INTERNATIONAL
SPACE
SCIENCE
INSTITUTE

Annual Report 2022

Cover Page

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

1. The central pair of galaxies are genuinely two separate galaxies. The four bright points circling them, and the fainter one in the very center, are actually five separate images of a single quasar (known as 2M1310-1714), an extremely luminous but distant object. (Image Credit: ESA/Hubble, NASA, T. Treu Acknowledgment: J. Schmidt)

2. This landscape of "mountains" and "valleys" speckled with glittering stars is actually the edge of a nearby, young, star-forming region called NGC 3324 in the Carina Nebula. Captured in infrared light by the James Webb Space Telescope. (Image Credit: NASA, ESA, CSA, and STScI)

3. Illustration of the planet Saturn (Image Credit: Y. Gominet/IMCCE-Observatoire de Paris/CNRS, France – textures NASA)

4. The Sun (Image Credit: ESA/ATG medialab, NASA/ Johns Hopkins)

5. The thin boundary in Earth's protective magnetic field, or magnetosphere, shown here between the blue and yellow regions. (Image Credit: NASA's Goddard/ Space Flight Center/Mary Pat Hrybyk-Keith/Conceptual Image Lab/Josh Masters)

6. Image showing the high central region of the Greenland ice sheet and is captured by the Copernicus Sentinel-2 mission in August 2021. (Image Credit: Copernicus Sentinel data (2021), processed by ESA)

Imprint

Publisher
International Space Science Institute
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Printed by
Länggass Druck AG
Länggassstr. 65
3000 Bern 9
Switzerland

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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 program 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 Chair of the Board of Trustees

This 27th business year of the International Space Science Institute (ISSI), namely, from January 1, 2022, to December 31, 2022, has seen the completion of a healing process. It is with enormous relief and great pleasure that we witness, after the significant and lasting perturbations generated by the Covid crisis, the resuming of all ISSI scientific activities. We can conclude, thanks to an efficient vaccination policy offered to a large fraction of the population, that the Covid pandemic is essentially behind us, allowing, again, in-person meetings, with a remaining small fraction of International Team and Workshop attendees choosing remote connections.

The 2022 ISSI Visiting Committee met in Bern on April 26–27, 2022. This team of five efficient scientists, (Stéphane Berthet, Vice-rector, Univ. of Geneva; Martin Hewitson, Chair SSAC, MPI for Gravitational Waves; Peter Huber, Sublevo AG, Switzerland; Stephan Ulamec, Chair SSEWG, DLR and Chair of the ISSI Visiting Committee, Andrew Watson, member ACEO, Univ. of Exeter) was able to speedily produce a very positive report, extremely useful for the future of ISSI. We are grateful to all of them for their encouraging advice, e.g., emphasizing the "raison d'être" of ISSI, i.e., bringing scientists in person together in Bern in a multi-disciplinary atmosphere with the aim of scientific added values.

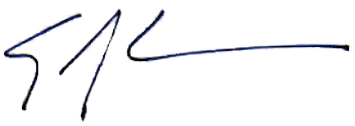
During this past year, important changes happened in the ISSI directorate: three of the four directors are new. On January 1, 2022, Michael Rast took up his duties as new ISSI Director for Earth Observation. On September 1, 2022, Thierry Dudok de Wit took up his duties as new ISSI director for Solar and Plasma Physics. Welcome to both of them. During his time as ISSI Executive Director, which ended on December 31, 2022, Tilman Spohn has successfully conducted ISSI through the difficult years of the Covid pandemic, inaugurating, e.g., the series of Game Changers Online Seminars. Tilman Spohn has also led ISSI in the recent process of resuming all scientific activities. We are grateful to him. Antonella Nota, from STScI in Baltimore, USA, is the next ISSI Executive Director; she took up her duties on January 1, 2023. Originally from Padova, Italy, Antonella Nota has the Italian nationality. Until May 2022, Antonella Nota was the Head of the European Space Agency (ESA) Office at STScI, in Baltimore. Over the years, she has been, among other responsibilities, ESA HST Project Scientist, JWST Project Scientist, and Head of the Science Division at STScI. Welcome to her.

The ISSI Board of Trustees (BoT) has undergone some changes. Those who left the Board are Willy Benz (University of Bern), Johan Bleeker (The Netherlands), Véronique Dehant (Belgium), and Luis de Leon Chardel (Beyond Gravity Ruag). We are grateful to all of them. We welcome the incoming members who are Linda Tacconi (Germany), Nicolas Thomas (University of Bern), and Holger Wentscher (Beyond Gravity Ruag). The ISSI BoT has elected Willy Benz as its next chair, effective on July 1, 2023.

The ISSI funding process by ESA has been simplified and solidified in 2022, thanks to the helpfulness of both ESA and the Swiss Space Office upper managements. This process ended up in the signature in December 2022 of a new funding agreement signed between ESA and ISSI for the next three years. We are grateful to ESA for its essential financial support.

Another important event of this past year was the signature of the extension, for another three-year period, of the agreement of cooperation between ISSI Bern and ISSI Beijing, via the National Space Science Center of the Chinese Academy of Sciences. We look forward to further developing the already excellent and productive synergy between our two institutes.

We are grateful to all ISSI main actors, namely, its directorate and its staff, its Science Committee, and its BoT, for their excellent work and continuous dedication. ISSI is an Institute for Advanced Studies, one of a kind, at which scientists from all over the world come to work together to analyze and interpret space-based data, frequently in synergy with ground-based data. We are extremely grateful to all ISSI funding agencies. We hope that ISSI will be in a position of broadening its scientific activities through the simultaneous increase of the number of its funding agencies and of their financial support.



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

From the leaving Executive Director

Dear friends of ISSI!

Four years passed quickly! I still recall my first staff meeting in January 2019 as the new executive director following Prof. Rafael Rodrigo. I attended this meeting remotely from Pasadena, California, where I was tending for my heat flow experiment on the NASA InSight lander on Mars. Who would have thought that remote meetings would become as important as they did in the years to follow? When I moved back to Europe in March 2019 things seemed to evolve as they were expected. We were preparing for a two-days retreat to discuss with the ISSI Board, the Science Committee and external experts how ISSI should move forward in the coming years. This retreat – held at the ISSI premises – turned out to be the last meeting at Hallerstrasse 6 for months to come! All in all, the pandemic would cause ISSI to shut down for a total of about a year with intermittent periods of reduced activities and visitor numbers. Perhaps one of the sad highlights was the much-anticipated workshop on Global Change in Africa in January 2021 which had to be fully remote, unfortunately!

It was so great then to see the ISSI community come back in large numbers in the spring of last year 2022. A record number of 1031 scientists have attended more than 100 activities (International Teams, Working Groups, Workshops and Fora) in Bern since the spring in 2022, with more than 700 in addition attending from remote. This compares with a pre-pandemic number of around 950 visitors/year. To compensate for the pandemic times, ISSI was running at >150% of its usual capacity and continues to do so into the year of 2023; a workload happily accepted.

Our main concern during the pandemic was, of course, the well-being of our visitors and staff but we were much concerned about keeping the ISSI program alive, which we could accomplish with the help of online services. Our efforts then of making ISSI more digital will hopefully continue to serve the institute in the future. ISSI's popular online seminar series was launched in the summer of 2020 and has attracted more than 10'000 attendees to date and the ISSI tools (the Workshops, Working Groups, Teams, Fora and the Visiting Scientist's program) were made more flexible and accessible also from remote. The quiet months were used to build a more spacious auditorium named after ISSI's founding father Johannes Geiss. ISSI invested into digitalization and web-based communication services with software apps to ease collaboration and the Johannes Geiss Auditorium and the three meeting rooms were equipped with state-of-the-art hardware for hybrid meetings. Open access publishing was made the norm. Finally, we were able to put ISSI's funding on a more stable foundation and improve the social security plans of the staff.

I am sure that ISSI will continue to flourish under its new leadership, with Antonella Nota taking over the executive director's position on January 1st, 2023. I am confident that ISSI will keep serving the entire space science community with all the aspects and subfields it served over the past more than 25 years, keeping a good balance and producing excellent research! There remains my deep appreciation of the ISSI staff and of what we could achieve together!

Tilman Spohn
Executive Director 2019–2022

From the new Executive Director

I am delighted to introduce myself as the new ISSI Executive Director. I joined this splendid and unique organization in January 2023, and after five months on this job, I feel very privileged to call ISSI my new home. An astrophysicist by background, I bring to this job many years of scientific leadership in large organizations, an active scientific life, and a deep appreciation for the role that an institution like ISSI holds, to advance space science in Switzerland, Europe and the world.

Starting with its central location in Europe, in beautiful Bern, ISSI advances science by inviting scientists from all over the world to gather and discuss compelling scientific topics in a neutral, welcoming, and collaborative multidisciplinary setting. Fully recovered from the pandemic hiatus, ISSI is now bustling with activities, having welcomed more than 1000 visitors in 2022. The demand to come and visit ISSI, as an individual scientist or a team, is quickly surpassing pre-pandemic levels, and we are expecting it will grow further over the years.

Looking at the future, ISSI's future is bright. The financial situation is solid and stable and my plan is to build on the accomplishments of my predecessors to develop ISSI's great potential further and keep in step with the fast evolution of science.

I was especially attracted to come to ISSI by the multidisciplinary nature of this institution. There is so much to explore in bringing diverse communities together, share experiences and lessons learned. In addition, as scientists, we are fortunate that we are living in a golden era, where ambitious space missions are being flown, are operated in synergy and where scientific discoveries are happening at a very fast pace in multiple disciplines. In the years, ISSI has already held a huge role in facilitating the scientific dialogue, and, within ISSI's leadership team, we already actively discussing together how to best position ISSI for a future of advancing science and serving effectively our vast scientific community. Stay tuned as we develop our scientific plan for the next few years. I can already anticipate that our shared goals are to expand our reach, make ISSI's initiatives more accessible and open to you all, and be inclusive, diverse, and welcoming as ISSI has always been.

One final word about the ISSI staff: I would be remiss not to acknowledge the amazing team that is at the foundations of this organization. It is a small team, but offers a concentrate of scientific expertise and technical and administrative excellence that is very unique. And they are all ready to welcome you when you visit.

Finally, my gratitude to the ISSI Board of Trustees, and especially Chair Prof. Georges Meylan and Deputy Chair Prof. Monica Tosi for entrusting me at the helm of this unique organization, and to my predecessors, who have invested their vision, their career and their scientific leadership in creating and shaping the ISSI we all enjoy today.

I look forward to welcome you all in person to ISSI in the not too distant future.

Antonella Nota
ISSI Executive Director from 2023

From the Directors

The twenty-seventh year of ISSI started out as the previous year had ended continuing with a COVID-related quasi lock-down. Fortunately, the situation improved in the following months, and brought ISSI back to almost pre-COVID normality. Visitor numbers were low in the first months as had been the case in fall 2021. But in March and April 2022, the ISSI community came back and there was a lot of catching up to do. A record number of 1031 scientists have attended 100 activities (International Teams, Working Groups, Workshops and Fora) in Bern since then, with an addition of more than 700 participants attending remotely. ISSI was running at 150% of its usual capacity and continued to do so for the rest of the year; a workload happily accepted. It felt so good to be back to (almost) normal!

The year ended with a great success when ESA and ISSI signed an Agreement of Cooperation on December 15, 2022 to secure continued cooperation and stable funding for both the Space- and Earth sciences. The agreement of cooperation will foster the multi-disciplinary exploitation of space science and Earth science data from ESA missions to maximize their scientific return.

During the twenty-seventh year, six Workshops were held, in addition to four Working Group meetings, two Fora, one on Lunar Gravitational-Wave Observation and a second on Physical Links Between Weather in Space and Weather in the Lower Atmosphere, and 88 International Team meetings, all described in more detail on the subsequent pages. Of the 1031 visitors, 475 visited ISSI for the first time. Around 30% were female scientists and 15% were early career scientists, i.e. within 2 years of obtaining their PhD. ISSI is strongly committed to further supporting gender balance and the involvement of young scientists in its scientific activities.

ISSI's Game Changers online seminar series continued with four blocks and a total of 32 talks on "Habitability – From Cosmic to Microbial Scales", "Viewing Earth from Space – the Changing Environment and Climate of our Planet", "Captivating Cosmology: From the Big Bang to Tomorrow", and "Space Environmental Hazards: Mitigation and Prediction". More than 10 000 attendees haven been counted since the series started in the summer of the first pandemic year of 2020.

The publication record has grown in the past year with over 250 peer-reviewed papers published by International Teams. Seven SSSI books are in preparation or being brought together with their equivalent Space Science Reviews and Surveys in Geophysics online versions already (partly) published. Open access publishing has now become the norm.

On July 12th, ISSI organized an event to celebrate the release by NASA/ESA/CSA of the first images and spectra from the James Webb Space Telescope (JWST). Numerous representatives of the Swiss national space science community, industry, and government, as well as all ISSI Directors and Swiss media outlets gathered at ISSI. Before the live broadcast from NASA, several researchers presented their JWST projects – including Adrian Glauser, who led the Swiss contribution to the development of the MIRI instrument.

ISSI benefited from and enjoyed the stay of Marco Velli, who was our 2022 Johannes Geiss Fellow. Sandra Chapman was elected as the 2023 Johannes Geiss Fellow.

ISSI's Science Committee met again in-person for two regular meetings to review and discuss future activities. At the Spring meeting, the Committee reviewed 57 Team proposals and recommended 25 for implementation, 4 of which were joint with ISSI-Beijing. The rather low number of 57 applications reflected continued uncertainties due to COVID and unpredictable travel restrictions. For future International Team proposals, the Science Committee decided to implement a blind review process for the science justification section. Of course, the team composition and added value of ISSI remain essential aspects of the evaluation and the final ranking of the proposals. This new evaluation procedure will be effective as of the 2023 call for International Team proposals. At the Science Committee fall meeting, two Fora and five Workshops were recommended for implementation in 2023.

In the ISSI staff, we had the privilege of celebrating Andrea Fischer's 15 years of service to ISSI. We congratulate her most sincerely for her commitment. We warmly welcomed two new Directors in our Directorate team; Michael Rast, as of January 2022 for Earth Observations and Thierry Dudok de Wit, as of September 2022 for

From the Directors

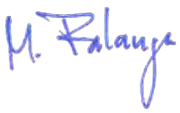
Solar and Space Plasmas. ISSI is privileged to have such committed Directors. Two postdoctoral researchers left us: Julia Venturini (Planetary Sciences) in January 2022 and Lorena Moreira (Earth Sciences) in May 2022, both after completing their two-year term. We thank them for their valuable contribution to ISSI, both in science and in helping to organize Workshops. The two open positions were filled with Christian Malacaria (High Energy Astrophysics) in June 2022, and Roland Hohensinn (Earth Sciences) in August 2022. After almost two years, our part-time secretary Yemisi Momoh found a new position and left ISSI in October 2022. We wish her all the best for her future career.

