on the magnetosphere and the ionosphere?

Cross-Scale Energy Transfer in Space Plasmas

Team Leaders: Rungployphan Kieokaew, Recherche en Astrophysique et Planétologie (IRAP), France and Yan Yang, University of Delaware, USA

Session: February 6-10, 2023

Scientific Rationale: How plasmas process and transport energy between large and small scales, eventually dissipating it to heat surrounding environments, is one of the most compelling problems in space and astrophysical plasmas. The underlying processes driving this transport and dissipation are fundamentally multi-scale in nature. At large scales, plasmas behave as conducting fluids and are described using magnetohydrodynamics (MHD). At small scales, they behave kinetically where the dynamics of ions and electrons become essential. Near-Earth space plasmas are the most accessible natural laboratories where the physics at work can be probed in situ. Multi-spacecraft missions with four identical satellites, forming a tetrahedral configuration in space, namely ESA's Cluster and NASA's Magnetospheric Multiscale (MMS), have been valuable tools to investigate the spatial structure of plasma processes.

Cluster and MMS allow us to probe plasmas at a single scale; however, energy transfer is inherently a cross-scale process where the electromagnetic and flow energy, contained at large scales, cascades to smaller scales before eventually dissipating into heat. To address such a problem, simultaneous observations of plasmas across multiple scales are critically needed. The community is now progressing towards a larger constellation of satellites to probe plasmas at multiple scales simultaneously. HelioSwarm (HS), consisting of 9 spacecraft, is such a mission recently selected by NASA to be launched in 2028.

The knowledge of energy transfer in turbulent plasmas is now rapidly evolving as driven by new high-resolution observations by Solar Orbiter, Parker Solar Probe, and MMS. Meanwhile, all the formulations have not been carefully applied and systematically compared, leading to misleading or incomplete conclusions. There is an urgent need in the community to step back and review formulations in order to facilitate the discussion of the energy transfer problems and the comparison of the relative importance of various processes. This project will help identify gaps and development needs in order to maximise the scientific returns of future cross-scale spacecraft constellations such as HelioSwarm.

Beam Plasma Interaction in the Solar Wind and the Generation of Type III Radio Bursts

Team Leader: Vladimir Krasnosselskikh, Université d'Orléans, CNRS, France

Session: Feburary 13-17, 2023

Scientific Rationale: Solar Type III radio bursts are amongst the strongest radio emissions within the Solar System. These intense radio signals are generated by energetic electrons, accelerated in the solar atmosphere and ejected into interplanetary space. The process of generation of radio waves occurs in two steps. First, the two-stream instability of an electron beam results in the growth of electrostatic (ES) Langmuir waves that later produce electromagnetic (EM) emission at the plasma frequency due to the scattering by plasma ions or to some nonlinear process while the coalescence of two Langmuir waves

can produce the harmonic emission. Analysis of electric field measurements on board satellites led to the understanding of the important role of the density fluctuations on the beam plasma interaction and the waves' generation. Recently new advances in experimental studies of waves in Type III solar radio burst source regions have been achieved thanks to important improvements in the ability to record long time series of electric field data. These time series, recorded by the Wind, STEREO Parker Solar Probe and Solar Orbiter spacecraft, provided a rich collection of Langmuir and Z-mode wave signals for analysis. Recent theoretical studies, modelling and computer simulations of the beam plasma interaction in randomly inhomogeneous plasmas also showed that they may strongly affect the beam plasma interaction, resulting in significant decrease of the wave activity, increase of the beam relaxation length and transfer of a significant part of the wave energy to energetic particles leading to the formation of a tail of energetic electrons. Another important advance is related to the increase of the time and frequency resolution of instruments on board satellites. It allowed the establishment and observation of the fine structure of the type III bursts' spectra. This important characteristic is often present in many type III bursts in different frequency ranges and is called striae. Theoretical modelling aiming to explain this feature shows that its characteristics are also related to the density fluctuations in the corona and solar wind. This Team will discuss new open questions arising from recent satellite observations, and synthesise our current understanding of the topic in a review article.

Transformation of Planetary Systems by Environmental Perturbations

Team Leader: J. M. Diederik Kruijssen, Heidelberg University, Germany

Session: February 27 – March 3, 2023

Scientific Rationale: Planetary systems are generally described as isolated systems, containing the host star and the orbiting planetary bodies. Recent observational and theoretical work has demonstrated that the architectures of planetary systems can be completely transformed by environmental perturbations, such as passing stars, binary interactions, or Galactic tides. Architectures of planetary systems with ages up to several Gyr are observed to correlate with their stellar-dynamical environment. This discovery has existential implications: if the stellar environment destabilises and transforms planetary systems, this presents a new and fundamental axis for planetary system evolution and habitability. The key questions are now: precisely through what physical mechanism does the environment perturb planetary systems? How are the planetary systems impacted? And over what timescales does this transformation take place? Addressing these questions requires combining expertise in (1) the dynamical modelling of planetary system perturbations, (2) the characterisation of the degree of perturbation in both modelled and observed planetary systems, and (3) the detailed characterisation of the stellar-dynamical environment in which planetary systems are evolving. This interdisciplinary connects all of these areas, with a view to building a framework for the interpretation of Gaia and PLATO systems, and aid the target selection of the next generation of major space missions in this area, such as Ariel.

Improving the Description of Exosphere Surface Interface

Team Leaders: François Leblanc, CNRS/IPSL, France and Menelaos Sarantos, NASA Goddard Space Flight Center, USA

Session: January 30 – February 3, 2023

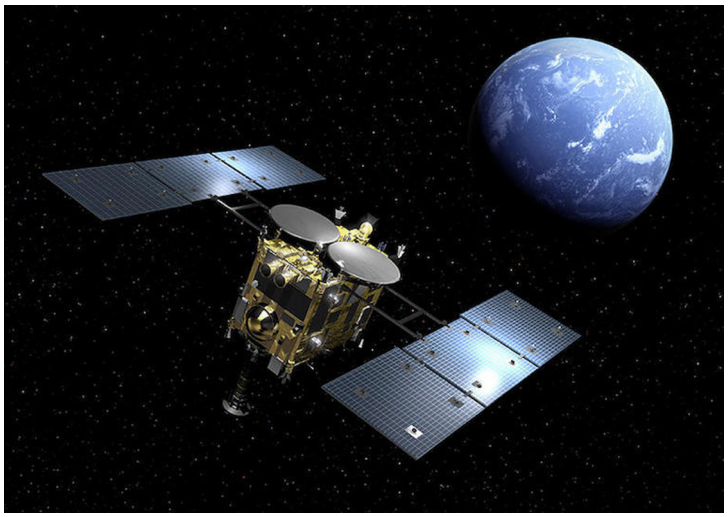
Scientific Rationale: When meteoroids, solar radiation and solar wind impact onto the surfaces of Mercury and the Moon, they can release many volatile species, producing weak atmospheres – surface bounded exospheres – in the process. Recent measurements (e.g., LADEE, LRO, MESSENGER, Chandrayaan-1 and ground-based observations) provided evidence of atmospheric variation with local time. Other measurements suggest variations of adsorbed water on the lunar surface with local time. These measurements indicate the necessity of considering how gases interact with the uppermost surface on a microphysical scale if we wish to understand macroscopic exospheric processes. For instance, lunar volatiles (e.g., argon and methane), which freeze out at night, do not sharply outgas at sunrise. Methane itself peaks about one hour of local time past the dawn terminator, and recent analysis of the NASA MESSENGER mission and ground-based dataset have revealed a curious cycle of sodium, with periodic afternoon enhancements of exospheric sodium that current models cannot explain. This multi-disciplinary Team creates higher-fidelity physical models of gas trapping within the first top few centimetres of soil, and of how this trapping produces complex feedback cycles observed in the atmosphere. The work combines data from both laboratory and spacecraft measurements with diverse modelling efforts that interconnect the surface and atmosphere.

Turbulence at the Edge of the Solar Corona: Constraining Available Theories Using the Latest Parker Solar Probe Measurements

Team Leader: Norbert Magyar, KU Leuven, Belgium
Session: September 4–8, 2023
Scientific Rationale: On the 28th of April 2021, for the first time in the history of human space exploration, a satellite entered the magnetically-dominated solar atmosphere, the solar corona. Since then, direct in-situ measurements of the turbulent magnetic and velocity fluctuations have been available around the critical Alfvén point, at which the flow of the solar wind becomes super-Alfvénic. One of the leading explanations for the 80-year-old mystery of how the solar corona is heated to multi-million degrees K is the turbulence of the coronal plasma, cascading wave energy to the smallest scales where it can be efficiently thermalised. Several theoretical and numerical works aim to address the dynamical details of how turbulence evolves in the coronal plasma, leading to different predictions of the nature of turbulence, for example what happens at or around the critical Alfvén point. Within this project, predictions of available theoretical models of what turbulence should look like at the outer edge of the solar corona will be compared to the latest measurements by Parker Solar Probe, by a Team including leading observational, theoretical, and numerical experts in the field.