After four years, at the end of 2022, our Executive Director, Tilman Spohn, left ISSI. We would like to thank him for everything he has done for ISSI during his term. He kept the institute active during the pandemic by using online seminars and remote access techniques and by engaging with the entire ISSI community and even increasing the visibility of ISSI. He leaves a thriving institute, fully staffed by motivated employees, and with funding secured for the next several years. It was a pleasure to work with him because of his open-mindedness and clear visions based on substance, hard work, and his dedication to the mission of excellence as a small and beautiful institute. When leaving Tilman Spohn stated: *"I am confident that ISSI will keep serving the entire space science community with all the aspects and subfields it served over the past more than 25 years, keeping a good balance and producing excellent research! I will fondly remember the 4 years with you at ISSI and what we accomplished together"*.

As of January 2023, the ISSI Board of Trustees has appointed Antonella Nota as the new Executive Director. We wish her a good start in her new and challenging position.

Tilman Spohn

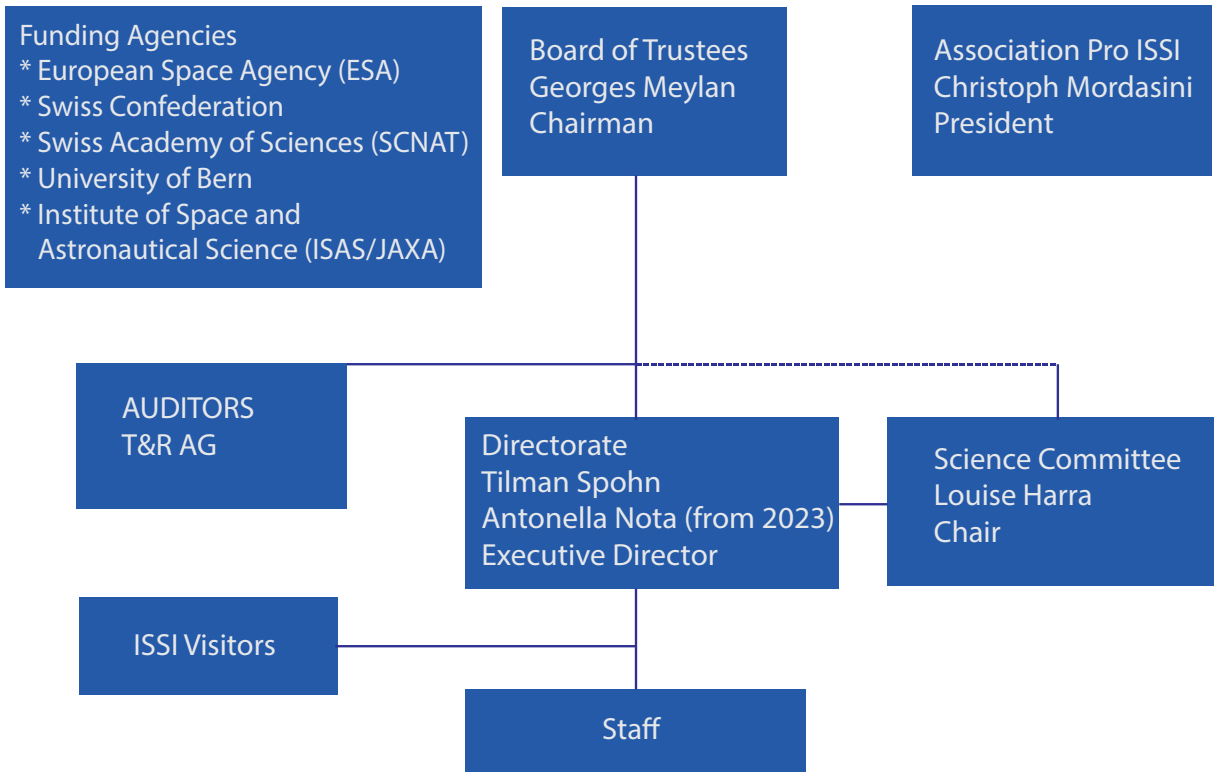
Thierry Dudok de Wit



Maurizio Falanga

Michael Rast

About the International Space Science Institute



The International Space Science Institute (ISSI) is a nonprofit organization 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 Georges Meylan.

The **Science Committee**, chaired by Louise Harra, 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 Tilman Spohn (Executive Director), Maurizio Falanga (University of Bern), Thierry Dudok de Wit and Michael Rast. As of January 2023, Antonella Nota is ISSI's new Executive Director.

The **Association Pro ISSI** promotes the idea of ISSI by organizing public lectures, where 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: The 27th Year

The Program and its Elements

ISSI's mode of operation is generally fivefold: multi- and interdisciplinary Workshops, Working Groups, International Teams, Forum, and Visiting Scientists. 1031 international scientists participated in the scientific activities of ISSI in person in 2022. 475 visited ISSI for the first time.

Workshops consist of up to 50 invited scientists exchanging their views on a scientific theme, typically during a week's duration. 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 the 27th year, six Workshops were organized, summaries of which can be found on the following pages.

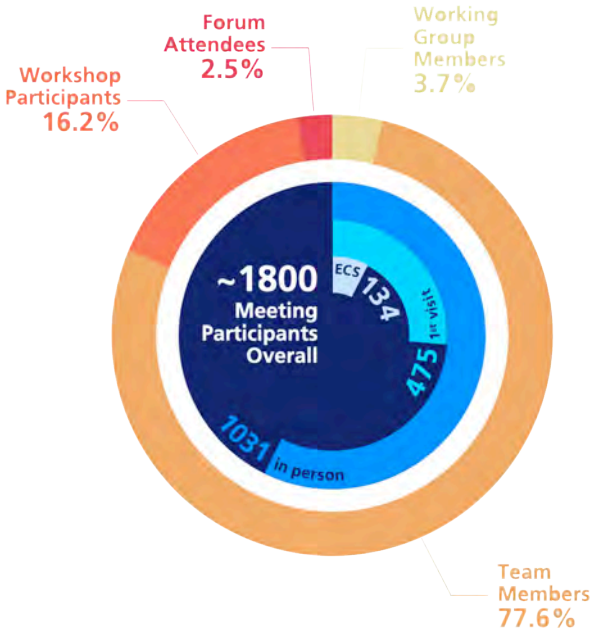
International Teams consist of about 15 external scientists, addressing a specific scientific topic in a self-organized fashion. The results of these activities are customarily reported in scientific journals. Details can be found starting on page 22.

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

Working Groups have a smaller number of members and meet as often as necessary to achieve the assigned objective. One new Working Group started its project in 2022. 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 to 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 2022, 12 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 honor 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)** Program 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. A record number of 134 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 https://www.issibern.ch/program/tools/. 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

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. In 2022 there was a line of talks on "Habitability – From Cosmic to Microbial Scales". This was followed by a series entitled "Viewing Earth from Space – the Changing Environment and Climate of our Planet" which specifically focused on science issues of our carbon-, energy- and water cycle, crucial for a deeper understanding of the Earth as integrated system, including climate and global environmental processes and impact parameters as well as related societal challenges. In the series "Captivating Cosmology: From the Big Bang to Tomorrow" the speakers addressed our current understanding of signature cosmic epochs and constituents, and looked ahead to future missions and experiments.
The space environment is traditionally associated with hazards that can have adverse effects on humans and technology. Various strategies have been developed to mitigate them or to find ways to predict their impact. The last series in 2022 on "Space Environmental Hazards" took a closer look at the close link between space science and the societal impacts of these hazards.
The webinars were recorded and are available at www.issibern.ch/publications/game-changers-seminars/ where upcoming talks are being advertised too. Between roughly 100 and 400 participants have attended the live webinars, many as loyal participants throughout the series.

Habitability – From Cosmic to Microbial Scales

Origin of Life with Antonio Lazcano (University of Mexico, Mexico) – 27 January 2022

Cosmic Explosions and Galactic Life with Tsvi Piran (The Hebrew University of Jerusalem, Israel) – 10 February 2022

A Cosmic Perspective: Searching for Aliens, Finding Ourselves with Jill Tarter (SETI Institute, California, USA) – 17 February 2022

Life in Extreme Environments with Ricardo Amils (University of Madrid, Spain) – 24 February 2022

The Habitable Zone Hypothesis: A Critical Look with David C. Catling (University of Washington, USA) – 3 March 2022

Is Water and Rock all that is needed? Geology, Life and Habitability with Frances Westall (CNRS Orléans, France) – 10 March 2022

Life as an Agent of Sustaining Habitability with Aditya Chopra (Visiting Fellow, Australian National University) – 17 March 2022

Space Weather, Space Climate and Habitability on Earth with Thierry Dudok de Wit (University of Orléans, France) – 31 March 2022

The Habitability of Galaxies and the Spread of Life with Raphaël Gobat (Catholic University of Valparaíso, Chile) – 7 April 2022

Viewing Earth from Space – the Changing Environment and Climate of our Planet

Future Food and Water Security – the Role of Remote Sensing with Wolfram Mauser (Ludwig Maximilians University, Germany) – 6 May 2022

Changing Northern Lands – Thawing Ground and Expanding Use with Annett Bartsch (b geos, Austria) – 13 May 2022

The Earth Energy Imbalance and its Implications with Karina von Schuckmann (Mercator Ocean International, France) – 19 May 2022

Arctic Changes Derived from Satellites with Johnny Johannessen (NERSC, Norway) – 3 June 2022

Water and Energy Cycle from Satellites: From Global to Storms Scales with Rémy Roca (CNRS, France) – 10 June 2022

Embedding Space into Natural Capital Stewardship and the Global Carbon Markets with Jacqueline McGlade (FLS, FRSA, Kenya) – 17 June 2022

Creating "Agency" to Act on Climate Change with Chris Rapley (UCL, United Kingdom) – 23 June 2022

ESA CLIMATE CHANGE INITIATIVE in support of Terrestrial Carbon science: A view from Space with Clement Albergel (ESA Climate Office, UK) – 30 June 2022

Game Changers Online Seminars

State of the Climate Crisis: Changes in Climate Extremes and Relevance of Remote Sensing Data with Sonia I. Seneviratne (ETH Zurich, Switzerland) – 7 July 2022

Captivating Cosmology: From the Big Bang to Tomorrow

On the Emergence of Relativistic Structure from Discrete Space-Time with Tim Maudlin (New York University, USA) – 8 September 2022

An Infinity of Worlds: Cosmic Inflation and the Beginning of the Universe with Will Kinney (University of Buffalo, USA) – 15 September 2022

The Cosmic Neutrino Background with Julien Lesgourgues (RWTH Aachen, Germany) – 22 September 2022

Inflation Ends, What's Next? A Story of How the Hot Big Bang Began with Mustafa Amin (Rice University, USA) – 29 September 2022

Latest from the CMB with Erminia Calabrese (Cardiff University, UK) – 6 October 2022

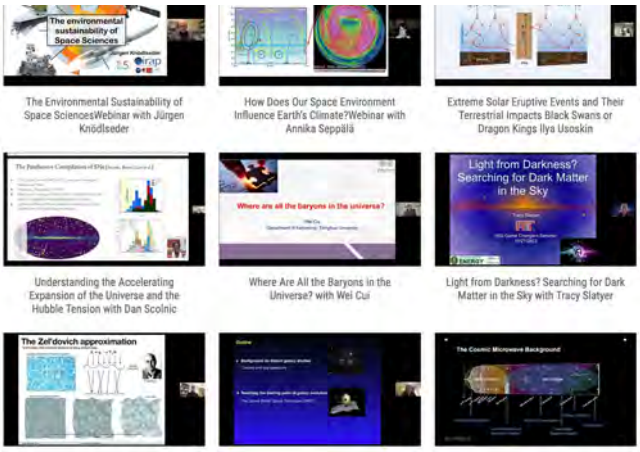
The First Steps of Galaxy Evolution with Karina Caputi (University of Groningen, NL) – 13 October 2022

Structure Formation and the Cosmic Web with Oliver Hahn (University of Vienna, Austria) – 20 October 2022

Light from Darkness? Searching for Dark Matter in the Sky with Tracy Slatyer (MIT Department of Physics, Cambridge, USA) – 27 October 2022

Where Are All the Baryons in the Universe? with Wei Cui (Tsinghua University, China) – 3 November 2022

Understanding the Accelerating Expansion of the Universe and the Hubble Tension with Dan Scolnic (Duke University, USA) – 10 November 2022



All online seminars are recorded and are available on ISSI's webpage: https://www.issibern.ch/publications/game-changers-seminars/

Space Environmental Hazards: Mitigation and Prediction

Extreme Solar Eruptive Events and Their Terrestrial Impacts: Black Swans or Dragon Kings? with Ilya Usoskin (University of Oulu, Finland) – 24 November 2022

How Does Our Space Environment Influence Earth's Climate? with Annika Seppälä (University of Otago, New Zealand) – 2 December 2022

The Environmental Sustainability of Space Sciences with Jürgen Knödlseder (CNRS, Toulouse, France) – 9 December 2022

Flying with Space Weather: Auroras to GPS with Klaus Sievers (IFALPA – International Federation of Airline Pilots´ Associations) – 16 December 2022

Lunar Gravitational-Wave Observation

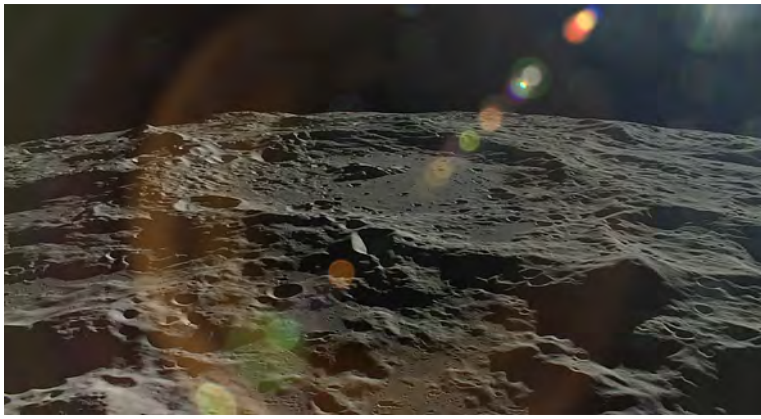
5–6 October 2022

Lead experts in seismology, planetary science, gravitational-wave (GW) detection, and multi-messenger astrophysics met in Bern to discuss a common vision for lunar GW detection to be realized in the coming decades. The Moon offers an extremely quiet environment ideal for GW detectors. Permanently shadowed regions at the lunar poles offer the additional advantage of cold and thermally more stable environments. Such conditions can be created on Earth only through great experimental effort and with significant technological risks.

In order to realize breakthrough detector concepts on the Moon, one must understand the geophysics, geology, and deep internal structure of the Moon much better than today. This draws a natural and fruitful connection between GW and lunar science, and instruments to be deployed on the Moon in the coming years for geophysical studies provide important information also for lunar GW detection. Conversely, lunar GW detectors will be formidable geophysical stations. It is to be expected that this connection will lead to many interesting synergies. These connections were drawn in various discussions at the Forum, for example, in talks on lunar GW response, lunar seismic backgrounds, and methods to mitigate background noise in GW detector data. Furthermore, all GW detector concepts discussed at the Forum rely on seismic sensing technology, either because the detector would measure the deformations of the Moon produced by GWs, or because seismometers are needed as part of a vibration-control system. A new generation of laser retro-reflectors might be a basis for the development of future optical components in long-baseline lunar laser interferometers.

Several presentations were given about the GW science case of lunar GW detectors. Especially the decihertz band, which is inaccessible from Earth and will remain uncovered by the LISA detector, offers great opportunities for breakthrough observations. It would be possible to study the distribution of intermediate-mass black holes at high redshift to understand their role as seeds of massive black holes found today in the center of most galaxies. Decihertz observations would also make it possible to study the merger of white-dwarf binaries, which are considered a possible progenitor of supernovae type 1a. New ideas about the detection of GWs emitted by jets were discussed. The observation of an electromagnetic counterpart to these GW signals would greatly enhance our understanding of these sources. Lunar GW detection would also create synergies with other GW detectors. Observations of the same GW source together with terrestrial or space-based detectors would greatly enhance capabilities to analyze GW signals.

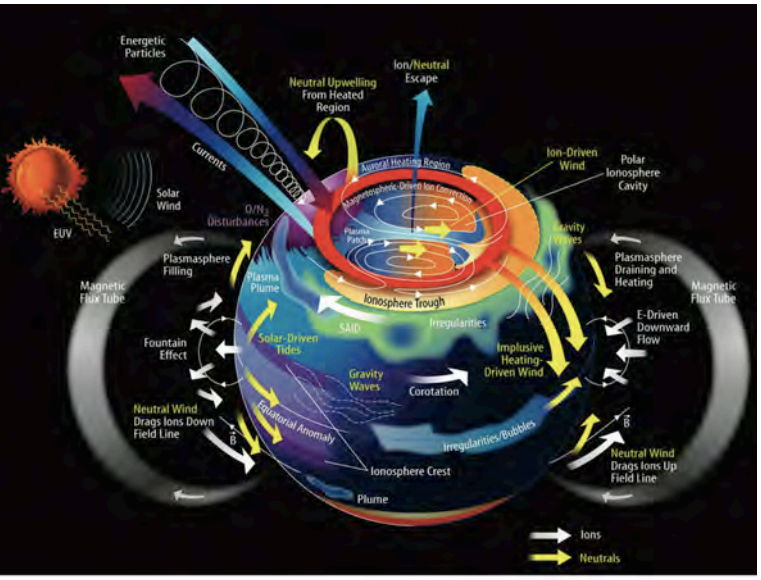
Forums are informal and free-ranging debates among some twenty-five high-level participants on open questions of a scientific nature or on science policy matters. Forums do not necessarily lead to formal recommendations or decisions.



A high-definition image of the Mars Australe lava plain on the Moon taken by Japan's Kaguya lunar orbiter in 2007. (Image Credit: JAXA/NHK)

The Forum was a great success with the clear message that lunar GW detectors can play an important role in the landscape of future GW detectors. The collaboration between planetary scientists and GW scientists must continue to be able to realize the vision of lunar GW detection, which will also benefit lunar science.

Jan Harms and Maurizio Falanga



Processes coupling atmosphere, ionosphere and magnetosphere driven by Solar input. (Image courtesy of Joe Grebowsky, NASA Goddard Space Flight Center)

Physical Links Between Weather in Space and Weather in the Lower Atmosphere

14–16 November 2022

The Earth's atmosphere interfaces with the "sea of plasmas" surrounding it via its Ionosphere and the upper and middle Atmosphere, providing an interface layer through which a broad diversity of energy transfer processes takes place. Developing an integrative understanding of global geospace energy transfer processes affecting this layer is a major scientific challenge with important societal implications.

The Forum to that respect on "Physical Links Between Weather in Space and Weather in the Lower Atmosphere" took place at ISSI between 14 and 16 November 2022. Main object of this Forum was to develop a deeper understanding of the solar and terrestrial interactions through energy transfer processes between the Ionosphere and the upper- and middle atmosphere, thus possibly enabling the detection of signatures by natural and anthropogenic hazards. The results of this analysis should be based on the existing worldwide capability in the field and should support the conceptual design of a future space-borne observing capability.

The Forum noted good progress and results demonstrating the value of studying forcing from above (impact of weather in space on the weather in the middle and lower atmosphere). Likewise, the Forum saw similar studies/projects that demonstrated the scientific value of including forcing from below in the studies of weather in space. The Forum encouraged these links to be analyzed in a broader perspective, and with more scientists and scientific sub-disciplines involved.

Further the Forum recommended to consider the establishment of a framework where all related observations can be brought together for assimilation and visualization (including data from ground-and space based systems). This would necessitate an interoperable 'working' environment with homogeneity in data formats. etc.

One of the conditions for such environment would be to improve discoverability and interoperability of ground and space based data. This could enable the development the concept of an Ionosphere-Thermosphere-Mesosphere Observatory, using existing and planned missions as focal points.

Further a gap analysis and roadmap of ancillary investigations and/or measurements that could be inserted into the ground + satellite observations expected around 2030 would need to be provided.

The Forum suggested to further these recommendations and address the topics raised by the Forum in more depth as part of an ISSI Workshop, which ought to follow the Forum rather soon.

Rune Floberghagen, Anja Stromme, Matthew Taylor, and Michael Rast

New Vision of the Saturnian System in the Context of a Highly Dissipative Saturn

9–13 May 2022

The Workshop brought together many experts on the Saturnian system, including dynamicists, planetologists, star physicists and observers, to cover all the physical aspects that could be related to tides in Saturn. Four years after the end of the Cassini mission, we now have a good overview of the essential mechanisms that are at work in the Saturnian system. In particular, it is well understood that the Saturn system is like an ecosystem, where all parts of it are connected through complex dynamical interactions: rings, moons and magnetosphere; Saturn's atmosphere and rings; Saturn's deep interior and moons' dynamics and interior through tides. However, important questions still required to be debated before our ISSI international Workshop. In that respect, the recent discovery of a new tidal dissipation mechanism currently at play inside Saturn opened new roads for assessing the past history of this system. Hence, putting together all these aspects into one workshop was essential.

A lot of discussion time was evidently required, but we could benefit from the work that had been done in advance, especially in the context of the pandemic that forced us to postpone our meeting for months. Working groups had been established and online short meetings had taken place to discuss certain technical aspects in smaller groups. The working groups were the following: Rings composition; Rings age; Moons formation and long-term orbital evolution; origin of Enceladus tidal dissipation; possible tidal lock mechanism in Jupiter and exo-planets.

During our Workshop, a summary of each subgroup discussion was presented, followed by extra talks. Overall, we revisited some of the key questions that concerns the Saturnian system. This includes the age of the rings and the main moons, their possible formation mechanism, the origin of tidal dissipation within Saturn and Enceladus, and eventually the role that the Saturnian system can to other systems.

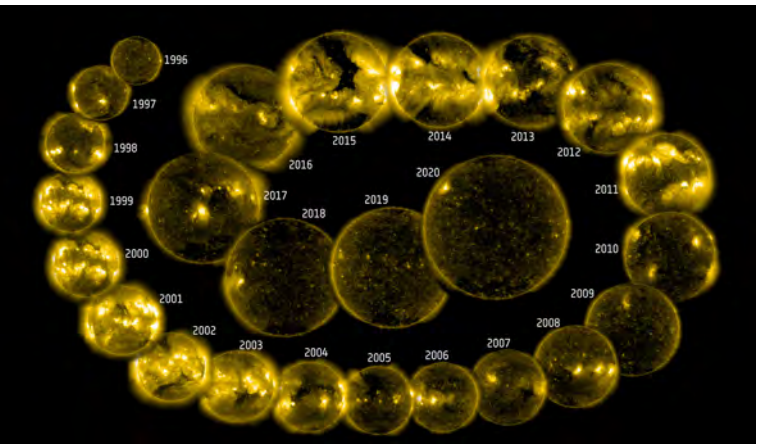
Since the end of the Workshop, all participants are actively working on the Space Science Reviews articles. The originality of our book will be the interdisciplinary (fully open to controversial ideas) approach, the introduction of up-to-date scientific results derived from Cassini, not published in any other book at the time. As a consequence, any reader interested in understanding the essential results and open questions concerning the rings and satellites of Saturn may find some interest in our book. Moreover, the multidisciplinary approach shall give the reader a broad sense of the current techniques used and theoretical knowledge acquired in planetology in 2023.

The Workshop was convened by Valéry Lainey (IMCCE, France), Michel Blanc (IRAP, France), Aurélien Crida (Obs. de la Côte d'Azur, France), Maryame El Moutamid (Cornell University, USA), Gianrico Filacchione (IAPS, Italy), Carly Howett (SRI, USA), and Linda Spilker (NASA JPL, USA).

Valéry Lainey

Workshops are selected by the Directorate in consultation with the Science Committee. Proposals or suggestions for Workshops may originate from the external community. The program 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.

Participants of the Workshop "New Vision of the Saturnian System in the Context of a Highly Dissipative Saturn"



SOHO has observed two of the Sun's 11-year sunspot cycles, as solar activity waxes and wanes. This montage of 25 images captured by the spacecraft's Extreme Ultraviolet Imaging Telescope provides a snapshot of the changing face of our Sun. (Image Credit: SOHO (ESA & NASA))

Solar and Stellar Dynamos: A New Era

13–17 June 2022

The magnetic activity of the Sun has a major impact on the terrestrial space environment and can also disturb technical systems on Earth, such as power grids. Similarly, the activity of other stars affects the habitability of exoplanets. The generation of magnetic flux in stars by self-excited dynamo processes is therefore a topic with relevance reaching beyond solar and stellar physics.

During the last decade, a wealth of observations from observatories on the ground and in space, together with a new generation of large-scale numerical simulations, allowed us to approach the true complexity of the interaction of turbulent convection, rotation, and magnetic fields, thus leading to substantial progress in our understanding of solar and stellar dynamos. Dynamo models addressing the variation of the magnetic field in the solar interior and at its surface in the course of the 11-yr activity cycle have become more and more detailed and realistic. The crucial processes of formation, rise, and emergence of magnetic flux loops in the course of the solar dynamo process are now studied in simulations covering the whole range from the convection zone into the corona. The operation of small-scale dynamo processes is revealed by high-resolution solar observations, which can be directly compared with numerical simulations of radiative magneto-hydrodynamics. Space missions such as Kepler are dramatically increasing the amount of information on rotation, magnetic activity, and cycles for a wide range of stellar parameters.

These developments herald the beginning of a new era in dynamo research. Understanding of the underlying processes and the possibility to compare with a broad base of observational data puts the necessary parametrizations in simplified dynamo models on a firmer basis. It now becomes possible to study dynamos for a wide range of stellar parameters and evolutionary stages. The ubiquitous magnetic fields generated by small-scale dynamos are important for a many astrophysical systems. They affect crucial aspects of convective turbulence such as the transport of energy and angular momentum, as well as the driving of large-scale flows.

At this stage of affairs, it was the right time to review and put into perspective the wealth of results from observations, simulations, and simplified models in the form of an ISSI Workshop, bringing together more than 50 established as well as young researchers working in the relevant areas: solar and stellar observations from space and ground, numerical simulations, turbulence theory, and dynamo models. This gave the unique opportunity to broadly review the state of the art, outline the open questions, and discuss approaches to make further progress.

The Topical Collection of review papers in Space Science Reviews resulting from the Workshop and its collection in the form of an ISSI book (Space Sciences Series of ISSI) will provide a unique up-to-date comprehensive and critical overview of the whole field, aimed as a reference volume for years to come.

The Workshop was convened by Robert Cameron (MPI for Solar System Research, Göttingen, Germany), Paul Charbonneau (Université de Montréal, Canada), Mausumi Dikpati (NCAR, Boulder, USA), Hideyuki Hotta (Chiba University, Japan), Leonid Kitchatinov (Institute for Solar-Terrestrial Physics, Irkutsk, Russia), and Manfred Schüssler (MPI for Solar System Research, Göttingen, Germany).

Manfred Schüssler

Magnetic Reconnection: Explosive Energy Conversion in Space Plasmas

27 June – 1 July 2022

Magnetic reconnection is a fundamental energy conversion process in collisionless plasmas. While the changes in topology of the magnetic field take place inside a small region where electrons become unmagnetized, regions of acceleration and heating of plasma are distributed at larger scales, driving global plasma transport or leading to sporadic magnetic energy release on global scales such as substorms, flares and gamma ray bursts. Among the different plasmas, Geospace is a natural plasma laboratory to study the ground truth of how magnetic reconnection operates in nature, since plasmas and fields in action can be directly measured at high cadence. Multi-point measurements, where temporal and spatial variations can be separated, are essential for detecting the complex energy conversion processes relevant to magnetic reconnection. Observations by Cluster and THEMIS enabled us to study magnetic reconnection in terms of large-scale consequence and ion-scale physics by obtaining spatial structure using the multi-spacecraft capabilities. The MMS mission, launched in March 2015, enabled for the first time the exploration of electron-scale physics with high-time resolution measurements from the four-spacecraft. With these advances in in-situ measurement capabilities, studying non-ideal MHD and kinetic physics of magnetic reconnection and relevant plasma processes became possible for the first time from spacecraft observations, and a number of new analysis schemes have been newly developed for characterizing the temporal/spatial changes of the complex plasma processes. Recent advances in theoretical simulations have significantly contributed to understanding magnetic reconnection not only for Geospace but for astrophysical plasma. Dedicated simulation runs for direct comparison between the theory and the observations became possible in the MMS era for electron-scale physics.

Traditional Workshop picture of the participants

The objective of the Workshop is to review the significant progress made in the MMS era in research on magnetic reconnection and relevant processes in space plasma, based on in-situ multi-point observations and theoretical simulations and also to discuss the magnetic reconnection beyond Geospace plasma: astro, solar, planetary as well as laboratory. The Workshop gathered 56 scientists (42 face-to-face and 14 remote) from 10 countries, with 8 early career scientists from different expertise. The Following five topics are highlighted in the workshop (1) Micro-scale processes of magnetic reconnection, (2) Role of waves and turbulence, (3) Multi-scale aspects and large-scale context/consequence of magnetic reconnection (4) Magnetic reconnection in other environments: planets, sun and solar wind, astrophysical context, laboratory, (5) Advanced data analysis techniques and simulation techniques. Following the Workshop, a collection of comprehensive papers on magnetic reconnection covering both the most advanced research in the MMS era and tutorials about in-situ space plasma data analysis and simulation schemes will be published in a volume of the Space Science Series of ISSI and as a Topical Collection in Space Science Reviews by Springer, organized in 16 chapters.

The Workshop was convened by (in alphabetic order) James L. Burch (Southwest Research Institute, USA), James F. Drake (University Maryland, USA), Barbara L. Giles (NASA/GSFC, USA), Michael Hesse (NASA/ARC, USA), Masahiro Hoshino (University of Tokyo, Japan), Benoit Lavraud (CNRS/LAB, France), Rumi Nakamura (OEAW/IWF, Austria), and Roy B. Torbert (University New Hampshire, USA).

Rumi Nakamura

Workshops

The Workshop "Strong Gravitational Lensing" took place in the new Johannes Geiss Auditorium at ISSI. Most of the involved scientists could participate physically, about ten colleagues joint remotely.