Timing and Processes of Planetesimal Formation and Evolution (ISSI – ISSI Beijing Team)

Team Leader: Wladimir Neumann, Technical University Berlin, Germany
Session: March 20–23, 2023
Scientific Rationale: Accretion processes in protoplanetary discs produce a diversity of small bodies that contribute to the composition of planets and can survive as asteroids or comets. There is a predominant paradigm that small bodies played a crucial role in potentially multiple reshuffling events throughout the Solar System and in both early and late accretion of terrestrial planets. Despite a high scientific attention paid to these bodies, their early evolution is not well understood, in particular, the timescales of accretion and thermal processes at different heliocentric distances, as well as the nature of planetesimal populations that produced various groups of present planetary objects.
Both meteorite analyses and space missions have produced fascinating new data. The JAXA spacecraft Hayabusa2 at the near-Earth asteroid (NEA) Ryugu has revealed a top-shaped rubble-pile object made of hydrated materials similar to carbonaceous chondrites (CC) in their spectral appearance. Similar observations have been made with the NEA Bennu by the NASA mission OSIRIS-REx, raising



An artist's depiction of the Hayabusa2 spacecraft passing near Earth. (Image Credit:JAXA)

urgent questions about the nature of these rubble-pile NEA parent bodies. From nucleosynthetic isotopic anomalies, a dichotomy is observed between non-carbonaceous (NC) and carbonaceous (C) meteorites formed within two genetically distinct reservoirs initially located either inside (NC) or outside (C) the orbit of Jupiter that remained isolated for several million years. These isotopic fingerprints can be further combined with precise chronology of meteorite parent bodies and of C-like NEAs to constrain dynamical processes in the early Solar System, such as the timescale of Jupiter's growth, inward scattering of C bodies, their incorporation into the growing terrestrial planets, and delivery of highly volatile species to Earth. By revealing Ryugu's nature, its relationship to meteorites, and the NEA composition, the data available from the analysis of samples returned by Hayabusa2 will provide a powerful boost to the discussion of the above cosmochemical topics.
In parallel to meteorite analyses, latest sample return missions to NEAs (Hayabusa1&2, OSIRIS-REx), and space missions to small bodies underway (DESTINY+, Lucy, Psyche), modellers have developed new numerical tools that are able to properly treat asteroids and meteorite parent bodies, as well as the dynamical evolution of the early Solar System. The Team addresses the chronology of meteorite parent bodies and NEA samples by improving age measurement techniques and applying advanced numerical tools that will fit the thermo-chronological data available and acquired. This work leads to a new understanding of the timescales of accretion and parent body processes at different heliocentric distances in the early Solar System, as well as of the planetesimal populations that produced various groups of planetary bodies (e.g., NEAs, C chondrite parent bodies, etc.).

First Light at Cosmic Dawn: Exploiting the James Webb Space Telescope Revolution

Team Leaders: Pascal Oesch, University of Geneva, Switzerland and Michael Maseda, University of Wisconsin-Madison, USA
Session: February 19-23, 2023
Scientific Rationale: The James Webb Space Telescope (JWST) is one of the grand scientific experiments of the 21st century. By far the largest and most sophisticated observatory ever sent into space, JWST has already begun to revolutionise our understanding of the distant Universe in its first year of operations. Over a hundred times more powerful in terms of sensitivity and resolution than its predecessor, the Hubble Space Telescope, JWST is also vastly more complex, containing a suite of instruments using next-generation technologies and operating at hitherto poorly explored infrared wavelengths. To unlock the full potential of this revolutionary facility requires highly specific expertise from different sub-disciplines of astronomical and computer science research.
The Team addresses one of the core science goals of JWST: finding the first stars and galaxies in the Universe that formed after the Big Bang. The Team members develop new techniques needed to analyse the first JWST observations and interpret these data using computational simulations, with the goal of understanding the physics of the first galaxies. It aims to build bridges between groups that do not normally coordinate research, ensuring that knowledge of the inner workings of complex datasets is disseminated amongst researchers, and mitigating systematic biases that are known to exist in comparisons between observations and simulations.

Ion Kinetic Instabilities in the Solar Wind in Light of Parker Solar Probe and Solar Orbiter Observations

Team Leaders: Leon Ofman and Lan Jian, NASA Goddard Space Flight Center, USA
Session: September 4–8, 2023
Scientific Rationale: The perihelia observations by Parker Solar Probe (PSP) provide unprecedented measurements of proton and alpha particle populations, in particular their non-Maxwellian velocity distributions, and associated kinetic wave activity, providing signatures of ion kinetic instabilities in the inner heliosphere reaching the acceleration region of the solar wind. The kinetic instabilities provide a crucial step in the cascade of energy from large (fluid) to small (kinetic) scales and eventual plasma heating. The inner heliospheric observations obtained from the PSP SPAN-I and FIELDS instruments as well as by the Solar Orbiter (SolO) SWA instrument suggest turbulent wave spectra in the ion-kinetic range and wave particle interactions that can provide insights into the solar wind acceleration and heating processes close to the Sun. The theoretical understanding of these observations is now being developed, supported by computational modelling of the solar wind plasma.
The Team consists of experts in solar wind plasma data analysis, modelling, and theory that will synthesise a new understanding of the PSP and SolO observational data, combined with theoretical knowledge and state-of-the-art computational modelling. The Team implements synergy between observations and theory, and focuses on developing the new thinking required for the understanding of the PSP data at perihelia encounters. The results will provide progress on the most important outstanding science questions of solar wind plasma physics, i.e., the heating and acceleration of the solar wind ions. The Team will establish the relation between various solar wind types (e.g., slow, Alfvénic), ion kinetic scale waves, and the velocity distributions of protons and alpha particles. In particular, it will investigate polarisation and spectral data of ion electromagnetic cyclotron waves (ECWs) during periods of enhanced activity and the variability of the ion heating connecting theoretical/modelled instabilities and resonances. It will also explore the proton and alpha particle non-Maxwellian velocity distributions, temperature anisotropies, and beam dynamics during switchbacks (i.e., radial magnetic field polarity reversals).

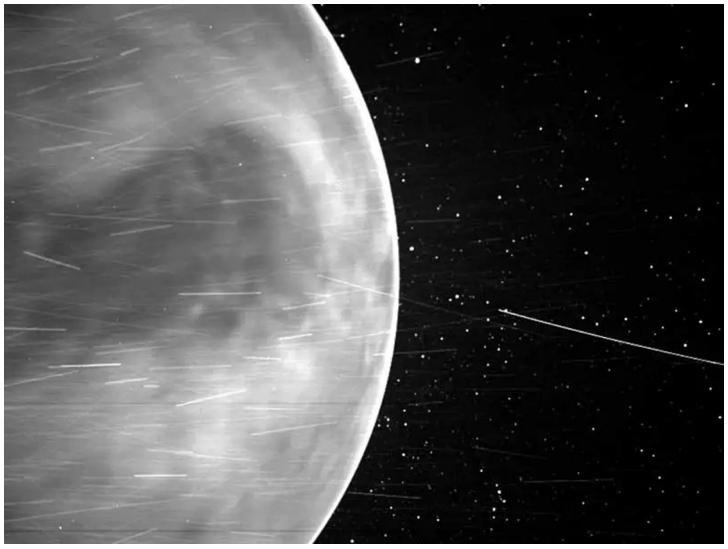
The Cosmic Baryon Cycle from Space

Team Leader: Céline Péroux, European Southern Observatory (ESO), Germany
Session: no meeting in 2023
Scientific Rationale: Years of astrophysical studies have placed interactions between galaxies and the circumgalactic medium at the centre of our quest to understand galaxy evolution. Determining what drives the physical processes at play in the circumgalactic medium still remains a complex problem in galaxy formation, in large part due to the lack of significant observational constraints. The Team advances our understanding of the multi-phase circumgalactic medium gas of intermediate redshift galaxies (z~1), by combining expertise ranging from instrument building and telescope operations, advanced processing and analysis of space-based data, observations ranging from mm to optical domains, as well as advanced cosmological simulations. An important component of the project relies on over 130 orbits of observations with the Hubble Space Telescope (HST) secured by the Team. The HST project combines a statistical approach for the analysis of absorption signatures from the circumgalactic medium with dedicated observations in emission of specific targets of interest. The main goal of the survey is to reveal and understand the physical processes responsible for the rapid transformation of baryons inside and outside of galaxies to address

the following questions: What is the physical relation between galaxies and their gaseous haloes? How is the circumgalactic medium enriched with metals? What is the dynamical structure of gas flows in the circumgalactic medium? Which future observational programmes and space-based facility development should we aim for?