Strong Gravitational Lensing

18–22 July 2022

The first gravitationally lensed quasar – Q0957+571A,B – was discovered in 1979. By now more than 300 multiply imaged quasars are known, they have been explored since then for a wide range of cosmological questions: measurements of time delays, determination of the Hubble constant, detection of microlensing, measurements and limits on compact and smooth dark matter, exploration of quasar size and luminosity profile, to name just a few. In 1986/7, giant luminous arcs were discovered, background galaxies which are strongly lensed by foreground galaxy clusters. These highly magnified high redshift galaxies help us better understand formation and evolution of galaxies in the early universe as well as the mass substructure in galaxy clusters. Recently, a number of new and exciting strong lensing discoveries and predictions make this field very timely and open up new routes for exploration, e.g. the discovery of gravitationally lensed supernovae (which had been suggested by Sjur Refsdal in the early 1960s!), and we are all eager to soon see the first gravitationally lensed fast radio burst and gravitational waves.

So it was very timely to plan a Workshop on "Strong Gravitational Lensing". It was originally approved in 2019 and scheduled for summer 2020. Due to corona measures, it could not take place at the originally envisioned time. First, the conveners decided to postpone the Workshop. But the measures dragged on, and since nobody knew how long the pandemic constraints would last, the conveners decided to pursue the "reverse" scheme which had been suggested by the then executive director Tilman Spohn. So we started with an online kick-off meeting in January 2021, at which the main topics to be pursued were defined. Participants volunteered or were invited to join the various topical teams. This starting event was followed by 13 further online plenary meetings, roughly every six to eight weeks. In between, the various topics/chapters were worked on by the dedicated chapter teams. Some teams had worked very efficiently, so some chapters were already quite advanced at the time of the actual Workshop, others were still in early or middle stages.

The Workshop was planned as a hybrid meeting with the hope of a large fraction of actual physical participants. By and large we achieved this: 21 participants did come to Bern and took part physically at the meeting on the ISSI premises, about ten colleagues participated remotely at different sessions. With the excellent technical equipment at ISSI's Johannes Geiss Auditorium, this format worked very well acoustically and optically.

In the course of the many online plenary meetings, the originally defined set of topics/chapters at the online kick-off was slightly modified, largely because it became clear that some topics originally combined under one headline deserved separate chapters. The twelve chapters now envisioned for the Topical Collection in Space Science Reviews range from an introduction on the "Basics of strong lensing from theoretical, cosmological and observational perspectives", to the "Search for strong gravitational lensing – accidental and deliberate discoveries", "Strong lensing by galaxies", "Strong lensing by galaxy clusters", "Strong lensing and microlensing of quasars", "Microcaustics near macrocaustics", "Gravitational lensing as a cosmic telescope", "Probing the nature of dark matter on (sub-)galactic scales with strong lensing", "Time-Delay Cosmography: Estimating Hubble Constant and other cosmological parameters from strong lensing", "Strong lensing and microlensing of supernovae", "Strong lensing of gamma-ray bursts, fast radio bursts and gravitational waves", to "Diffraction in strong gravitational lensing".

The Workshop was convened by Frédéric Courbin (EPFL, Switzerland), Maurizio Falanga (ISSI Bern, Switzerland), Richard McMahon (IoA Cambridge, UK), Paul Schechter (Kavli Institute, MIT, USA), Sherry Suyu (MPI for Astrophysics and TUM, Garching, Germany), Priyamvada Natarajan (Yale University, USA), Joachim Wambsganss (Heidelberg University, Germany and ISSI Bern) and Liliya Williams (University of Minnesota, USA).

Joachim Wambsganss

Challenges in Understanding the Global Water Energy Cycle and its Changes in Response to Greenhouse Gas Emissions

26–30 September 2022

Radiative processes are key to the climate's water-energy cycle: Climate is determined by the imbalances of solar radiative heating and long-wave radiative cooling. The circulation of the atmosphere and ocean, the environment on land, and the biosphere are all driven by local radiative imbalances. Changes in climate can be caused by alterations of the radiation budget at the top of the atmosphere or at the surface, such as those induced by changing amounts of greenhouse gases or aerosols in the atmosphere or by changing land surface properties. The sensitivity of the climate response to changes in the radiative forcing is determined by many feedback processes that alter the radiation budget, especially the processes involved with clouds and water vapor. Understanding and quantifying the climate response to changes in radiative forcings requires consistent, global-scale, observations of the principal energy fluxes in climate system.

This view of Earth's horizon as the sunsets over the Pacific Ocean was taken by an Expedition 7 crew member onboard the International Space Station (ISS) on July 21, 2003. (Image Credit: ISS007-E-10807, Earth Science and Remote Sensing Unit, NASA Johnson Space Center)

The International Space Science Institute (ISSI) in Bern hosted a Workshop with scientists from Europe, North America and Japan to assess the current state of knowledge with respect to the monitoring of water-energy cycle changes from satellites. The workshop focused on coordinating space observations of the water-energy fluxes in the Earth system and evaluating their consistency as well as advancing analysis methods to apply them in climate change assessments. The objective of the Workshop was to discuss and identify the coming observational challenges, in the next decade, to improve our understanding of the global water and energy cycle with emphasis on satellite observations.

During the Workshop, the experts took stock of the status of the different emerging themes related to the Earth water-energy cycle. Addressed topics included estimates of the water and energy fluxes in the atmosphere, global-scale changes in droughts and heavy precipitation, changes in the Earth energy imbalance and ocean heat storage, and changes in the surface temperature in response to the changing water energy fluxes. The workshop showed that the science community is now providing consistent satellite estimates of the global water and energy fluxes of the planet Earth from the bottom of the ocean to the top of the atmosphere over the last two decades. In particular, observations allow now to get a consistent and objective picture of the global water and energy fluxes that explain the current Earth energy imbalance at the top of the atmosphere. This observational basis serves as a reference basis to better understand the subtle balances at stake among the Earth water and energy fluxes in the current climate. The challenge of the next decade for scientists is to detect, monitor and understand how climate change modify these balances in space and time (including the earth energy imbalance) leading to regional consequences that impact ecosystems and human communities. A key aspect to progress on this challenge is to improve the detection, the understanding and the modeling of the cloud changes and their relation with the radiative imbalance at the top of the atmosphere. The emergence of new observational approaches (e.g. mesoscale convective system tracking techniques) along with new modeling tools (e.g. convection permitting models) shows promise of significant progress in the next decade.

The Workshop will lead to a set of papers published as a volume of the Space Science Series of ISSI (SSSI) and, in parallel, as a special issue in Surveys in Geophysics.

The Workshop was convened by Benoit Meyssignac (CNES, Toulouse, France), Graeme Stephens (NASA, JPL, USA), Rémy Roca (LEGOS, Toulouse, France), Sonia Seneviratne (ETH Zurich, Switzerland), and Michael Rast (ISSI, Switzerland).

Benoit Meyssignac

Tipping Points and Understanding EO data needs for a Tipping Element Model Intercomparison Project (TIPMIP)

10–14 October 2022

Climate tipping points are defined by the Intergovernmental Panel on Climate Change (IPCC) as critical thresholds in a system that, when exceeded, can lead to a significant change in the state of the system. The risks gaining particular attention include shifts in the Amazon from rainforest to Savannah, a slowing- and potential shutting down of the Atlantic Meridional Overturning Circulation (AMOC), ice loss from the Greenland and Antarctic ice sheets as well as growing CO_2 and CH_4 emissions from thawing permafrost.

Our best global climate models don't yet include all potential climate tipping processes. This limits the scientific information available to guide policies that manage the risks to social systems, and we are still a long way from implementing an observing system that can monitor the onset of tipping points. In October 2023 about 40 researchers met to discuss how Earth Observations, together with modeling efforts, can support monitoring and process understanding of tipping points and their interactions, climate feedbacks, and abrupt climate change more broadly.

Coordinated coupled-model intercomparison projects are a useful approach to assess our understanding of climate processes by providing a standard set of experiments and initialization data that can be run by individual climate modeling centers around the world. Plans for the TIPMIP (TIPping element Model Intercomparison) project were outlined by Ricarda Winkelmann, who is based at the Potsdam Institute for Climate Impact Research, which will include exploring the sensitivity of tipping behavior in response to rising levels of carbon dioxide in the atmosphere.

Climate models rely on long-term EO datasets like the Essential Climate Variables (ECVs) to assess model skill, to constrain them and to set initial conditions. Many ECVs are based on remote sensing data, such as the suite developed by the ESA Climate Change Initiative. Applied to tipping points, there is scope to assimilate EO to improve process-based models.

The 4–5 decadal span of satellite records means that direct monitoring of trends and indicators for the onset of tipping points is restricted to 'fast' tipping points that occur over decades, that would apply to winter sea ice in the Arctic, the subpolar gyre, the Sahel/Monsoon system, forest dieback – both tropical and boreal, freshwater ecosystems, and Arctic permafrost. The Workshop heard of the potential to develop proxy indicators of tipping behavior and instabilities, for example to indicate the triggering of collapse of the Antarctic Ice Sheet.

Participants of the "Tip Mip" Workshop

A major strength of EO is the ability to capture multiple temporal and spatial scales, offering opportunity to study the timing of events, extreme and compound events and their impacts, as well as cascading impacts and pace of change.

Participants agreed on a book outline summarizing all the Workshop results and recommendations. The peer-reviewed papers will be published first as a special issue in Survey in Geophysics and co-published as a volume in Space Sciences Series of ISSI (SSSI).

The Workshop was convened by Annett Bartsch (b.geos, Korneuburg, Austria), Victor Brovkin, (MPI Hamburg, Germany), Jonathan Donges (PIK, Potsdam, Germany), Sophie Hebden (Future Earth, Oxford, UK), Tim Lenton, (University of Exeter, UK), Hannah Liddy (AIMES, NASA Goddard Institute for Space Studies, USA), Susanne Mecklenburg (ESA ESCAT, UK), Andrew Shepherd (Northumbria University, UK), Narelle van der Wel (WCRP, Geneva, Switzerland), and Michael Rast (ISSI, Switzerland).

Sophie Hebden

The Variability of the Airglow for the Detection of Atmospheric Dynamics

The Earth is surrounded by several self-luminous layers. The majority of them is located in the upper mesosphere / lower thermosphere (UMLT). The emissions of the atmospheric airglow can be measured with powerful spectrometers and imagers. Their signatures allow conclusions to be drawn about the spatio-temporal structures of dynamic processes such as atmospheric waves but also turbulence in the UMLT.

In principle, satellite-based measurements allow to answer a multitude of questions from fundamental and applied research. The first includes, for example, nonlinear wave-wave interactions and energy balance, the latter the recording of the activity of strong storm systems (differential angular momentum), of volcanic activity as well as of earth and seaquakes and much more. The use of a constellation of small satellites allows the optimal observation configuration depending on the measurement target (formation flight, e.g. for tomography or pointing applications).

There exists a large number of different ground-based instruments used for hydroxyl (OH*) airglow observation all over the world. Several stations are loosely working collaboratively in the coordinated Network for the Detection of Mesospheric Change (NDMC, https://ndmc.dlr.de).

From 24th to 28th October 2022, the Working Group (WG) on "The variability of the airglow for the detection of atmospheric dynamics with high temporal and spatial resolution over a large range in space and time, potentially leading to the concept of a satellite-borne mission" met for the first time in Bern, Switzerland.

The overall objective of this Working Group is to discuss a possible future NDMC satellite mission and to identify innovative methods for optimal observation configuration (incl. use of small satellites swarms) depending on the measurement target.

During the kick-off meeting, the Working Group especially addressed potential topics of a space-borne mission and the most suitable airglow lines to be measured for these purposes. These points were related to existing or planned satellite missions in the field of atmospheric dynamics. A special focus was put on tomographic measurements in order to derive three-dimensional information about atmospheric dynamics.

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.

This image taken by an astronaut aboard the International Space Station in 2018, our planet shines with orange light. This is airglow, a phenomenon that happens in planetary atmospheres. When radiation from the Sun strikes molecules in the atmosphere it energizes them, causing them to release energy that we can see as colors — most commonly red, green or blue, and in this case orange. (Image Credit: NASA)

This Working Group is convened by Sabine Wüst, and Michael Bittner (both DLR, Germany) and Michael Rast, (ISSI, Switzerland).

Sabine Wuest

International Teams

International Teams consist of about 8–15 external scientists, addressing a specific scientific topic in a self-organized 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 prioritization done by the Science Committee.

Listed are Teams that had a meeting at ISSI in the period of the 27th business year. A rationale is given only for the Teams selected in 2021; for the others see the previous Annual Reports.

Teams selected in 2018

Origins of 3He-Rich Solar Energetic Particles

Team leaders: Radoslav Bucik, Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany and James Drake, University of Maryland, College Park, USA
Session at ISSI: 5–8 December 2022

An Exploration of the Valley Region in the Lowlatitude Ionosphere: Response to Forcing from Below and Above and Relevance to Space Weather

Team leader: Jorge Chau, Leibniz Institute of Atmospheric Physics, Kühlungsborn, Germany
Session at ISSI: 11–15 July 2022

International Combination Service for Time-variable Gravity Field Solutions

Team leader: Adrian Jäggi, University of Bern, Switzerland
Session at ISSI: 4–8 July 2022

Are We Doing the Right Satellite Observations and Analyses for Quantifying Cloud-Mediated Aerosol Climate Forcing?

Team leaders: Alexander Kokhanovsky, VITROCISET, Darmstadt, Germany and Daniel Rosenfeld, The Hebrew University of Jerusalem, Israel
Session at ISSI: 22–26 August 2022

Looking at the Disc-Jet Coupling from Different Angles: Inclination Dependence of Black-Hole Accretion Observables

Team leaders: Sara Elisa Motta, University of Oxford, United Kingdom and Piergiorgio Casella, National Institute for Astrophysics (INAF), Monteporzio Catone, Italy
Sessionat ISSI: 28 November – 2 December 2022

COSWEB: The Cosmic Web and Galaxy Evolution

Team leader: Gregory Rudnick, University of Kansas, Lawrence, USA
Session at ISSI: 23–27 May 2022

Linking Solar and Stellar Variabilities

Team leader: Alexander Shapiro, Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany
Session at ISSI: 25–29 August 2022

Resolving the Microphysics of Collisionless Shock Waves

Team leader: Lynn Wilson, NASA Goddard Space Flight Center, Greenbelt, USA
Session at ISSI: 2–5 August 2022

Teams selected in 2019

Complex Systems Perspectives Pertaining to the Research of the Near-Earth Electromagnetic Environment

Team leader: Georgios Balasis, University of Athens, Greece
Session at ISSI: 15–17 November 2022

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 at ISSI: *12–16 June 2023*

Models of VHE Emission In Pulsars: Evaluation of the Current State-Of-The-Art and Future Prospects

Team leaders: Ionnis Contopoulos, Academy of Athens, Greece, and Demosthenes Kazanas, NASA Goddard Space Flight Center, Greenbelt MD, USA
Session at ISSI: 12–16 September 2022

Tropical Width Impacts on the Stratosphere (TWIST)

Team leader: Sean Davis, NOAA, Boulder CO, USA
Session at ISSI: 19–23 September 2022

Provenances of our Solar System's Relics

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

A Reference Quality Model for Ocean Surface Emissivity and Backscatter from the Microwave to the Infrared

Team leaders: Stephen English, ECMWF, Reading, United Kingdom, and Catherine Prigent, CNRS LERMA, Paris, France
Session at ISSI: 18–19 October 2022

Exploring the Solar Wind in Regions Closer than ever Observed before

Team leader: Louise Harra, World Radiation Center, Davos Dorf, Switzerland
Session at ISSI: 15–19 August 2022

Foreshocks across the Heliosphere: System Specific or Universal Physical Processes?

Team leaders: Heli Hietala, Imperial College London, United Kingdom, and Ferdinand Plaschke, Austrian Academy of Sciences, Graz, Austria
Session at ISSI: 3–7 October 2022

A New View of Ring-Planet Interactions from Cassini's Grand Finale

Team leaders: Hsiang-Wen Hsu, LASP, Boulder CO, USA, and Ali Sulaiman, University of Iowa, USA
Session at ISSI: 18–22 July 2022

Space Weather Induced Direct Ionisation Effects on the Ozone Layer

Team leader: Antti Kero, University of Oulu, Sodynkylä, Finland
Session at ISSI: 5–9 September 2022

Interrogating Field-Aligned Solar Flare Models: Comparing, Contrasting and Improving

Team leaders: Graham Kerr, NASA Goddard Space Flight Center, Greenbelt MD, USA, and Vanessa Polito, Bay Area Environmental Research Institute, Moffett Field CA, USA
Session at ISSI: 22-26 August 2022

Using Energetic Electron and Ion Observations to Investigate Solar Wind Structures and Infer Solar Wind Magnetic Field Configurations (ISSI – ISSI-Beijing Team)

Team leaders: Gang Li, University of Alabama, Huntsville AL, USA, and Linghua Wang, Peking University, China
Session at ISSI: 25-29 July 2022

Characterization of Cometary Activity of 67P/Churyumov-Gerasimenko Comet

Team leader: Andrea Longobardo, INAF, Rome, Italy
Sessions at ISSI: 22–24 January 2022 and 27–29 June 2022

Understanding the Properties of the Terrestrial Gamma-Ray Flash Population

Team leader: Martino Marisaldi, University of Bergen, Norway
Session at ISSI: 13–17 June 2022

Closing the Gap Between Ground Based and In-Situ Observations Of Cometary Dust Activity: Investigating Comet 67P to Gain a Deeper Understanding of other Comets

Team leaders: Raphael Marschall, Southwest Research Institute USA, and Oleksandra Ivanova, Astronomical Institute of Slovak Academy of Sciences, Slovak Republic
Session at ISSI: 12–14 December 2022

What Determines the Dynamo Effectivity of Solar Active Regions?

Team leader: Kristof Petrovay, Eötvös Loránd University, Budapest, Hungary
Session at ISSI: 20–24 June 2022

Modeling Space Weather and Total Solar Irradiance over the Past Century (ISSI – ISSI-Beijing Team)

Team leader: Alexei Pevtsov, National Solar Observatory, Sunspot NM, USA
Session at ISSI: 2–5 August 2022

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

Team leader: Johan Richard, Université de Lyon, Saint Genis Laval, France
Session at ISSI: 18–22 July 2022

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 at ISSI: 11–14 April 2022

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 at ISSI: 11–14 April 2022

Magnetic Open Flux and Solar Wind Structuring of Interplanetary Space

Team leader: Manuela Temmer, University of Graz, Austria
Session at ISSI: 7–11 November 2022

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 at ISSI: *30 January – 3 February 2023*

International Teams

The International Team led by Hella Garny started their project in 2020, but was able to meet in person at last at ISSI in Bern in June 2022, after travel restrictions had been lifted worldwide.

Active Galaxies in Crisis: A Statistical Study of Ultra-Violet Variability (ISSI – ISSI-Beijing Team)
Team leader: Martin Ward, Durham University, United Kingdom
Session at ISSI: 3–7 October 2022

Zooming in on Rocky Planet Formation
Team leaders: Rens Waters, SRON, Utrecht, The Netherlands, and Inga Kamp, University of Groningen, The Netherlands
Session at ISSI: 12–16 December 2022

The Identification and Classification of 3D Alfvén Resonances
Team leader: Andrew Wright, University of St Andrews, United Kingdom
Sessions at ISSI: 15–19 August 2022 and 5–9 December 2022

Why Ionospheric Dynamics and Structure Behave Differently in the African Sector?
Team leaders: Endawoke Yizengaw, The Aerospace Corporation, El Segundo CA, USA, and Keith Groves, Boston College, Chestnut Hill MA, USA
Session at ISSI: 25–29 July 2022

Deciphering Compositional Processes in Inner Airless Bodies of our Solar System
Team leader: Francesca Zambon, INAF, Rome, Italy
Session at ISSI: 23–25 May 2022

Sombreros and Lampposts: The Geometry of Accretion onto Black Holes
Team leaders: Andrzej Zdziarski, Polish Academy of Sciences, Warszawa, Poland, and Tomaso Belloni, INAF, Merate, Italy
Session at ISSI: 12–16 September 2022

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 at ISSI: 7–11 November 2022

Langmuir Probes, a 100 Year Workhorse: Easy to Fly but Difficult to Interpret
Team Leader: Laila Andersson, University of Colorado, USA
Session at ISSI: *15–19 May 2023*

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 at ISSI: *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
Session at ISSI: 4–7 July 2022

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 at ISSI: 24–29 April 2022

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 at ISSI: 14–18 November 2022

Getting Ultra-Precise Planetary Radii with PLATO: The Impact of Limb Darkening and Stellar Activity on Transit Light Curves
Team Leader: Szilard Csizmadia, University of Bonn, Germany
Session at ISSI: 21–25 November 2022

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 at ISSI: 13–17 September 2021

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 at ISSI: *3-7 July 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
Session at ISSI: 3–7 October 2022

Stratospheric Age-of-Air: Reconciling Observations and Models
Team Leader: Hella Garny, DLR, Wessling, Germany
Session at ISSI: 7–10 June 2022

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

Towards Determining the Earth Energy Imbalance from Space
Team Leader: Margrit Haberreiter, World Radiation Center, Davos, Switzerland
Session at ISSI: 29–30 September 2022

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 at ISSI: *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 at ISSI: 19–22 April 2022

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 at ISSI: 11–15 July 2022

The Life Cycle of Comets
Team Leader: Rosita Kokotanekova, European Southern Observatory (ESO), Garching, Germany
Session at ISSI: 7–11 March 2022

The Metal-THINGS Survey of Nearby Galaxies
Team Leader: Maritza Lara-Lopez, Universidad Complutense de Madrid, Spain
Session at ISSI: 2–5 August 2022

Understanding Mesoscale Ionospheric Electrodynamics Using Regional Data Assimilation
Team Leader: Karl Magnus Laundal, University of Bergen, Norway
Session at ISSI: 14–18 March 2022

Population-Dynamical Archeology of Galaxies (ISSI – ISSI Beijing Team)
Team Leaders: Ryan Leaman, Max Planck Institute for Astronomy, Heidelberg, Germany, and Ling Zhu, Chinese Academy of Sciences, Shanghai, China
Session at ISSI: 21–25 November 2022

Strong Gravitational Lensing Studies with CSS-OS and EUCLID (ISSI – ISSI Beijing Team)
Team Leader: Ran Li, National Astronomical Obsevatories 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 at ISSI: *28 February - 3 March 2023*

Solar Extreme Events: Setting Up a Paradigm
Team Leaders: Fusa Miyake, Nagoya University, Japan and Ilya Usoskin, University of Oulu, Finland
Session at ISSI: 7–10 June 2022

Multi-Scale Magnetosphere-Ionosphere-Thermosphere Interaction (ISSI – ISSI Beijing Team)
Team Leader: Toshi Nishimura, Boston University, USA
Session at ISSI: 11–15 July 2022

International Teams

Multiwavelength View on Massive Stars in the Era of Multimessanger Astronomy
Team Leader: Lida Oskinova, University of Potsdam, Germany
Session at ISSI: 29 November–3 December 2021

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 at ISSI: 16–20 May 2022

Warm Coronae in AGN: Observational Evidence and Physical Understanding
Team Leaders: Pierre-Olivier Petrucci, Université Grenoble Alpes, Saint-Martin-d'Hères, France, and Giorgio Matt, Universita' degli Studi Roma Tre, Italy
Session at ISSI: 17–21 October 2022

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 at ISSI: 5–9 September 2022

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 at ISSI: 19–23 September 2022

Towards a Unifying Model for Magnetic Depressions in Space Plasmas
Team Leader: Martin Volwerk, SRI, Austrian Academy of Sciences, Graz, Austria
Session at ISSI: 15–19 August 2022

Molecular and Metallic Ions in the Magnetosphere
Team Leader: Masatoshi Yamauchi, Swedish Institute of Space Physics, Kiruna, Sweden
Session at ISSI: 7–10 June 2022

Teams selected in 2021

Star Formation Within Evolving Galaxies: The Revolution of Upcoming Space Missions
Team Leader: Angela Adamo, Stockholm University, Sweden
Session at ISSI: 29 August – 2 September 2022
Scientific Rationale: This Team gathers experts on star formation to create a coherent view of the process that leads to the build-up of galaxies across cosmic time. Deep multi-wavelength space observations of the universe have revealed that galaxies are rapidly growing in mass during the first few billion years after the Big Bang. In this period large fractions of gas are rapidly converted into stars, black hole seeds rapidly grow, metals are produced and ejected, and highly ionizing photons stream out of galaxies making the universe transparent to radiation (reionisation era). To date, however, we lack understanding of the physics that governs and regulates star formation and stellar feedback at sub-galactic scales. The James Webb Space Telescope (JWST) mission paves the way to understanding the star formation process at the physical scales that matter for rapidly evolving galaxies. This Team combines key expertise on different aspects of star formation in local and high-redshift galaxies, both in multi-wavelength observations and numerical simulations. The Team aims to 1. Identify key science questions to be addressed with JWST observations; 2. Create synergies between space observations with the Hubble Space Telescope (HST) and JWST, and ground-based facilities like ALMA, VLT, Keck; 3. Use cosmological simulations to make observational predictions.

Energy Partition Across Collisionless Shocks
Team Leader: Takanobu Amano, The University of Tokyo, Japan
Session at ISSI: 30 May – 3 June 2022
Scientific Rationale: Collisionless shock waves in dilute ionized gas in space are the most probable acceleration sites of high-energy cosmic rays. A shock wave converts a supersonic bulk-flow kinetic energy into energy in random motion of ions and electrons, including thermal and nonthermal particles, and turbulence. The absence of binary collisions between individual particles at the collisionless shock raises the fundamental question: How is the energy partitioned into the different components? Answering this question requires understanding of the complicated physics of collisionless dissipation at the shock. This has been a common interest between space physics and astrophysics. Furthermore, laboratory astrophysics using high-power lasers has been an emerging field that shares a great interest in the same problem.
Since this topic is intrinsically interdisciplinary, this Team

consists of researchers from all these different fields, with a broad range of backgrounds. Team members will discuss the problem of energy partition by combining state-of-the-art knowledge that has been obtained with different approaches: theory, kinetic simulations, in-situ and remote-sensing observations, as well as laboratory experiments. Specific questions that will be addressed in the context of energy partition include the ion-electron equilibration, the nonthermal particle production rate, and the role played by turbulence. The interdisciplinary discussion will also address future research directions.

Revisiting Star Formation in the Era of Big Data

Team Leaders: Marc Audard, Université de Genève, Switerland and Odysseas Dionatos, University of Vienna, Austria

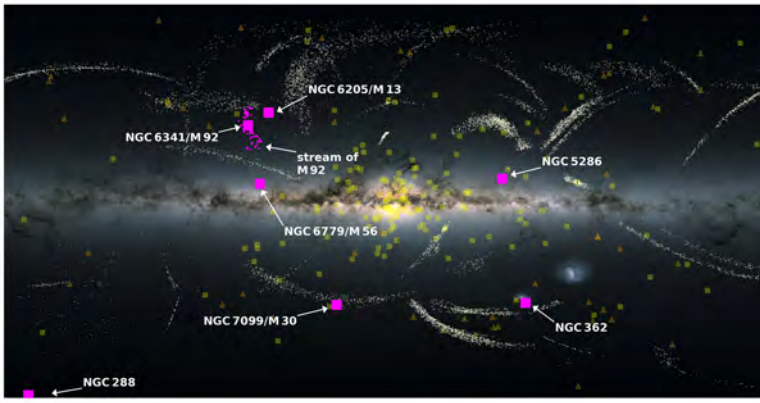
Session at ISSI: 9–13 May 2022

Scientific Rationale: The standard paradigm describing the formation of stars and planets, introduced almost 40 years ago, is being challenged by discoveries suggesting that (i) the mass reservoir for star formation continuously grows during the protostellar collapse, (ii) the growth of stellar embryos is not continuous but likely episodic, (iii) the formation of planets occurs synchronously rather than sequentially to their host stars and (iv) the co-evolution of proto-star/planet systems occurs faster than assumed.

Thanks to many surveys from ground and space facilities, star formation has entered the Big Data era. Gaia now provides photometry, spectroscopy, parallax, proper motions, and radial velocities for millions (up to a bit more than a billion, for some parameters) of sources that allow a much more precise determination of the populations of star forming regions, and thus their age and luminosity. Observations at infrared and millimeter regimes (Spitzer and Herschel, IRAM, NOEMA, VLA, ALMA), which are essential for the characterization of protostars, can be complemented with crucial information in X-rays from e.g., XMM-Newton, and the ongoing e-ROSITA all-sky survey.

Nowadays higher quality and larger volumes of data, more advanced computing methods and higher computing power exist, which allow us to revisit the standard star-formation paradigm and the evolutionary scheme of young stars, using new machine learning techniques applicable to big data.

This Team combines experts in star formation, survey data, big data analysis, and machine learning to use multi-wavelength data to derive a new evolutionary scheme for young stellar evolution.



This image shows the Milky Way as seen by Gaia. The squares represent the location of globular clusters, the triangles the location of satellite galaxies, and the small dots are stellar streams. The dots and squares in purple are objects brought into the Milky Way by the Pontus merging galaxy. (Image Credit: ESA/Gaia/DPAC, CC BY-SA 3.0 IGO)

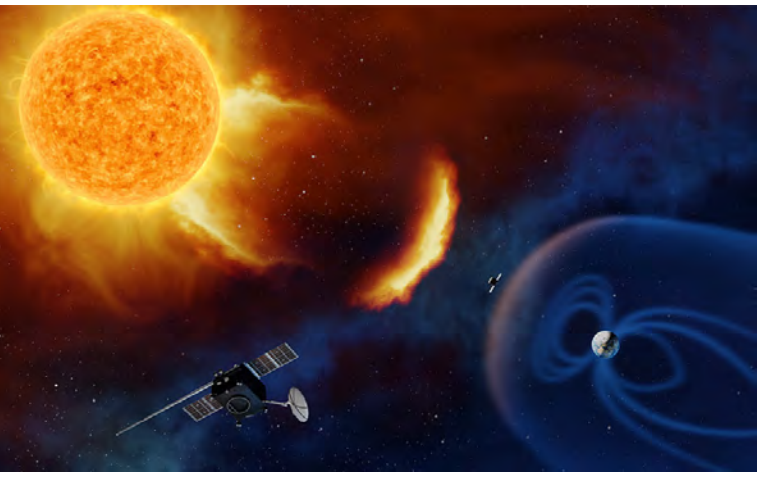
Geomagnetic Activity and Solar Cycle Dependence of Electromagnetic Ion Cyclotron (EMIC) Wave Activity and Wave Parameter in the Earth's Magnetosphere

Team Leaders: Remya Bhanu and Alexa J. Halford, NASA Goddard Space Flight Center, USA

Session at ISSI: 19–23 September 2022

Scientific Rationale: Electromagnetic ion cyclotron (EMIC) waves in the Pc1-2 frequency range (0.1–5 Hz) are generated by unstable ion distributions in the Earth's magnetosphere owing to magnetospheric compressions or magnetotail particle injections. They contribute to the ring current ion and relativistic electron loss during geomagnetic storm times. However, no consistent relationship of EMIC wave occurrence to geomagnetic storm and non-storm periods, or to storm phases has been found. The physics behind the generation of EMIC waves and eventually the loss of particles by these waves differ during different storm phases. Hence, it is extremely important to understand the EMIC wave occurrence and typical wave and plasma parameters during various storm phases.