Multi-Wavelength Studies of the Culmination of Structure Formation in the Universe

Team Leader: Gabriel Pratt, CEA Saclay, Service d'Astrophysique, France
Session: November 6–10, 2023
Scientific Rationale: Clusters of galaxies provide valuable information on cosmology, from the physics driving galaxy and structure formation, to the nature of dark matter and dark energy. They are the nodes of the cosmic web, constantly growing through accretion of matter along filaments and via occasional mergers, and their matter content reflects that of the Universe (~85% dark matter, ~12% X-ray emitting gas and ~3% galaxies). Clusters are therefore excellent laboratories for probing the physics of the gravitational collapse of dark matter and baryons, and for studying the nongravitational physics that affects their baryonic component. As cluster growth and evolution depend on the underlying cosmology (through initial conditions, cosmic expansion rate, and dark matter properties), their number density as a function of mass and redshift, their spatial distribution, and their internal structure, are powerful cosmological probes. The hot ($T \sim 10^7$ - 10^8 K) tenuous X-ray emitting plasma, the intracluster medium (ICM), accounts for the vast majority (~85%) of the baryonic content. It emits X-rays through bremsstrahlung emission and at millimetre wavelengths through the interaction of CMB protons with the hot ICM electrons, producing the Sunyaev-Zeldovich effect (SZE). This ISSI Team was awarded one of the first *Multi-Year Heritage (MYH) programmes* – called *CHEX-MATE* – using the ESA X-ray satellite XMM-Newton. This project has obtained complete and homogeneous X-ray exposures of 118 Planck SZE-selected galaxy clusters. The sample comprises a minimally-biased census both of the population of clusters at the most recent time ($0.05 < z < 0.2$), and of the most massive objects to have formed at $z < 0.6$. It was designed to answer the following questions: What is the absolute cluster mass scale? What is the imprint of the formation process on the equilibrium state of clusters, and how does this impact our ability to weigh them through their baryon signature? What are the statistical properties of the cluster population? How does cluster detectability depend on baryon physics? Can we accurately measure how the properties of the cluster population change over time? What are the ultimate products of structure formation?



Venus from Parker Solar Probe: As Parker Solar Probe flew by Venus in February 2021, its WISPR instrument captured these images showing the nightside surface of the planet. (Image Credits: NASA/APL/NRL)

Seismicity on Venus: Prediction & Detection

Team Leader: Iris van Zelst, German Aerospace Center, Germany
Session: January 23–27, 2023
Scientific Rationale: With the selection of multiple missions to Venus by NASA and ESA planned to launch in the coming decade, the research community will greatly improve our understanding of Venus as a planet. However, the selected missions cannot tell us anything about the seismicity on Venus, which is a crucial observable to constrain the tectonic activity and geodynamic regime of the planet, and its interior structure. This Team of experts in seismology, geology, and geodynamics assesses the seismic activity on Venus from a theoretical and instrumental perspective. It aims to provide estimates of the current seismicity on Venus based on constraints from, e.g., geodynamic modelling and surface fault mapping. Using these estimates, the Team will determine the associated ground motion and atmospheric perturbations that can be expected on Venus as a result of seismicity.
To detect these seismic signals during future missions, the Team reviews the feasibility, advantages, and disadvantages of seismic observation techniques on the surface (e.g., broadband seismometers, distributed acoustic sensing methods), from a balloon, and from orbit. Consolidating the results from both the theoretical and instru-

mental parts this project makes a major contribution to understanding the present-day seismicity of Venus and will result in recommendations for future payload configurations for Venus missions with seismological science objectives.

Synthetic Gravity Wave Analyses for New Exploitation of Satellite Data (SWANS)

Team Leader: Corwin Wright, University of Bath, United Kingdom
Session: October 16-20, 2023
Scientific Rationale: Small-scale gravity waves (GWs) are vital to the dynamics of Earth's atmosphere, but are difficult to simulate accurately in weather and climate models. While major advances have been made in recent years in our ability to observe GWs from space, translating these advances to model development is complicated by the fragmentary view these observations provide.
For the project SWANS (Synthetic Gravity Wave Analyses for New Exploitation of Satellite Data), this Team combines space-based observations and high-resolution simulations to demonstrate a novel pathway to better representation of GWs and their effects in next-generation models. This is achieved by adapting a widely-used satellite development technique, the Observing System Simulation Experiment, to the problem of the effectively-fixed GW observing system. The Team produces detailed information on how current instruments 'see' GWs when their sensing parameters are reproduced in state-of-the-art high-resolution atmospheric models. In doing so, it can identify deficiencies in the current GW observational constellation and improved ways to observationally constrain GW parametrisations in next-generation weather and climate models. The Team's link to international projects within the *World Climate* and *World Weather Research Programmes*, ensuring broad dissemination and a pathway to real-world impact on numerical weather prediction and climate modelling.

Magnetohydrostatic Modeling of the Solar Atmosphere with New Datasets (ISSI–ISSI Beijing Team)

Team Leaders: Xiaoshuai Zhu, Chinese Academy of Sciences, China and Iulia Chifu, University of Göttingen, Germany
Session: no meeting in 2023
Scientific Rationale: Gaining insight into the magnetic fields and plasma in solar active regions is very important for studying various solar activities. So far the main approach to obtaining the three-dimensional (3D) magnetic field structure of active regions is to extrapolate the magnetic field from magnetograms measured in the photosphere. A basic assumption in the past was to completely neglect all plasma effects and to perform the so-called force-free field (FFF) extrapolations. A couple of methods (e.g PFSS, linear FFF, nonlinear FFF) are available. Among these methods, until now, the NLFFF performed the best when compared with observations. While the force-free assumption is well justified in the solar corona, it is not the case in the photosphere and chromosphere. New approaches that take into account plasma forces (e.g., plasma pressure and gravity) developed rapidly in the last decade, for example magnetohydrostatic (MHS) extrapolations. It was found that the MHS extrapolation when applied to simple test cases performs better than the NLFFF extrapolation in terms of the accuracy of the reconstructed magnetic field. To calculate the plasma forces correctly, the MHS extrapolation requires a very high-resolution magnetogram (<100 km) which could not be obtained regularly in the past. However, such regular measurements of the magnetic field are possible with the advent of the Daniel K. Inouye Solar Telescope (DKIST). Moreover, the Solar Orbiter (SolO) provides an additional view angle which helps to constrain the magnetic field modelling. The Team focuses on improving the MHS modelling with unprecedented observations. Such improvements to already available magnetic field models will help the solar community to better understand activities in the solar atmosphere.

International Teams approved in 2023

The following listed teams have been selected for implementation from the proposals received in response to the 2023 Call for International Teams:

Quantitative Comparisons of Solar Surface Flux Transport Model
Team Leader: Graham Barnes (team leader) NorthWest Research Associates, USA

Coastal Sea Level Rise: Observations and Causes
Team Leader: Anny Cazenave, LEGOS, Toulouse, France

The Mesosphere and Lower Thermosphere at Low Latitudes (MLT-LoLa): Its Day-To-Day Variability and its Contributions to Thermospheric/Ionospheric Weather (ISSI–ISSI Beijing Team)
Team Leaders: Jorge L. Chau, Leibniz Institute of Atmospheric Physics, Germany and Huixin Liu, Kyushu University, Japan

Models and Observations of the Middle Corona
Team Leaders: Giulio Del Zanna, University of Cambridge, Cambridge, UK and Matthew West, Southwest Research Institute, Boulder, USA

Active Galactic Nuclei in Next Generation Surveys
Team Leader: Sotiria Fotopoulou, University of Bristol, UK

Shocks, Waves, Turbulence, and Suprathermal Electrons in the Very Local Interstellar Medium
Team Leaders: Frederico Fraternale, University of Alabama, USA and Stella Ocker, Cornell University, USA

Collisionless Shock as a Self-Regulatory System
Team Leader: Michael Gedalin, Ben-Gurion University, Israel

Constraining Trade-Cumuli Feedback by Means of Process Understanding
Team Leader: Geet George, TU Delft, Germany and Hauke Schulz, University of Washington, USA

Exploiting Intracluster Light for Cosmology and Galaxy Evolution with Next Generation Facilities
Team Leader: Nina Hatch, University of Nottingham, UK

The Extremely Low Surface Brightness Universe: Calling for Synergy between the ESA Euclid and ARRAKIHS Space Missions
Team Leaders: Kate Isaak and René Laureijs, European Space Agency, the Netherlands

Perspectives on Stratospheric Aerosol Observation
Team Leaders: Corinna Kloss, Forschungszentrum Jülich GmbH, Jülich, Germany and CNRS, Orléans, France and Mahesh Kovilakam, ADNET Systems Inc /NASA Langley Research Center, Hampton, USA

Meteors and Phenomena at the Boundary between Earth's Atmosphere and Outer Space
Team Leaders: Alexander Kozlovsky, Sodankylä Geophysical Observatory of the University of Oulu, Finland and Renata Lukianova, Institute of Seismology, Kazakhstan

Understanding the Release of Hard X-Rays, Type III Radio Bursts and In-Situ Electrons in Solar Flares (ISSI–ISSI Beijing Team)
Team Leaders: Gang Li, University of Alabama in Huntsville, USA and Linghua Wang, Peking University, Beijing, China

Understanding the Mars Space Environment through Multi-Spacecraft Measurements (ISSI–ISSI Beijing Team)
Team Leaders: Wenya Li, National Space Science Center Beijing, China and André Galli, University of Bern, Switzerland

Investigation of the Lithosphere Atmosphere Ionosphere Coupling (LAIC) Mechanism before the Natural Hazards (ISSI–ISSI Beijing Team)
Team Leaders: Dedalo Marchetti, Jilin University, China and Essam Ghamry, National Research Institute of Astronomy and Geophysics (NRIAG), Egypt

Development of Galaxy Zoo: JWST
Team Leader: Karen Masters, Haverford College, USA

REASSESS - gRound and spacE-bAsed analySis of Strong sEp eventS and Study of their terrestrial effects
Team Leader: Alexander Mishev, University of Oulu, Finland

International Teams approved in 2023

Novel Insights Into Bursts, Bombs, and Brightenings in the Solar Atmosphere from Solar Orbiter
Team Leaders: Chris J. Nelson, European Space Agency, the Netherlands, and Lakshmi Pradeep Chitta, Max Planck Institute for Solar System Research, Germany

Tomographic Inversion of Synthetic White-Light Images: Advancing Our Understanding of CMEs in 3D
Team Leaders: Erika Palmerio, Predictive Science Inc., USA and David Barnes, Rutherford Appleton Laboratory, UK

Unveiling Energy Conversion and Dissipation in Non-Equilibrium Space Plasmas
Team Leaders: Oreste Pezzi, University of Calabria, Italy and Paul Cassak, West Virginia University, USA

Bridging the Gap: From Terrestrial to Icy Moons Cryospheres
Team Leaders: Ana-Catalina Plesa, DLR, Germany and Julia Kowalski, RWTH Aachen University, Germany

"Genes from Space" – Leveraging Earth Observation Technologies to Monitor Essential Genetic Diversity
Team Leaders: Meredith C. Schuman and Claudia Röösli, University of Zurich, Switzerland

Evolution of Turbulence in the Expanding Solar Wind
Team Leaders: Luca Sorriso-Valvo, KTH – Royal Institute of Technology, Stockholm, Sweden and Lina Hadid, Laboratoire de Physique des Plasmas, Palaiseau, France

Jupiter's Non-Auroral Ionosphere
Team Leader: Tom Stallard, Northumbria University, UK

Understanding the Physical Processes that Control the Magnetotail Structure and Dynamics within Unmagnetized and Hybrid Magnetospheres
Team Leader: Katerina Stergiopoulou, University of Leicester, UK

A Multi-Mission Approach to Close the Gaps in Understanding of the Structure and Variability in the Mars Upper Atmosphere
Team Leader: Ed Thieman, University of Colorado at Boulder, USA

The Thermal and Petrological History of Mercury's Heterogeneous Mantle
Team Leaders: Nicola Tosi, DLR, Berlin, Germany and Olivier Namur, KU Leuven, Belgium

Tracking Plasma Flows in the Sun's Photosphere and Chromosphere: A Review & Community Guide
Team Leaders: Benoit Tremblay, National Solar Observatory, and Maria D. Kazachenko, University of Colorado, Boulder, USA

3-D Chemical Kinetics Model Benchmark for Hot Jupiter Atmospheres
Team Leader: Shang-Min Tsai, The University of Oxford, UK

Coastal Resilience Using Satellites: CRESTE
Team Leader: Emma Imen Turki, Normandy University, France

Johannes Geiss Fellow and Visiting Scientists

The Johannes Geiss Fellowship (JGF) is established to attract to ISSI – for limited duration visits – international scientists of stature, who can make demonstrable contributions to the ISSI mission and increase ISSI's stature by their presence and by doing so will honour Johannes Geiss for his founding of ISSI and his contributions to ISSI, and for his many contributions to a broad range of space science disciplines.

Sandra Chapman, Johannes Geiss Fellow 2023, and Roland Hohensinn, ISSI Post Doc

Sandra Chapman is the Johannes Geiss Fellow 2023 and is a plasma physicist working on problems in astrophysics and in the laboratory. She is currently Professor of Physics and Director of the Centre for Fusion, Space and Astrophysics at the University of Warwick and adjunct Professor at UIT. Her early work on nonlinear plasmas was recognised with the COSPAR Zeldovich Medal (commission D) and the EGS Young Scientists' Medal. She was selected to give the 2014 Royal Astronomical Society James Dungey Lecture and the 2020 Ed Lorenz Lecture at the Fall meeting of the American Geophysical Union. Sandra is part of a team awarded a 2021 Lloyd's of London Science of Risk Prize. She has been awarded the 2022 Royal Astronomical Society Chapman Medal and the 2024 Johannes Alfvén Medal of the European Geosciences Union. In the following paragraphs she answers a few questions – asked by Roland Hohensinn, ISSI Post Doc – about her research. **Roland Hohensinn** is a postdoctoral fellow in Earth Sciences and data scientist. He does research on uncertainty quantification from satellite remote sensing data, with a focus on space geodetic techniques (GRACE/GRACE-FO terrestrial water storage, long-term GPS ground motions).

Roland Hohensinn: Sandra, please explain the beauty of your science.

Sandra Chapman: I have been privileged to be able to work across a variety of topics under the general heading of 'plasma physics'. Plasmas are not only ubiquitous in the Universe, they are also fundamentally non-linear and, in space and astrophysical systems particularly, are far from equilibrium. So our study of plasma physics touches upon some of the deepest physics questions: how does entropy increase in a collisionless plasma? How do we go from physics which on the microscale is reversible, but on the macroscale, irreversible, without collisional dissipation? How are particles accelerated, how do energy and momentum flow between fields and particles?
The models and mind-pictures that we use are based on the equations of Maxwell, Lorentz, Liouville et al., and these are fundamentally beautiful in their structure and expression. I am a great fan of 'the truth is usually beautiful' approach to physics.

Roland Hohensinn: Which transformations do you see your field undergoing at the moment?

Sandra Chapman: Thinking about space plasma physics, I think this is a particularly exciting, and challenging time. When I was beginning my physics career, the norm was to have access to the data from a single satellite and to look in detail at single time-series, perhaps to try some conjugate study with ground-based observations or a second satellite. Plasma simulations were highly restricted in dimension and could only capture one physical scale of interest. Now we are in a data-rich era with imaging, multiple satellites and hundreds of ground-based observations, all at unprecedented spatial and temporal resolution, but these observations are not homogeneous. Alongside this, we now have the capability to build and run computer simulations which evolve the fully non-linear plasma physics across multiple physical space and timescales. We need to think of new ways to extract, visualise, interrogate and compare the relevant information from these data, both from observations and simulations. There are many new tools for this that are well-established in other fields: networks, machine learning, AI. But the critical first step in this process is in formulating the physics questions to be asked of the data and building this into the analysis pathway, otherwise it is 'garbage in, garbage out'. I don't think that human physicists will be out of a job anytime soon!

Roland Hohensinn: How do you see the current and future role of ISSI in space sciences?

Sandra Chapman: It is one of life's ironies that the more a science career progresses, the less time there is available to actually do science. So institutes like ISSI are an invaluable refuge that combine time to think with opportunities to discuss. Physics has no borders and space science in particular is intrinsically international. ISSI in particular offers the flexibility to co-ordinate international teams on new topics. The ways in which we communicate our science, to each other, and to the wider public, are also changing rapidly and ISSI I think is well positioned to play a key role in this.

Visiting Scientists

Individual Scientists are invited for extended periods to work on scientific subjects at the forefront in areas of interest to ISSI. The results of this research are to be published as books or in major scientific journals, with appropriate acknowledgment to ISSI.