This Team focuses on understanding the storm phase dependence of the EMIC waves and relevant plasma parameters, along with their dependence on various geomagnetic indices and solar wind parameters, and incorporate the results in global numerical simulations. This will be achieved by comparing results with in-situ EMIC wave data, past and present (and future), e.g.: (i) CRRES, the predecessor to the Van Allen Probes which precessed through the Earth's magnetosphere during a very active solar cycle, (ii) THEMIS which has a wider



Artistic rendition of extreme Solar activity propagating towards Earth. (Image Credit: ESA/A. Baker, CC BY-SA 3.0 IGO)

radial (L shell) coverage and CLUSTER which has a polar orbit covering wider latitudes, (iii) AMPTE with similar orbits as Van Allen Probes which precessed during the ascent of solar cycle 22, and (iv) Japan's ARASE (ERG) launched in 2016, another mission with orbits similar to Van Allen Probes.

Imaging the Invisible: Unveiling the Global Structure of Earth's Dynamic Magnetosphere

Team Leader: Natalia Buzulukova, NASA Goddard Space Flight Center, USA
Session: 16–20 May 2022
Scientific Rationale: The Earth's magnetosphere shields our planet from hazardous space weather effects caused by solar disturbances and energetic particles. However, the description of the global structure of the magnetosphere and its changes during major disturbances, such as storms and substorms, is extremely difficult, because the magnetosphere is very sparsely sampled by in situ observations. One way to mitigate this problem is to probe the magnetosphere remotely – from space (with constellations of low Earth orbit (LEO) spacecraft or space-borne auroral imagers), or with ground radars and all-sky cameras. A complementary approach is to employ global first-principle models to describe the magnetospheric structure and evolution, linking solar wind perturbations to their ultimate space weather impacts. Finally, historical databases of in situ spacecraft observations (e.g., the magnetic field) or extended LEO observations of near-Earth regions (e.g., the plasmasphere) can be mined to build sophisticated empirical models (e.g., artificial neural networks) that learn from large-volume data sets. These approaches remain limited if taken alone, so this Team addresses the problem of the description of the magnetosphere as a global system in a concerted fashion, concentrating on the following unanswered questions: (1) What are the global storm/substorm distributions and variations of magnetospheric electric currents, plasma pressure and density, and how well can they be reproduced with models and remote sensing, given the extreme scarcity of in-situ observations? (2) What methods are able to combine and constrain global simulations with empirical reconstructions and with global images of the magnetosphere, obtained with ENA, X-ray, low-altitude or ground-based measurements?

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: 7–11 March 2022
Scientific Rationale: Sea-level rise is one of the most damaging consequences of climate change and is projected to displace millions of people and cause billions of dollars in economic losses by 2100. However, robust estimates of the rate of sea-level rise remain a major scientific challenge, particularly in coastal areas where they are needed most. Despite remarkable progress in understanding the causes of global and regional sea-level rise, we still do not fully understand how coastal sea-level changes relate to open-ocean forcing. It is widely recognized that coastal sea level can fluctuate coherently over large distances along the coast and be decoupled from changes in the nearby open ocean. The continental slope can act to insulate the coastal zone from open-ocean changes, but we do not understand exactly how, where, and to what extent, this happens.
The two key gaps in our knowledge are: (1) the extent to which open-ocean changes affect coastal sea level and (2) how this relates to alongshore coherence. Tide gauges provide sea-level measurements at the coast but not on continental shelves and they are spatially sparse. Satellite altimetry provides observations at ungauged locations, and on the shelf and in the open ocean, but such observations tend to be unreliable within about 20 km from the coast due to land contamination of the signal.
This project addresses these knowledge gaps through new coastal altimetry observations that leverage recent advances in processing and technology. A further aim is to provide specific recommendations for future improvement of space observations (altimetry and gravimetry) and coastal oceanographic observations.

Modeling Mercury's Dynamic Magnetosphere in Anticipation of BepiColombo

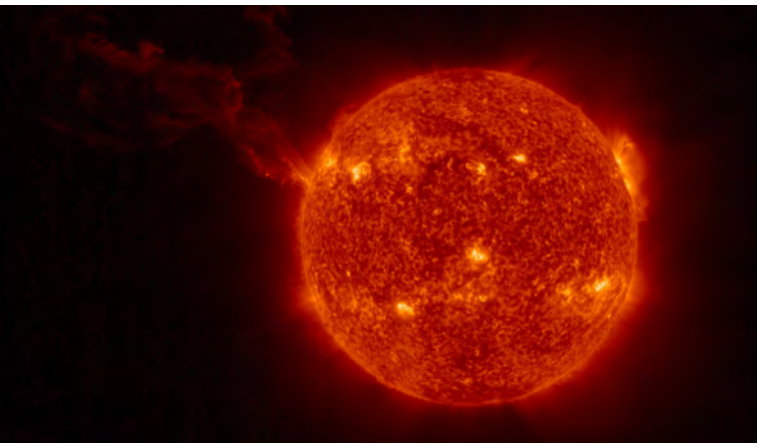
Team Leader: Jan Deca, University of Colorado Boulder, USA and Sae Aizawa, CNRS, Toulouse, France
Session: 30 May – 3 June 2022
Scientific Rationale: Mercury has one of the most dynamic magnetospheres in the solar system, which can completely reconfigure itself on the order of minutes. This can be caused by external events such as variations in the solar wind and interplanetary magnetic field, or it can be "self-triggered" when the magnetosphere surpasses its own threshold for instabilities to develop. BepiColombo is delivering new "local" data with unprecedented spatial and temporal resolution. To correctly interpret these, complementary modeling is required to provide the global context.
This Team combines scientists and members from the plasma instruments' team of BepiColombo and MESSENGER to:
1. Model and characterize structure and evolution of the Hermean magnetosphere in response to changes in the upstream plasma. Shape and location of the magnetospheric boundaries, and the relative importance of the different current systems are key for interpreting coordinated observations from BepiColombo's Magnetospheric (Mio) and Planetary Orbiter (MPO).
2. Identify kinetic interactions in the Hermean plasma environment, such as particle acceleration, heating, and wave generation. Disentangling the details of the energy budget of Mercury's magnetosphere also furthers our understanding of the magnetospheres of other bodies in the solar system.
In preparation of BepiColombo's arrival at Mercury in late 2025, modeling the planet's magnetized environment and assessing the role of microphysics in the global dynamics of the system will help the instrument and science consortia anticipate the prevailing conditions at various stages of the mission.

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: 27–29 June 2022
Scientific Rationale: Recent studies have demonstrated the presence – in (semi-)permanently shadowed areas, e.g. crater rims – of surface and subsurface water ice on planetary bodies like Ceres, the Moon and Mercury. This is not only of astrobiological significance, it also provides important information about a body's internal evolution. For these reasons, it is critical to evaluate the stability of water ice on the surface or in the shallow subsurface of planetary bodies.

Artist impression of BepiColombo flying by Mercury. The spacecraft makes nine gravity assist manoeuvres (one of Earth, two of Venus and six of Mercury) before entering orbit around the innermost planet of the Solar System in 2025. (Image Credit: ESA/ATG medialab)

To-date no complex numerical modeling has integrated an Eulerian approach, which provides a complete thermophysical representation of the simulated sites, with a Lagrangian approach, which simulates the likely water vapor emission, as well as the interaction of volatiles with the regolith (dust). This project aims to bridge this gap through:
1. Application to representative ice-rich sites on the Moon, Ceres and Mercury of a numerical and 3-D finite element method (FEM) thermophysical model, based on digital terrain models (DTM) and illumination conditions at reference sites.
2. Implementation of a Smoothed Particle Hydrodynamics (SPH) code to study water vapor emission and volatile-dust interaction, building on the FEM temperature maps. Water vapor emission can be triggered both by local illumination and impact events.
This synthetic description of the physical characteristics of ice-rich areas on planetary surfaces will provide critically needed theoretical support for existing (e.g. Dawn, Rosetta, BepiColombo, ExoMars) and future space missions.



The Full Sun Imager of the Extreme Ultraviolet Imager (EUI) on board the Solar Orbiter spacecraft captured a giant solar eruption on 15 February 2022. Solar prominences are large structures made of tangled magnetic field lines that keep dense concentrations of solar plasma suspended above the Sun's surface and often take the form of arching loops. (Image Credit: Solar Orbiter/EUI Team/ESA & NASA)

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*

Scientific Rationale: A key observational feature in the emission of solar and stellar flare energy release is the presence of pronounced intermittent pulsations and oscillatory patterns ("quasi-periodic pulsations", QPPs). The occurrence of QPPs, with timescales ranging from milliseconds to several minutes, places important constraints on models of solar flare processes, e.g. magnetic energy release, particle acceleration, and heating. While the underlying physical mechanism for generating QPPs remains unknown, a full description of the phenomenon is critical for achieving a unified solar flare model. In recent years significant advances have been made independently in both the observations and modeling of flaring QPPs, but we now require a coordinated cross-cutting collaboration between the modeling and observational communities.

This Team will combine past and new X-ray observations of a select number of flares with state-of-the-art flare modeling to achieve a self-consistent, end-to-end understanding of fundamental time variability and QPPs in solar flares. This is timely as a) observational analysis tools can now robustly identify QPP signatures through a variety of methods, b) current and near-future solar (e.g. Solar Orbiter/STIX) and stellar (e.g. TESS) data provide short-period variability information for the Sun and other stars, and c) advanced numerical models of flares have recently been able to naturally produce quasi-periodic emission signatures.

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: 2–6 May 2022

Scientific Rationale: Reconstructing the evolution of Earth's atmosphere over geological time provides a window into Earth's history, and also helps determine if, and when, Earth-like conditions for habitability can exist on other planetary bodies.

Atmospheric evolution is controlled by several factors, e.g. the initial redox state of the planet, biospheric reactions, sub-surface activities, and net particle escape of atmospheric constituents into space. The atmosphere is also impacted by the stellar environment through radiative and particle fluxes, where the latter may be controlled by the geomagnetic field. At present, thermal escape of neutrals from Earth is limited to the lightest elements (H and He). Escape of heavier elements like oxygen and nitrogen may be facilitated via the ionosphere, the charged particle component of the upper atmosphere. Ionospheric outflow has been observed by spacecrafts, and is regulated by the Earth's magnetic field, solar extreme ultra-violet photon flux striking the upper atmosphere, and electromagnetic driving from the solar wind. How critical is the role played by planetary magnetic fields for the retention of a habitable atmosphere? Addressing this question involves two challenges: (1) limited knowledge of when planets gain or lose their ability to create a global core dynamo field, and (2) lacking understanding of how such fields, through their coupling to plasmas in and outside the magnetosphere, control atmospheric escape. This Team addresses the problem of atmospheric heavy element loss on current and geological scales, starting from surface-air interactions, atmospheric chemistry, circulation patterns, ionization by solar radiation, to ionosphere-magnetosphere and solar wind interactions. It includes experts from space sciences and planetary sciences, paleomagnetism, and Earth and atmospheric sciences.

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: 22–26 November 2022

Scientific Rationale: The kinetic physics of electrons plays a fundamental role in the heliosphere. The solar wind heat flux controls the solar wind energy budget and determines the overall solar wind acceleration. Most of the solar wind heat flux is carried by the strahl, suprathermal electrons at coronal temperatures collimated by the magnetic field. Kinetic processes (e.g., whistler-type electron-scale instabilities) are likely the main driver of heat flux regulation during solar wind propagation. The efficiency of these wave-particle interactions depends on solar-wind conditions and heliocentric distance.

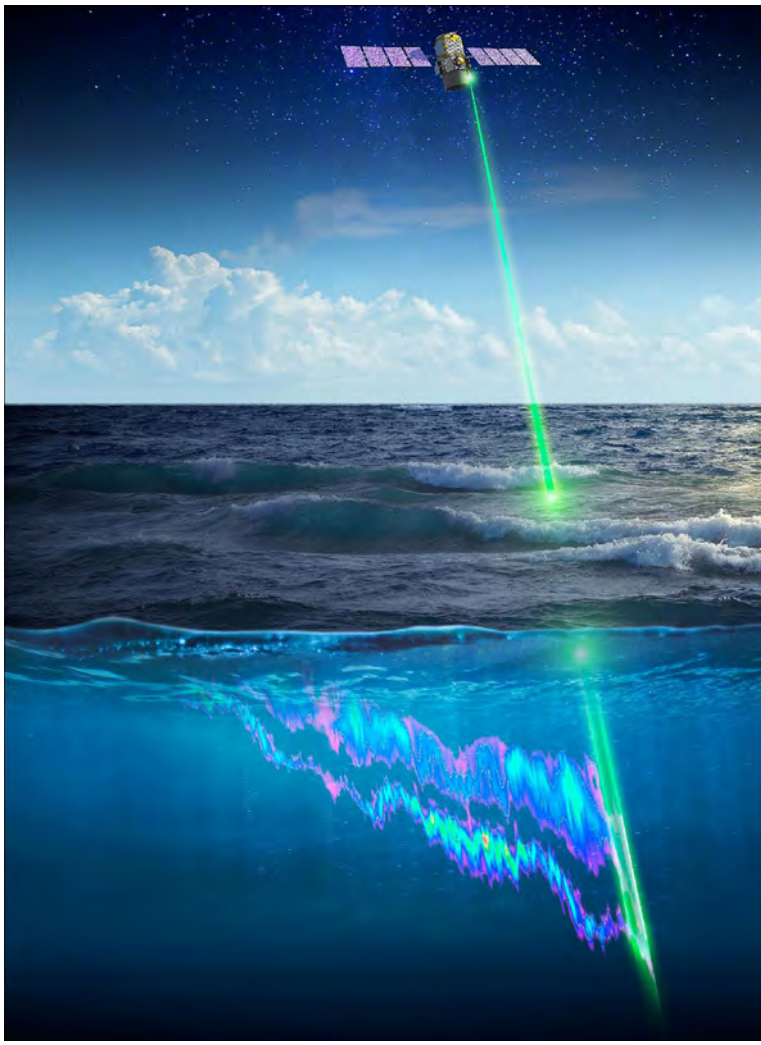
This Team will further our understanding of solar wind energy flux by combining data from Parker Solar Probe (PSP), Solar Orbiter (SO), Magnetospheric MultiScale, Wind, and the legacy missions Ulysses and Helios, with simulations and theory. It will address three problems: (1) Which kinetic processes contribute the most to heat flux evolution in the solar wind, how do they vary in different solar wind regimes and with heliocentric distance, and how efficiently do they regulate heat flux? (2) Kinetic physics in solar wind modeling: the Team will provide analytical ``heat flux operators'' for the kinetic processes identified in step 1, as an essential foundation for multi-scale modeling of the solar wind. (3) The origin problem, by reconstructing electron Velocity Distribution Functions (VDFs) in the low solar corona. The reconstructed VDFs will bear signatures of the mechanisms behind the escape of high-energy electrons into the solar atmosphere, and will shed light on how the heliosphere itself is formed.