The following Visiting Scientists have worked at ISSI in the course of the 28th year:

Barbora Bila, Institute of Physics, Silesian University in Opava, Czech Republic, working period: 7–14.12.2023

Natalia Buzulukova, NASA GESC, USA, working period: 9–29.7.2023

Martin Cafolla, University of Warwick, UK, working period: 24–30.9.2023

Sandra Chapman, Johannes Geiss Fellow 2023 and University of Warwick, UK, working periods: 7–21.5.2023, 1–30.9.2023, 15.10.–18.11.2023

Shohreh Didari, Shiraz University, Iran, working period: 26.7.–25.8.2023

Weiqing Han, University of Colorado at Boulder, USA, working period: 5.5.–1.8.2023

Debora Lancova, Institute of Physics, Silesian University in Opava, Czech Republic, working period: 7–14.12.2023

Geraint Jones, University College London, UK, working periods: 30.3.–30.4.2023

Philip Judge, National Center for Atmospheric Research, Boulder, USA, working period: 20.2.–17.3.2023

Christian Maier, University of Vienna, Austria, working period: 3–14.4.2023

Piyush Marmat, Indian Institute of Technology Roorkee, Roorkee, India, working period: 1.3.–30.4.2023

Alexander Milovanov, ENEA, Frascati, Italy, working period: 7.6.–6.7.2023

Christina Novotna, Institute of Physics, Silesian University in Opava, Czech Republic, working period: 7–14.12.2023

René Šprňa, Institute of Physics, Silesian University in Opava, Czech Republic, working periods: 8–19.5.2023 and 7–14.12.2023

Tomas Stanovsky, Institute of Physics, Silesian University in Opava, Czech Republic, working period: 7–14.12.2023

Ilya Usoskin, University of Oulu, Finland, working periods: 24.5.–23.6.2023 and 1–28.10.2023

Marco Velli, Johannes Geiss Fellow 2022, working period: 10.10.2022–5.4.2023

Nick Watkins, University of Warwick, UK, working periods: 7–21.5.2023, 1–30.9.2023, 15.10.–18.11.2023

The Association Pro ISSI

The Association Pro ISSI was founded in 1994 under Swiss law with the goals to create a Space Science Institute in Switzerland and to communicate the fascinating results of space sciences to the Swiss public. With the creation of the Foundation ISSI in 1995 the first objective was reached. Today, Pro ISSI focuses on providing outreach activities for ISSI. It forms a bridge between ISSI and the public via its members, who are mostly laypeople, but often represent universities, industry, politics, and public administration. The Association organises public lectures and publishes the SPATIUM magazine. The Pro ISSI Association, which consists presently of 109 members, also meets once per year for its general assembly. In 2023, a number of changes occurred in the Board of Pro ISSI: PD Dr. Martin Rubin (University of Bern) took up the appointment as vice-president of Pro ISSI. Dr. Annette Jäckel was followed by Prof. Jonas Kühn (University of Bern) as treasurer, and Dr. Yasmine Calisesi was followed by Dr. Oliver Müller (EPFL) as secretary. Dr. Anuschka Pauluhn and PD Dr. Andreas Verdun continue as editors of SPATIUM, while Prof. Christoph Mordasini continues to serve as the president.

Strategy Meeting

The last few years have seen a slow but steady decrease in the number of members of Pro ISSI by about 4 members per year which could eventually become financially problematic for the self-sufficiency of the association. As for other similar associations, the decrease is mainly related to the relatively high average age of the Pro ISSI members and the difficulty in reaching the younger generations in a changing environment with access to plentiful space-related online information and talks. To address this development, in October 2023 a meeting was organised by the Board of Pro ISSI to identify strategies to counteract the decrease. The Pro ISSI Board, the ISSI directorate, and several external professional communication experts participated. Key recommendations included: a better use of the synergies between ISSI and Pro ISSI (involvement in outreach of some of the excellent scientists passing through ISSI), a diversification of the events organised including large radiating events and special events for VIPs, an increase in visibility by a presence at major already existing events, intensification of communication with related associations, and a better understanding of the interests of the members. Several of these recommendations were already implemented, namely through a more efficient collaboration of Pro ISSI and ISSI and a large co-organised podium event on the subject "Unveiling the First Billion Years in the History of the Universe with Revolutionary New JWST Observations" on 14th of March 2024.

Public Talks

As usual, in 2023, 3 in-person public lectures were organised. To increase the international reach, the events were also live-streamed online. The talks are also recorded and available via the ISSI homepage/youtube. The in-person meetings make it possible to have the important personal interactions between Pro ISSI members and the speakers.

On 15th of March 2023, Prof. Dr. Marco Velli (UCLA) gave a presentation on space plasma physics and solar magnetic activity. In 2022, he had been awarded the Johannes Geiss Fellowship.

On 24th of May 2023, Nobel Prize winner Prof. Dr. Michel Mayor gave a talk on "Billions of planets in the Milky Way: The Quest for Earth-Twins and Maybe Life". A talk by a Nobel Prize winner marks one of the highlights in Pro ISSI's history to date.

Finally, on 1st November 2023 the annual General Assembly took place, followed by the talk of Dr. Antonella Nota, Executive Director of ISSI on "The Extraordinary First Year of Science of the James Webb Space Telescope".

SPATIUM

The Association's magazine SPATIUM elaborates on selected Pro ISSI lectures. It appears usually twice per year (three in 2022 because of the 50th jubilee edition). During the reporting period, issue No. 52 was published in May 2023, entitled "Space Debris." It was prepared by Prof. Thomas Schildknecht based on his 2022 Pro ISSI talk.

The second SPATIUM in 2023 by Prof. Marco Velli planned for December 2023 was delayed as the authorial work took longer than anticipated. To compensate, Pro ISSI editor Dr. Anuschka Pauluhn made a special effort and prepared in December an extra SPATIUM 53 "Solar Missions – getting closer to the Sun". Exceptionally, it was published at the beginning of 2024 as an online edition.

Together with all previous issues of SPATIUM, these editions can be found on Pro ISSI's homepage www.issibern.ch/association-pro-issi/spatium/

Work was also initiated to update the graphical layout of the SPATIUM. This forms another element of the changes in the association.

Christoph Mordasini

Financial Overview

The 28th financial year of ISSI resulted of the year is a surplus of around 12 kCHF as opposed to a budgeted deficit of 21 kCHF. This much better result was thanks to lower personnel costs and to lower expenditures for Workshops and Teams than budgeted, in roughly equal amounts. The result would have been even better if it hadn't been for another decline of the Euro to CHF exchange rate. The deficit is still fully covered by positive results from previous years.

On the revenue side the contributions from ESA (Directorates of Science and of Earth Observation) and from the Swiss Confederation (State Secretariat for Education, Research and Innovation SERI and Swiss Academy of Natural Sciences SCNAT) were received as budgeted and are gratefully acknowledged, as is the contribution from our Japanese partner, JAXA/ISAS.

In addition to the direct contributions listed here it is important to note that ISSI also receives indirect contributions that do not appear in the table below: One of the directors is employed directly by the University of Bern, and ISSI also benefits from the University through in-kind contributions such as internet connectivity, free access to all printed and online license resources of the UniBE libraries etc.

Maurizio Falanga

Statement of Operations (in CHF) for the 28th Financial Year (1.1.2023-31.12.2023)

	Expenses	Revenues
ESA Science Directorate and Earth Observation		1'504'800.00
Swiss Confederation		1'350'500.00
Swiss Academy of Sciences (SCNAT)		217'500.00
ISSI Partners: ISAS/JAXA		23'636.50
Salaries and related costs [1]	1'237'194.61	
Fixed costs	292'192.85	
Operating costs [2]	266'425.93	
Investment (depreciated)	204'100.05	
Workshops, Working Groups, Teams, Visitors [3]	1'126'736.29	
Other income or cost [4]		42'452.78
Result of the year	12'239.55	
Total	**3'138'889.28**	**3'138'889.28**

Remarks:

[1] **Salaries:** It should be noted that the majority of the ISSI staff members (including directors) are scientists actively conducting research as well as taking care of organisational, editorial, and administrative tasks.

[2] **Operating costs** include repair and maintenance, insurance, supplies, administration, and public relations.

[3] **Workshops, etc**. also include the balance from income and expenses of guest apartments.

[4] **Other income or cost** includes extraordinary income, interest income, and income due to variations in monetary exchange rates.

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The list shows the status at the end of the 28th business year on 31st December 2023.

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The list shows the status at the end of the 28th business year on 31st December 2023.

Staff Activities

Listed are activities in which ISSI staff scientists participated in 2023. This includes presentations given, meetings attended, outreach, honors received, and chairmanships held.