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

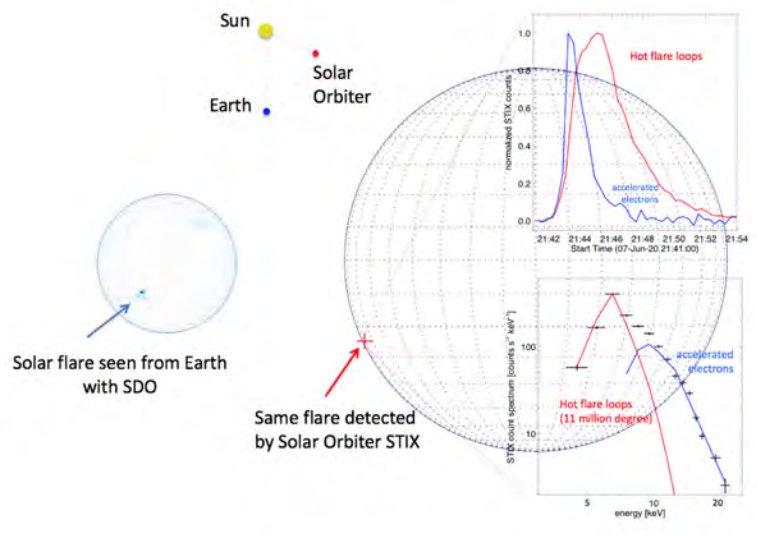
Session: 2–4 May 2022

Scientific Rationale: Space-borne passive ocean color observations began in the late 1970s with the Coastal Zone Color Scanner mission. An uninterrupted record of global ocean color data has been sustained since 1997. These passive observations enabled a global view of the distribution of phytoplankton and marine primary productivity. They are, however, limited to clear sky, day-light, high Sun elevation angles, ice-free oceans and exponentially weighted toward the ocean surface. Moreover, processing of ocean color images requires knowledge of the atmospheric components (gases, air molecules and aerosols).



Lidar – Light Detection and Ranging – is a remote sensing method used to examine the surface of the Earth. Researchers used the space-based CALIPSO lidar to measure the planet's largest animal migration, which takes place when small sea creatures swim up from the depths at night to feed on phytoplankton, then back down again just before sunrise (Image Credit: NASA, Timothy Marvel)

Satellite lidars (Light Detection and Ranging) are a natural complement to passive sensing techniques, as they operate under thin clouds, between holes in broken clouds, and in polar regions, providing vertical measurements during the day and night. Despite not having received much consideration for ocean color remote sensing so far, new interest from the ocean community in satellite lidars was triggered by studies using CALIOP/CALIPSO and ATLAS/Ice-Sat-2 to estimate the ocean particulate backscatter and ocean color over the globe and in the polar regions (and over the water column for ATLAS).



The X-ray Spectrometer/Telescope (STIX) studies solar X-ray emissions, which are exclusively emitted during solar flares. The STIX team observed a solar flare on 7 June 2020. Although weak, the flare was still large enough to test almost all the aspect of STIX functionality. (Image Credit: Solar Orbiter/STIX Team/ESA & NASA)

As these space-borne lidars are primarily dedicated to atmospheric and land measurements, this Team addresses the challenges for their adaptation to oceanic studies: (1) Validation of CALIOP and ATLAS retrievals including inter-comparison of their results, and (2) analysis of the limitations of the current space-borne lidars. This work will help define a scientific roadmap for a future dedicated space-borne oceanic profiling lidar.

Measuring Solar Flare Hard X-ray Directivity using Stereoscopic Observations with Solar Orbiter/STIX and X-ray Instrumentation at Earth (ISSI – ISSI Beijing Team)

Team Leaders: Natasha Jeffrey, Northumbria University, United Kingdom and Samuel Krucker, Fachhochschule Nordwestschweiz, Switzerland
Session: 4–8 April 2022
Scientific Rationale: The hard X-ray (HXR) imaging spectrometer STIX on board Solar Orbiter delivers the first opportunity to systematically perform stereoscopic X-ray observations of solar flares with a new X-ray fleet: ASO-S/HXI, Aditya-HEL1OS, GECAM, and potentially with PADRE, a proposed CubeSat carrying STIX cross-calibrated detectors. These observations will provide the first reliable measurements of HXR directivity, our link to the angular distribution of flare-accelerated electrons, and constrain the processes that can accelerate electrons in the corona and in other astrophysical objects. Such observations must be compared with theory and state-of-the-art modeling, taking into account transport effects and realistic plasma conditions, all of which can change the properties of the measured HXR directivity. Robust measurements of HXR directivity intrinsically rely on the calibration accuracy of the independently developed detector systems of the different HXR telescopes. This Team brings together experts for each of the different instruments with theorists. Its aim is to establish requirements on the calibration accuracy derived from simulations so we can distinguish between different theoretical models, and then work out a joint calibration approach of the different detectors to reach the required accuracy. This effort is timely since the first joint observations between STIX and instruments at Earth (Aditya-HEL1OS and GECAM solar data) became available in 2021.

Understanding Interhemispheric Asymmetry in MIT Coupling

Team Leader: Hyomin Kim, New Jersey Institute of Technology, USA
Session: 29 August – 2 September 2022
Scientific Rationale: Observational and modeling studies reveal interhemispheric differences in MIT coupling, which are manifested in various signatures in geospace. These differences can be attributed to natural circumstances and external drivers that interfere with complex coupling processes of the MIT system and complicate their signatures. Coupling processes associated with energy input from the heliospheric system, and the resulting feedback from the geospacer, can be incorrectly estimated when neglecting north-south asymmetries.
Interhemispheric studies have not been extensively conducted due to both observational and modeling challenges. This Team will study what type of interhemispheric asymmetry is present, how MIT coupling is affected by asymmetry, how to incorporate interhemispheric differences and their effects on MIT coupling in models and observations, and which observation and modeling effort should be made to advance our knowledge in these topics. The Team is composed of experts in interhemispheric MIT coupling studies, many of whom operate high-latitude ground stations in both hemispheres providing critical infrastructure and/or have experiences with various near-Earth satellite data (e.g., Cluster, CHAMP, Swarm, Ampere, Polar, IMAGE, DMSP) and model simulations (e.g., TIE-GCM, GITM). This work is timely in view of recent community efforts to increase interhemispheric observational capability, and to form scientific groups/projects on this topic.

Transition from Supervolatile-Driven Activity to Water-Driven Activity in inbound Dynamically New Comets

Team Leader: Fiorangela La Forgia, University Parthenope Naples, Italy

Session: 7–11 March 2022

Scientific Rationale: Dynamically New Comets (DNCs) are the most preserved bodies in the Solar System and provide a unique opportunity for investigating the unaltered pristine materials from which the Solar System formed. DNCs are already active at about 26 AU from the Sun, where the temperature is too cold to allow water ice to sublimate. At those distances, the sublimation of supervolatile ices like CO2 and CO is considered responsible for activity. However, little is known about the specifics of activity pattern switches between being driven by supervolatiles and water, respectively. The ESA mission Comet Interceptor will target a DNC to be identified and selected at about 8-10 AU from the Sun, on its inbound orbit. Comet Interceptor will approach its target around perihelion (about 1-1.5 AU).

This Team will investigate and characterize the transition from supervolatile-driven activity to water-driven activity via a multidisciplinary approach that takes advantage of (1) results from ice sublimation laboratory experiments; (2) models and results from thermodynamic and numerical simulations of dust/gas coma; (3) insights from models of cometary formation and evolution; and (4) observational evidence re. the activity mechanisms. The latter comprises direct measurements of DNCs at varying heliocentric distances, in-situ measurements from previous space missions at comets for comparison and ground-truth, and overall results from remote-sensing instruments for other types of comets.

The aim is to build up robust observational methods and modeling strategies for improving our ability to anticipate the activity levels and patterns of inbound DNCs in preparation for the Comet Interceptor mission. This will influence target selection and therefore enhance the science return, as well as the safety of the mission itself.

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: 24–28 October 2022

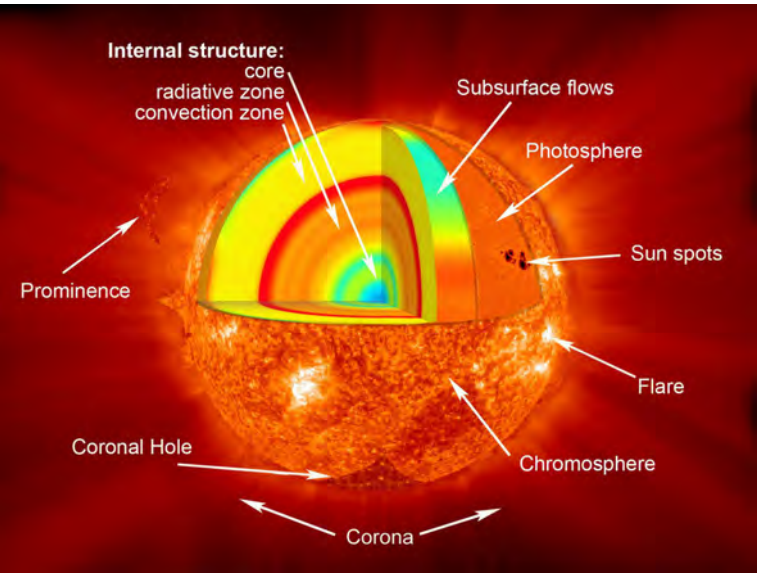
Scientific Rationale: Recent observations of dwarf galaxies have uncovered several tensions with cosmological predictions, such as an unexpected spatial alignment around massive galaxies (the plane of satellite problem), a discrepant dark matter content, and a higher-than-expected population of globular clusters. They add to other known problems and challenge the otherwise highly successful Λ + Cold Dark Matter (ΛCDM) model of cosmology.

An archetypal dwarf galaxy: The constellation of Ursa Major (The Great Bear) is home to Messier 101, the Pinwheel Galaxy. Like the Milky Way, Messier 101 is not alone, with smaller dwarf galaxies in its neighborhood. (Image Credit: ESA/Hubble & NASA)

Unfortunately, detailed studies of dwarf galaxies are hampered by their low luminosities and surface brightness and have so far been limited to a few nearby galaxy groups, including our own Local Group. Using the Canada France Hawaii Telescope this Team has observed over 200 fields around giant galaxies to a faint surface brightness limit, identifying some 2210 dwarf galaxies. With HST and VLT/MUSE follow-up programs the Team will answer pressing questions in the field: Is there a population of dark matter deficient dwarf galaxies with extreme globular cluster systems? Do the properties of dwarf galaxies vary with their environment? Is there more evidence for co-rotating planes of dwarf galaxies? The new data will enable the construction of statistically meaningful samples, to test if the challenges to our cosmological model persist or instead vanish.

This Team aims to develop a deeper understanding of dwarf galaxies and their globular clusters, building on expertise in galaxy formation and cosmological simulations. It will also discuss next-generation surveys with space missions such as Euclid, and future strategies for detecting dwarf galaxies and globular cluster populations.

International Teams



The sun and its atmosphere consist of several zones or layers: the Core, the Radiative Zone, and the Convection Zone. The solar atmosphere is made up of the Photosphere (the visible surface of the Sun), the Chromosphere (an irregular layer above the photosphere where the temperature rises from 6000°C to about 20,000°C), a Transition Region (a thin and very irregular layer of the Sun's atmosphere that separates the hot corona from the much cooler chromosphere), and the Corona (the Sun's outer atmosphere). (Image Credit: NASA/Goddard)

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: 12–16 September 2022
Scientific Rationale: The Sun exhibits a myriad of ejections and eruptions that are key for the mass and energy balance of the solar atmosphere and provide a significant input to the solar wind and coronal heating. Among these, surges are fundamental given their association with many other explosive and/or ejective phenomena like Ellerman Bombs, ultraviolet (UV) bursts, and coronal jets. The understanding of these bursty ejections of cool and dense plasma has progressed slowly due to the complexity of the physics of the chromosphere. Two main challenges must be overcome to clarify driving mechanisms and their relationship to other dynamic phenomena at various scales: one is the adequate treatment of the physics of the chromospheric plasma; the other is the need to directly compare numerical simulations and observations through forward modeling and inversion.

This Team has two main interconnected goals: (1) develop the first radiative MHD model of surges in 3D, and (2) get a complete characterization of the spectral profiles of surges in the main chromospheric lines, such as Hα and Mg II h&k. The Team will use the state-of-the-art Bifrost code to explore for the first time the role of nonequilibrium ionization of hydrogen in surges. High-resolution observations from the Swedish 1-m Solar Telescope (SST) and the Interface Region Imaging Spectrograph (IRIS) will be used to obtain representative profiles of surges in different wavelengths through unsupervised machine learning techniques. This work will open a new avenue for directly comparing numerical experiments with observations, thus providing a joint perspective on surges that is currently missing in solar physics.

Magnetotail Dipolarizations: Archimedes Force or Ideal Collapse?

Team Leader: Evgeny Panov, Austrian Academy of Sciences, Graz, Austria
Session: 16–20 May 2022
Scientific Rationale: In the magnetotail, highly variable bulk plasma flows provide sunward transport of mass, energy, and magnetic flux, often via bursty flows and transient dipolarization fronts (DFs). DFs are attributed to magnetic reconnection outflows due to a tearing instability. Theory and simulations suggest that tearing instability might be preceded by an ideal-MHD collapse of the magnetotail current sheet with fast flows but no magnetic topology changes. Similar fast flows can result from an interchange-type instability caused by magnetic buoyancy, when flux tubes with reduced plasma content are brought from the distant tail toward the planet, similar to air bubbles in water lifted to the surface by the Archimedes force. Both ideal collapse and buoyancy motions may change magnetotail configuration and favor reconnection. However, the contribution of these "pre-reconnection" motions to magnetotail dipolarization remains unclear.
Recent work suggests that buoyant plasma motions could indeed explain fast plasma flows and DFs in the Earth's magnetotail. Moreover, ballooning/interchange motions appear to dominate the transport processes in the big planets' magnetodiscs. These motions may be the primary ideal-MHD driver of topology changes in Kronian and Jovian magnetospheres via the so-called Vasyliunas convection cycle. In contrast, steady dayside and nightside reconnection provides the Petschek convection cycle in the Earth's magnetosphere. Both cycles have been at the focus of multiple missions (Cassini, Juno, Cluster, THEMIS and MMS), as well as dedicated theory and simulations, so tackling the following unanswered questions with a Team is timely:

• Which distinctive features of magnetic buoyancy and ideal collapse can help identify these two processes in observations?
• What are the MHD and kinetic peculiarities of the two processes?
• How are heavy ions involved in the buoyancy motions, ideal collapse and reconnection?
• How can we discern the ionospheric manifestations of these magnetospheric processes?