Presentations

January 13, 2023 – M. Sargent: "The radio-AGN main sequence", contributed talk at the 2023 winter meeting of the SKACH consortium, Basel, Switzerland

January 24, 2023 – M. Sargent: "Extragalactic survey science in the 2020s - The role of radio continuum observations with the SKA", invited seminar at INAF-Brera Observatory, Milan, Italy

January 29 – February 3, 2023 – M. Falanga: Working with Luigi Stella on X-ray binary systems, Farewell symposium of Prof. Dr. Luigi Stella, Bormio, Italy

February 27, 2023 – M. Sargent: "Tracking Galaxy Activity - Looking back in time with SKA1 alongside other southern hemisphere facilities", contributed talk at the conference "Coordinated Surveys of the Southern Sky", ESO Garching, Germany

March 7, 2023 – M. Sargent: "NGC4921- Die Vielfalt des Universums auf einen Blick", invited outreach talk for the series "Faszination Astronomie Online" of the Haus der Astronomie in Heidelberg, Germany (on-line)

March 2023 – A. Nota: Il Telescopio Spaziale Webb: l'inizio di una rivoluzione scientifica, Istituto Veneto di Scienze, Lettere ed Arti, Venezia, Italy

April 23–28, 2023 – R. Hohensinn: From noise-to-signal: enhancing the sensitivity of long-term GNSS by explaining non-linear station motions (No. EGU23-10251). In EGU Meeting 2023, Copernicus Meetings, Vienna, Austria

April 2023 – A. Nota: The Hubble Space Telescope - 30 years of discoveries, Colloquium at Raytheon, Aberdeen, UK

May 24, 2023 – M. Sargent: "Tracking galaxy activity across cosmic time - Synergistic science with WST and SKA", invited talk at the Symposium "Science with the future Wide-Field Spectroscopic Telescope", Vienna, Austria

June 2, 2023 – M. Sargent: "(SKACH) Headline science in SKA1-MID band 6", invited review talk at the 2023 summer meeting of the SKACH consortium, Geneva Observatory, Switzerland

June 23, 2023 – C. Malacaria: A polarimetric-oriented X-ray stare at EXO 2030+375 with IXPE, Insight-HXMT and SRG/ART-XC, Vasto accretion meeting (19 to 23 June, 2023) Durham, UK

June 22, 2023 – M. Sargent: "Science in SKA1-MID band 6", contributed talk at the "SKA-MID band 6 SKACH science" workshop, Bern, Switzerland

July 5, 2023 – C. Malacaria: Feeding the spinning top, Team Meeting, ISSI, Bern, Switzerland

July 7, 2023 – T. Dudok de Wit, A dream come true, penetrating a stellar atmosphere, keynote talk at the Congress of the French Physical Society, Paris, France

July 10, 2023 – M. Falanga: Talk on A review on building up ISSI-BJ to its current status, 10th Anniversary of ISSI-Beijing, China

July 14, 2023 – T. Dudok de Wit, Mankind's first visit to a star: the Parker Solar Probe mission, Athena Network Conference (online)

July 11–20, 2023 – R. Hohensinn: The potential of using smartphone GNSS receivers for the detection of ionospheric irregularities. In XXVIII General Assembly of the International Union of Geodesy and Geophysics (IUGG), Berlin, Germany

July 11–20, 2023 – R. Hohensinn and M. Rast: Temporally correlated signals in GRACE TWS data and implications on the choice of functional and stochastic time series models. In XXVIII General Assembly of the International Union of Geodesy and Geophysics (IUGG), Berlin, Germany

July 20, 2023– M. Falanga: ISSI-BJ forum on Detecting missing Baryons in the Universe, China

September 7, 2023 – M. Sargent: "From sunspots to the birth of Earth-like planets and the earliest galaxies - Status update on the SKACH band 6 white paper", invited talk at the Swiss SKA Days 2023, Zurich, Switzerland

October 9, 2023 – T. Dudok de Wit, Activité solaire et variations climatiques, public lecture at the Fête de la Science, Orléans, France

November 1, 2023 – A. Nota: The extraordinary first year of science of the James Webb Space Telescope, Pro ISSI Talk, Bern, Switzerland

November 30, 2023 – M. Falanga: Talk on Interaction

of gravitational waves with the pulsar magnetosphere, RAGTime conference, Silesian University in Opava, Czech Republic

December 4-6, 2023 – M. Falanga: Lecture on "White dwarf physics in Astronomy and Astrophyscis", Silesian University in Opava, Czech Republic

December 11-15, 2023 – R. Hohensinn: Offset detection from GNSS time series data: comparing an (unsupervised) augmented Kalman filter approach and supervised machine learning methods. In AGU Fall Meeting 2023, San Francisco, USA

December 11-15, 2023 – R. Hohensinn and M. Rast: Terrestrial water storage and ground water storage variations: a quantitative analysis of the latest GravIS GRACE/GRACE-FO level 3 data products. In AGU Fall Meeting 2023, San Francisco, USA

December 13, 2023 – T. Dudok de Wit, Frôler le Soleil avec la mission Parker Solar Probe, public lecture at French Astronomical Society, Paris, France

December 14, 2023 – M. Sargent: "Pathway to science with the SKA and highlights from the precursors", invited talk at the Swiss CTA Observatory Days 2023/24, Bern, Switzerland

December 14, 2023 – M. Falanga: Very High Energy emissions from Pulsars systems, Swiss CTA Meeting

Meetings

January 12/13, 2023 – M. Sargent: SKACH Consortium meeting, Basel, Switzerland

January 29 – February 3, 2023 – M. Falanga:, Prof. Dr. Luigi Stella Farewell symposium Bormio, Italy

February 6–8, 2023 – M. Rast: 10th EARSeL Workshop on Land Ice and Snow - Remote Sensing of the Cryosphere: methods and applications from regional to global scale, University of Bern, Switzerland

February 13/14, 2023 – M. Sargent: Astronomy from the Moon, Royal Soc. London, UK (on-line)

February 27 – March 3, 2023 - M. Sargent: Coordinated Surveys of the Southern Sky, ESO Garching, Germany

March 14, 2023 – M. Sargent: Joint Workshop of the SKA Extragalactic Continuum and HI science working groups (on-line)

March 21–23, 2023 – M. Rast: 6th Virtual Alpine Observatory (VAO) Symposium 2023, Grainau, Germany

April 19, 2023 – M. Sargent: Joint Workshop of the SKA Extragalactic Continuum and Cosmology science working groups (on-line)

April 25/26 – M. Sargent: Space Community Days Switzerland 2023, Bern, Switzerland

May 8–11, 2023: The Variability of the Airglow for the Detection of Atmospheric Dynamics, 2nd Working Group meeting

May 23/24, 2023 – M. Sargent: Science with the future Wide-Field Spectroscopic Telescope, Vienna, Austria

May 30–31, 2023 – ISSI Staff: Retreat Schloss Münchenwiler, Switzerland

June 1/2, 2023 – M. Sargent: SKACH Consortium Meeting, Geneva Observatory, Switzerland

June 10–14, 2024 – C. Malacaria: Awarded the "Disentangling pulse profiles of (mostly) accreting neutron stars" Working group, ISSI, Bern, Switzerland

June 22, 2023 - M. Sargent: SKA-MID band 6 SKACH – science workshop, Bern, Switzerland

July 3–7, 2023 – C. Malacaria: Team Meeting: Feeding the Spinning Top - Spin Evolution of Accretion-Powered Pulsars in High-Mass X-Ray Binaries, ISSI, Bern, Switzerland.

July 10 2023, – M. Falanga: 10th Anniversary of ISSI-Beijing, China

July 5–7, 2023 – T. Dudok de Wit, Congress of the French Physical Society, Paris, France

July 20–21, 2023 – M. Falanga: ISSI-BJ forum on Detecting missing Baryons in the Universe, Beijing, China

August 14–18, 2023 – M. Falanga: Visiting the "Silesian University in Opava", Czech Republic

September 6/7, 2023 – M. Sargent: Swiss SKA Days 2023, Zurich, Switzerland

September 16, 2023 – M. Rast: Opening Space Eye Observatory, Niedermuhlern, Switzerland

September 25–29, 2023 – M. Falanga: Asia Pacific Space

Cooperation Organisation (APSCO), , CubeSat student competition expert for science evaluations, Beijing China

October 17–24, 2023 – M. Falanga: ISSI-BJ-APSCO Space Science School on Exploring the Moon, in Si Racha, Chon Buri Province, Thailand

October 24-27 – M. Falanga: Visiting the "Xiangtan University", Hunan Province, China

October 25–27, 2023 – A. Nota, A. Gimenez, C. Malacaria: "International cooperation to advance space science, ISSI, Bern, Switzerland

October 26, 2023 – M. Rast: Virtual Alpine Observatory Executive Board meeting, TU Munich, Germany

October 29–30, 2023 – T. Dudok de Wit, European Heliophysics Conference, Noordwijk, the Netherlands

November 20–24, 2023 – T. Dudok de Wit, European Space Weather Week, Toulouse (co-organizer), France

November 28–30, 2023 – M. Rast: The Variability of the Airglow for the Detection of Atmospheric Dynamics, 3rd Working Group meeting

November 27 – December 1, 2023 – M. Falanga:, RAG-Time conference, Silesian University in Opava", Czech Republic

December 13/14, 2023 – M. Sargent, M. Falanga: Swiss CTA Observatory Days 2023/24, Bern, Switzerland

Chairperson- and Memberships, Honors

Thierry Dudok de Wit
- Chair of the Sustainability Working Group of The European Space Weather and Space Climate Association (E-SWAN)
- Associate Editor of the Journal of Space Weather and Space Climate
- Evaluator /Rapporteur of several programmes and fellowships: ESA EE-12 missions, The Research Foundation Flanders, Australian Aufrande Programme, SCOSTEP Visiting Scientists Programme, etc.
- Reviewer for Astronomy and Astrophysics, The Astrophysical Journal, Journal of Geophysical Research, Solar Physics, Scientific Reports, Geophysical Research Letters

Maurizio Falanga
- Member of International Astronomical Union (IAU)
- Member of International Academy of Astronautics (IAA)
- Member of European Astronomical Society (EAS)
- Member of Swiss Society for Astrophysics and Astronomy (SSAA)
- Member of the, SCNAT - Swiss Commission for Astronomy (SCFA)
- Member of the SCNAT - Swiss Committee on Space Research (CSR)
- Member of the Editorial Board, Space Science Reviews Journal, Springer
- Member of the Einstein Probe mission CAS science team
- Member of the NICER User Group, NASA

Antonella Nota
- January 2023 - Appointed Fellow of the American Astronomical Society
- Member of AAS, IAU and IVSLA
- Honours: Emeritus Astronomer, STScI and Fellow, AAS
- Board Member AAVSO (2023)
- Board Member BSMF

Michael Rast
- Member of the Faculty of Geosciences, Ludwig-Maximilians Universität, Munich, Germany
- International Center for Earth Simulation (ICES) - Member of the Expert Committee
- Virtual Alpine Observatory (VAO) – Executive Board Observer for ISSI
- Eagle Wings, Protecting the Alps Foundation - Ambassador
- Austrian Research Promotion Agency (FFG) - Reviewer

Mark Sargent
- Member of International Astronomical Union (IAU)
- Member of European Astronomical Society (EAS)
- Member of Swiss Society for Astrophysics and Astronomy (SSAA)
- Member of the Royal Astronomical Society (RAS)
- Member of the COSMOS-LOFAR management team
- Co-chair of the SKA Extragalactic Continuum science working group
- Board member for the Swiss SKA Consortium (SKACH)
- Reviewer for MNRAS
- Reviewer for European Research Council (ERC) grant proposals
- Reviewer for STFC Consolidated Grants scheme and for STFC Ernest Rutherford Fellowships

Staff Publications

Listed are all papers written or co-authored by ISSI staff members that appeared in 2023.

Aichinger-Rosenberger, M. (incl. R. Hohensinn) et al. MPG-NET: A low-cost, multi-purpose GNSS co-location station network for environmental monitoring. Measurement 216, 112981 (2023).

Alizai K. (incl. M. Falanga), A catalogue of unusually long thermonuclear bursts on neutron stars, Mon. Not. R. Astron. Soc., 521, 3608–3624, (2023).

Bakala, P. (inc. M. Falanga) et al. Extreme amplification regimes of the Schwarzschild gravitational lens. Astron. Astrophys. 673, A164 (2023).

Bait, O., Sargent, M. T. inter alios, The Low-redshift Lyman Continuum Survey: Radio continuum properties of low-z Lyman continuum emitters, A&A (submitted; 10.48550/arXiv.2310.18817)

Bizien, N. (incl. T. Dudok de Wit) et al. Are Switchback Boundaries Observed by Parker Solar Probe Closed? Astrophysical J, 958(1):23 (2023).

Bostancı, Z. F. (incl. C. Malacaria) et al. NICER Observations of Thermonuclear Bursts from 4U 1728-34: Detection of Oscillations prior to the Onset of Two Bursts. Astrophys. J. 958, 55 (2023).

Bozzo, E. (incl. M. Falanga) et al., A detailed analysis of X-ray emission-line velocities of Capella from over 20 yr of Chandra/HETG spectroscopy, Mon. Not. R. Astron. Soc.: Lett, 522, L66–L71 (2023).

Branchesi, M. (incl. M. Falanga) et al. Lunar Gravitational-Wave Detection. Space Sci. Rev. 219, 67 (2023).

Bruinsma, S. (incl. T. Dudok de Wit) et al. Thermosphere and satellite drag. Advances in Space Research, in press (2023).

Cavero, N. R. (incl. C. Malacaria) et al. The First X-Ray Polarization Observation of the Black Hole X-Ray Binary 4U 1630–47 in the Steep Power-law State. Astrophys. J. Lett. 958, L8 (2023).

Cazenave, A. et al. Guest Editorial: International Space Science Institute (ISSI) Workshop on Global Change in Africa. Surv Geophys 44, 1–5 (2023).

Clette, F. (incl. T. Dudok de Wit) et al. Recalibration of the Sunspot-Number: Status Report. Sol. Phys. 298, 44 (2023).

Cocchi, M. (incl. C. Malacaria) et al. Discovery of strongly variable X-ray polarization in the neutron star low-mass X-ray binary transient XTE J1701–462. Astron. Astrophys. 674, L10 (2023).

Colomban, L. (incl. T. Dudok de Wit) et al. Reconstruction of Polarization Properties of Whistler Waves From Two Magnetic and Two Electric Field Components: Application to Parker Solar Probe Measurements. J. Geophys. Res.: Space Phys. 128, (2023).

Coogan, R. T. (incl. M.T. Sargent) et al. Looking ahead to the sky with the Square Kilometre Array: simulating flux densities and resolved radio morphologies of $0 < z < 2.5$ star-forming galaxies. Mon. Not. R. Astron. Soc. 525, 3413–3438 (2023).

Davis, N. (incl. T. Dudok de Wit) et al. The Evolution of the 1/f Range within a Single Fast-solar-wind Stream between 17.4 and 45.7 Solar Radii. Astrophys. J. 950, 154 (2023).

El Azari, H. (incl. T. Dudok de Wit) et al. A Laboratory Evaluation of the New Automated Pollen Sensor Beenose: Pollen Discrimination Using Machine Learning Techniques. Sensors, 23(6) (2023).

Forsblom, S. V. (incl. C. Malacaria) et al. IXPE Observations of the Quintessential Wind-accreting X-Ray Pulsar Vela X-1. Astrophys. J. Lett. 947, L20 (2023).

Froment, C.(incl. T. Dudok de Wit) et al. Whistler waves generated inside magnetic dips in the young solar wind: Observations of the search-coil magnetometer on board Parker Solar Probe. Astron Astrophys, 672:A135 (2023).

Fukushima, S., Sargent, M. T. inter alios, ALMA observations of dust attenuation and star formation in red massive galaxies at z ~5, Astrophys. J. (submitted)

Funke, B. (incl. T. Dudok de Wit) et al. Towards the definition of a solar forcing dataset for cmip7. Geosc Model Devel, 2023:1–14 (2023).

Gardner, J. P. (incl. A. Nota) et al. The James Webb Space Telescope Mission. Publ. Astron. Soc. Pac. 135, 068001 (2023).

Gesu, L. D. (incl. C. Malacaria) et al. Discovery of X-ray polarization angle rotation in the jet from blazar Mrk 421. Nat. Astron. 7, 1245–1258 (2023).

Staff Publications

Gou, J., Shahvandi, M. K., Hohensinn, R. & Soja, B. Ultra-short-term prediction of LOD using LSTM neural networks. J. Geodesy 97, 52 (2023).

Guarcello M.G. (incl. A. Nota) et al. VizieR On-line Data Catalog: 2023yCat..36820049G

Halekas, J. (incl. T. Dudok de Wit) et al. The Value of the Moon for Heliophysics. Bull Amer Astron Soc, volume 55 (2023)

Hartley, P. (incl. M.T. Sargent) et al. SKA Science Data Challenge 2: analysis and results. Mon. Not. R. Astron. Soc. 523, 1967–1993 (2023).

Hohensinn, R. et al. Sensitivity of GNSS to vertical land motion over Europe: effects of geophysical loadings and common-mode errors. Journal of Geodesy (revision submitted, 2024).

Höning, D. & Spohn, T. Land Fraction Diversity on Earth-like Planets and Implications for Their Habitability. Astrobiology (2023) doi:10.1089/ast.2022.0070.

Huang, Z. (incl. T. Dudok de Wit) et al. New Observations of Solar Wind 1/f Turbulence Spectrum from Parker Solar Probe. Astrophysical J Lett, 950(1):L8 (2023).

Karbashewski, S. (incl. T. Dudok de Wit) et al. Whistler Wave Observations by Parker Solar Probe During Encounter 1: Counter-propagating Whistlers Collocated with Magnetic Field Inhomogeneities and their Application to Electric Field Measurement Calibration. Astrophys. J. 947, 73 (2023).

Kokorev, V. (incl. M.T. Sargent) et al. Dust giant: Extended and clumpy star-formation in a massive dusty galaxy at z = 1.38. Astron. Astrophys. 677, A172 (2023).

Krasnoselskikh, V. (incl. T. Dudok de Wit) et al. Ion Kinetics of Plasma Interchange Reconnection in the Lower Solar Corona. Astrophysical J, 959(1):15 (2023).

Krysztofiak, G. (incl. T. Dudok de Wit) et al. N2O Temporal Variability from the Middle Troposphere to the Middle Stratosphere Based on Airborne and Balloon-Borne Observations during the Period 1987-2018. Atmosphere, 14(3) (2023).

Li, Z. (incl. M. Falanga) et al. Broadband X-Ray Timing and Spectral Characteristics of the Accretion-powered Millisecond X-Ray Pulsar MAXIJ1816-195. Astrophys. J. 958, 177 (2023).

Lower, M. E. (incl. C. Malacaria) et al. The 2022 High-energy Outburst and Radio Disappearing Act of the Magnetar 1E 1547.0–5408. Astrophys. J. 945, 153 (2023).

Lu, Y. (incl. M. Falanga) et al. Type I X-ray bursts' spectra and fuel composition from the atoll and transient source 4U 1730–22. Astron. Astrophys. 670, A87 (2023).

Malacaria, C. et al. A polarimetrically oriented X-ray stare at the accreting pulsar EXO 2030+375. Astron. Astrophys. 675, A29 (2023).

Malacaria, C., Ducci, L.; Falanga, M. et al. The unaltered pulsar: GRO J1750-27, a supercritical X-ray neutron star that does not blink an eye. Astron Astrophys 669, A38 (2023).

Mandal, M. (incl. C. Malacaria) et al. Probing spectral and timing properties of the X-ray pulsar RX J0440.9 + 4431 in the giant outburst of 2022–2023. Mon. Not. R. Astron. Soc. 526, 771–781 (2023).

Mishra, R. (incl. M. Falanga) et al. Auroras on Planets around Pulsars. Astrophys. J. Lett. 959, L13 (2023).

Negro, M. (incl. C. Malacaria) et al. The IXPE View of GRB 221009A. Astrophys. J. Lett. 946, L21 (2023).

O'Rourke, J. G. (incl. T. Spohn) et al. Venus, the Planet: Introduction to the Evolution of Earth's Sister Planet. Space Sci Rev 219, 10 (2023).

Raouafi, N. (incl. T. Dudok de Wit) et al. Firefly: The Case for a Holistic Understanding of the Global Structure and Dynamics of the Sun and the Heliosphere. Bulletin of the American Astronomical Society, volume 55, page 333 (2023).

Rigoselli, M. (inc. C. Malacaria) et al., Timing the X-ray pulsating companion of the hot subdwarf HD 49798 with NICER. Mon. Not. R. Astron. Soc. 523, 3043–3048 (2023).

Sioulas, N. (incl. T. Dudok de Wit) et al. On the Evolution of the Anisotropic Scaling of Magnetohydrodynamic Turbulence in the Inner Heliosphere. Astrophysical J, 951(2):141 (2023).

Stauffer, R. (incl. R. Hohensinn) et al. Estimation of tropospheric parameters with GNSS smartphones in a differential approach. Meas. Sci. Technol. 34, 095126 (2023).

Suleimanov, V.F. (incl. C. Malacaria) et al. X-ray polarimetry of the accreting pulsar GX 301–2. Astron. Astrophys. 678, A119 (2023).

Taylor, M. (incl. M. Rast) et al. A cross-discipline approach to examine the physical links between Weather in Space and the Lower Atmosphere. (2023) doi:10.5194/egusphere-egu23-9081.

Tsygankov, S. S. (incl. C. Malacaria) et al. X-ray pulsar GRO J1008–57 as an orthogonal rotator. Astron. Astrophys. 675, A48 (2023).

Wang, Y., Sargent, M. T. inter alios, Cosmic evolution of radio-excess AGNs in quiescent and star-forming galaxies across 0<z <4, A&A (submitted; 10.48550/arXiv.2401.04924)

Xiao, M.-Y. (incl. M.T. Sargent) et al. The hidden side of cosmic star formation at z > 3. Astron. Astrophys. 672, A18 (2023).

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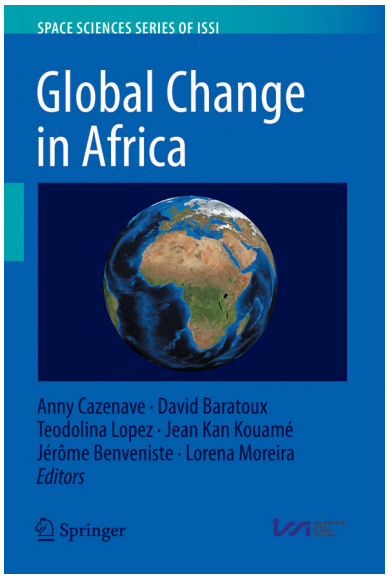

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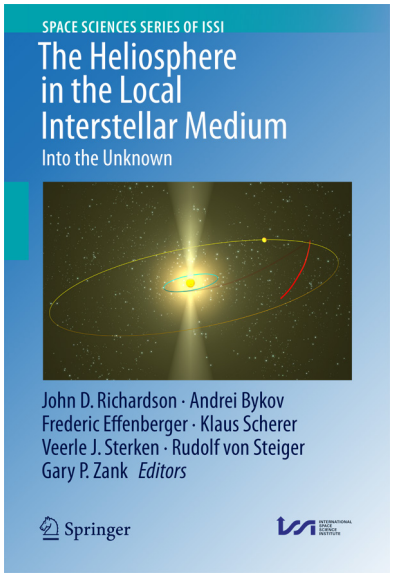

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International Space Science Institute Beijing

The International Space Science Institute in Beijing (ISSI-BJ) was jointly established by the National Space Science Center (NSSC) and the International Space Science Institute (ISSI) with the support of the International Cooperation Bureau and the Space Science Strategic Project of the Chinese Academy of Science (CAS). ISSI-BJ is a close cooperation partner of ISSI in Bern, Switzerland. Both institutes share the same Science Committee, the same study tools, and other information of mutual relevance and interest. However, both use independent operational methods and different funding sources. ISSI-BJ is a non-profit research institute.

Forums

July 20-21, 2023: Detecting Missing Baryons in the Universe

International Teams

July 10–14: "Magnetohydrostatic Modeling of the Solar Atmosphere with New Datasets", led by Zhu X. (CN) & Chifu I. (DE)
September 11–15: "Strong Gravitational Lensing Studies with CSS-OS and EUCLID", led by Li Ran (CN)
September 18–22: "Using Energetic Electron and Ion Observations to Investigate Solar Wind Structures and Infer Solar Wind Magnetic Field Configurations", led by Li G. (US) & Wang L. (CN)
October 30– November 3: "Understanding Electron-scale Magnetic Structures in Space Plasmas", led by Elena Grigorenko (RU) & Huishan Fu (CN)
December 4–8: "Magnetohydrodynamic Wavetrains as a Tool for Probing the Solar Corona", led by Li Bo (CN) & Nakariakov V. (UK)

Outreach Activities

On September 6th, ISSI-BJ organized one Understanding Science live event, with Executive Director Richard de Grijs as speaker of the talk "All Hands to Dance and Skylark! —Captain Cook and Health at Sea". Furthermore, the institute hosted many online seminars, divided in three series: "On Things to Come", which aims to connect with the scientific community and create a much-needed international bridge between institutes, space agencies, and experts from different countries and continents, that was in late 2023 rebranded as "Infinite Horizons"; "1001 Space Nights", in which were presented the research and scientific achievements of outstanding female Chinese scientists; and "Tropical View", seminars that were hosted to foster cooperation in space science and technology in the international academy community.

Space Science School

On October 17–24, 2023, the 3rd ISSI–BJ and APSCO Space Science School on "Exploring the Moon" was held at the Sirindhorn Center for Geo-Informatics (SCGI) located in the Space Krenovation Park (SKP), Si Racha, Chon Buri Province, Thailand. Throughout the School, 6 lecturers and 2 tutors from China shared their knowledge and experience with 25 students from 8 countries. After two days of lectures, the students were divided into two Working Groups, depending on their expertise and background: Understanding the Gravity Field of the Moon, and Field Geology of the Moon. The groups were to analyse evolution and geological events of the Moon. Each group had its own theme and agenda using actual observations, as well as computer models. The different groups were supported and guided by expert tutors.

China-ESA Mars Advanced School

The third China-ESA Mars Advanced School was jointly organized by the International Space Science Institute - Beijing (ISSI-BJ) and the European Space Agency (ESA). Inspired by the scientific investigations conducted by an ever-growing fleet of missions, the Mars School aimed to provide a broad overview of Martian planetary science, from its interior and surface to its atmosphere and interactions with space.

Publications

ISSI-BJ published the No. 21 Taikong issue on "Detecting Missing Baryons in the Universe". The Taikong magazine series constitutes the output of the Forums organized at ISSI-BJ. It reports the contents of the forums and reflects in a neutral way the Forum discussions and advice from all the participants.

Francesca Garfagnoli

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