Data Assimilation in the Ionosphere and Thermosphere (ISSI – ISSI Beijing Team)

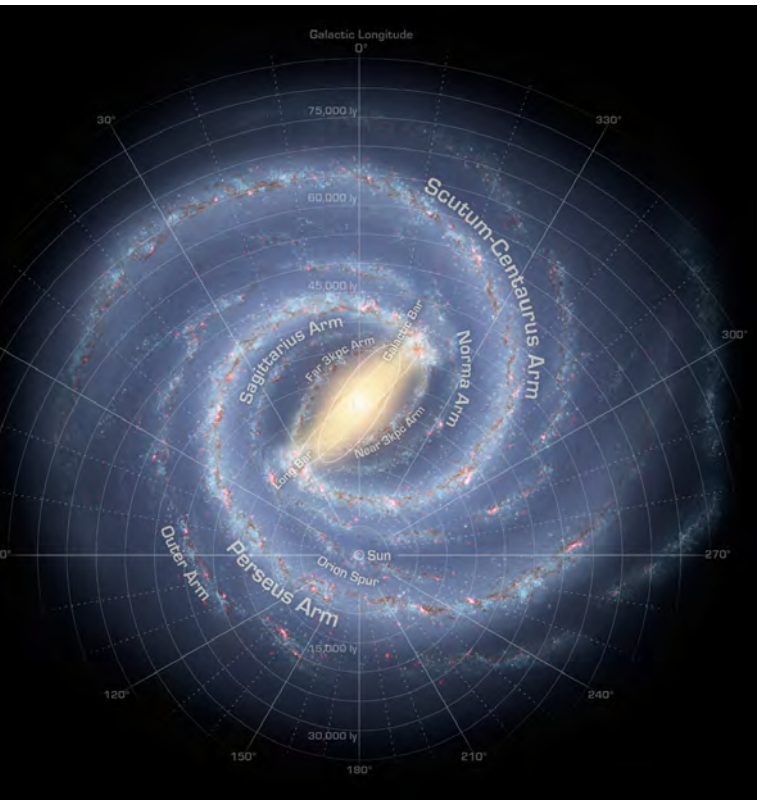
Team Leader: Nicholas Pedatella, NCAR/UCAR, USA
Session: 4–8 July 2022
Scientific Rationale: Specification and forecasting of the Earth's ionosphere and thermosphere (IT) is of critical due to its impact on, e.g., navigation signals (e.g., GPS) and satellite orbital drag. Following the path of troposphere numerical weather prediction, the IT community is adopting data assimilation techniques to improve specification and forecast capabilities. In addition to space weather applications, data assimilation models help with fundamental IT science. In particular, physics-based data assimilation models enable investigation of the predictability of the IT system, including the physical mechanisms controlling predictability. By providing the best estimate of the IT state, data assimilation models enable insights into the processes driving IT variability.
Data assimilation in the IT is a relatively recent endeavor, and methodologies remain relatively immature with a variety of approaches pursued. The capability of data assimilation models to investigate the predictability of the IT have yet to be fully exploited. The experts in data assimilation, numerical modeling, and observations constituting this Team will: (1) investigate the predictability of the IT, and (2) improve current IT data assimilation techniques. IT predictability will be investigated through detailed event analysis, and the (dis)advantages of different data assimilation techniques studied. The Team will also work on developing and exchanging data assimilation algorithms specific to IT research. This work is timely, given the recent availability of abundant new IT observations from the COSMIC-2, GOLD, and ICON missions.

Ice Beyond Earth: Laboratory Investigations of Planetary Ices

Team Leader: Ganna Portyankina, University of Colorado in Boulder, USA
Session: 25–29 July 2022
Scientific Rationale: Ices play an important role in surface processes throughout the Solar System. Ongoing Solar System missions are providing new remote-sensing information on (sub-)surface ices present on multiple planetary bodies, and future missions will continue to add to this data. To interpret these observations, we need to understand the physics of ices that are formed and evolve in alien conditions. Laboratory studies are often the only way to acquire empirical data on the physical state, properties, and behavior of different types/species of ices under conditions found on other planetary bodies. Physical models can then be refined and validated with lab results and used to understand remote-sensing data from planetary missions.
This Team focuses on the current state of experimental studies on extra-terrestrial ices and their application to space data. (Here "ices" refers to the solid state of volatile chemical compounds with low boiling point (nitrogen, water, carbon dioxide, carbon monoxide, ammonia, hydrogen, methane, sulfur dioxide). Experimental research requires sizable infrastructure investment, and hence careful long-term planning. However, this planning can be strategic when combined with state-of-the-art modeling and observational data. The objectives are to: (1) Search and review space-born data on planetary ices to identify a subset requiring lab measurements for analysis, (2) Evaluate status and capabilities of facilities available today, and prioritize lab-based research goals with a view to preparing for upcoming missions and feeding into mission-development; and (3) foster investment into and collaborations between labs from different countries which conduct experimental research on planetary icy environments.

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: 22–26 August 2022
Scientific Rationale: Titan, Enceladus, Europa and Ganymede belong to the family of ocean worlds because the Cassini mission and the Galileo mission demonstrated that a deep ocean of liquid water lies under an icy crust. Because liquid water is a key ingredient for life, these worlds represent both an exciting new frontier and a unique challenge for geochemistry. In the next decade, NASA's Europa Clipper and ESA's JUICE missions to the Jovian system and NASA's Dragonfly mission to Titan will be launched to increase our knowledge of these enigmatic objects. The Cassini mission has revealed that organics are produced in Titan's upper atmosphere and has suggested that other organics are present in the rocky core.
The goal is to investigate whether the upward flux from the silicate core to the ocean and the downward flux



Artist's concept of the Milky Way(Image Credit: NASA/ JPL-Caltech/R. Hurt)

from the surface to the ocean provide the necessary chemical disequilibria and energy to fuel extant microbial biospheres in Titan's ocean. This goal will be addressed by completing eight science objectives that will characterize the downward flux (3 objectives) and the upward flux (3 objectives). The seventh objective will determine whether these fluxes produce the necessary redox gradients. The last objective will develop a Habitat Suitability Model (HSM) for Titan's ocean to assess its biological potential. This work is done by an interdisciplinary Team composed of a diverse group of research scientists with the required complementary expertise.

The Early Milky Way

Team Leader: Else Starkenburg, University of Groningen, the Netherlands
Session: 10–14 October 2022
Scientific Rationale: Our home Galaxy is a unique place to study the early history of the Universe. By selecting stars that are almost fully devoid of heavy elements – and thus belong to the earliest generations of stars formed in the Universe – we can look far back in time. Studying these stars gives us precious information on the conditions in the early Galaxy, they track chemical as well as stellar evolution processes in ancient times, and they allow us to provide a detailed reconstruction of the build-up of our Milky Way galaxy.
Thanks to the Gaia mission a revolution is taking place in studies of the dynamical complexity of our Galaxy. However, to fully understand the Galaxy and its history back to the earliest times, this needs to be supplemented with large studies of stellar chemical abundance patterns. This Team will bring together these two critical ingredients as it coincides with the emergence of multi-object spectrographs with massively multiplexing capabilities – in particular the WEAVE survey (first light planned for August 2021). It will combine the catalogue makers for these special targets in WEAVE with the spectroscopic analysis experts in this field, authorities on Gaia data exploration, and the experts in modeling the early history of the Milky Way.

Distribution of Interstellar Neutral Hydrogen in the Sun's Neighborhood

Team Leader: Pawel Swaczyna, Princeton University, USA
Session: 20–24 June 2022
Scientific Rationale: The Sun travels through a partially ionized very local interstellar medium (VLISM) as it emits the solar wind, inflating a bubble called the heliosphere. Charged particles from the solar wind and VLISM are separated on two sides of the heliopause, but interstellar neutral (ISN) atoms enter the heliosphere. The ISN atom distribution evolves as ISN gas flows through the outer heliosphere due to collisions with other species. ISN atomic hydrogen (H) is the dominant species in the VLISM, whereas inside the heliosphere, neutral H is a sensitive indicator of different interaction processes between the Sun and the VLISM.
Neutral atom detectors like IBEX-Lo directly sample H atoms in the ISN, whose line-of-sight density distributions are also inferred from Lyman-α backscattered light, observed at 1 au (SWAN/SOHO) or with more distant probes (Voyager 1, New Horizons). Ionized ISN atoms form a suprathermal population of pickup ions (PUIs) in the solar wind, where recent observations of H PUIs with the charged particle detector New Horizons/SWAP revealed a higher density than expected. Several processes must be included when interpreting these observations. First, charge exchange and elastic collisions modify the ISN H distribution beyond the heliopause. Inside the heliosphere, charge exchange, electron impact collisions, and photoionization cause further ionization. Their ballistic trajectories are also modified by time-, distance-, and radial velocity-dependent solar radiation pressure.
To estimate the spatial distribution of ISN H inside the heliosphere, and its velocity distribution functions at key positions observed by the currently operating spacecraft,

this Team will develop a new model to replace a widely used, two-component approximation with primary and secondary components modeled with Maxwell distributions at the termination shock (TS). This approximation is likely responsible for discrepancies between ISN studies from different experiments. The Team will also study ISN H properties in the pristine VLISM. Good models of the ISN H distribution are necessary to interpret energetic neutral atom (ENA) observations, as well as to understand the global structure of the heliosphere. These results will help operational planning for future space instruments, e.g., on IMAP.

AsteroCatS – A Legacy Catalogue for Spectroscopic Surveys

Team Leaders: Marica Valentini and Guillaume Guiglion, Leibniz-Institut für Astrophysik Potsdam (AIP), Germany
Session: 9-13 May 2022
Scientific Rationale: Modern large-scale, ground-based stellar spectroscopic surveys produce large datasets of stellar atmospheric parameters, abundances and ages. These datasets are crucial for testing current chemo-dynamical models for the Milky Way and its formation. Two different approaches are usually adopted for deriving stellar parameters and chemistry from stellar spectra: "physical" spectroscopic pipelines that fit a synthetic spectrum to an observed one, and machine learning methods that derive stellar labels after being trained on spectra of well-known stars.
How can we ensure the accuracy, precision, and homogeneity of the parameters provided by surveys? Presently, spectroscopic surveys base their homogenization on only 36 benchmark stars, with each survey adopting its own training sample (often with incomplete parameter coverage, especially in the metal-poor regime) for machine learning. Abundance zero-points and trends thus vary from one survey to another, introducing erratic biases when used for characterizing our Galaxy.
This Team will produce an enduring remedy to this situation. Using targets with available asteroseismology and targets in clusters, we will build a reference catalogue of ~105 stars. The catalogue will include reliable atmospheric parameters, abundances, and ages that span the required range for Milky Way investigations. The reference catalogue will have a significant importance for present and future spectroscopic surveys such as 4MOST or MSE.

Understanding the Evolution and Transitioning of Distant Proto-Clusters into Clusters

Team Leader: Benedetta Vulcani, Osservatorio Astronomico di Padova, INAF, Italy
Sessions: 28 March – 1 April 2022 and 17–21 October 2022
Scientific Rationale: We currently have a broad-brush understanding of how the environment in nearby massive clusters affects cluster member galaxies via tidal and hydrodynamic processes. However, our knowledge is much more limited at higher redshift ($z > 1$-2), when these structures were forming and gas densities and star formation rates were much higher. Studies of the highest redshift progenitors of local clusters – called proto-clusters – are currently rare and limited.
So far, systematic comparisons of structures over a range in redshift, mass, and evolutionary stage are lacking and models of proto-clusters are largely untested. This lack of a systematic characterization of proto-clusters prevents us from obtaining a global view of how environment affects the properties of galaxies at the earliest stages.
This Team brings together researchers with diverse specializations (observations and simulations, integrated and spatially resolved data, different wavelengths and focusing on different cosmic epochs) to tackle questions that cannot be addressed in isolation. The immediate goals of the Team are to:
- Investigate the nature of the galaxies within (proto) clusters, by combining existing proto-cluster samples and accounting for systematics and selection biases.
- Characterize the role of proto-clusters in the evolution of galaxies destined to live in low-z clusters, by homogeneously combining existing samples of galaxies in (proto-) clusters and the co-eval field.
- Determine the fuel for SF in high-z (proto)cluster and field galaxies by characterising the different gas phases and comparing those results to theoretical predictions.
- Quantify the relative importance of different galaxy quenching processes in different environments, by spatially resolving tracers of stellar mass, gas, and SF within galaxies.

International Teams approved in 2022

The following listed teams have been selected for implementation from the proposals received in response to the 2022 Call for International Teams:

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 (ES) and Ingrid Cnossen, British Antarctic Survey, United Kingdom

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

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

Understanding the Activity of Comets Through 67P's Dynamics

Team Leader: Nicolas Attree, Technische Universität Braunschweig, Germany

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

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

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

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

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 at ISSI: 2–4 November 2022

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 at ISSI: 31 October – 4 November 2022

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

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

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

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

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

Transformation of Planetary Systems by Environmental Perturbations

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

Improving the Description of Exosphere Surface Interface

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

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 at ISSI: 5–9 December 2022

Timing and Processes of Planetesimal Formation and Evolution (ISSI – ISSI Beijing Team)
Team Leader: Wladimir Neumann, Technical University Berlin, Germany

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

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 at ISSI: 28 November – 2 December 2022

The Cosmic Baryon Cycle from Space
Team Leader: Céline Péroux, European Southern Observatory (ESO), Germany
Session at ISSI: 24–28 October 2022

Multi-Wavelength Studies of the Culmination of Structure Formation in the Universe
Team Leader: Gabriel Pratt, CEA Saclay, Service d'Astrophysique, France
Session at ISSI: 28 November – 2 December 2022

Seismicity on Venus: Prediction & Detection
Team Leader: Iris van Zelst, German Aerospace Center, Germany

Synthetic Gravity Wave Analyses for New Exploitation of Satellite Data (SWANS)
Team Leader: Corwin Wright, University of Bath, United Kingdom

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

Johannes Geiss Fellows 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 honor 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.

Marco Velli is the Johannes Geiss Fellow 2022 and Professor of Space Physics at the Earth, Planetary and Space Sciences Department, University of California, Los Angeles, USA. A student of the University of Pisa and Scuola Normale Superiore, he has spent research periods at the University of St. Andrews, Scotland, the Observatoire de Paris, France, Università della Calabria, Italy, and the Smithsonian CfA, Cambridge, MA, as well as the Jet Propulsion Laboratory, California Institute of Technology, where he remains a Senior Scientist. In the following paragraphs he answers a few questions – asked by Christian Malacaria, ISSI Post Doc – about his scientific work. Christian Malacaria is an X-ray astronomer with expertise in observations and data analysis of compact objects. He is a member of several X-ray missions such as Fermi/GBM, NICER and IXPE.

Christian Malacaria (ISSI Post Doc, sitting left) and Marco Velli (Johannes Geiss Fellow 2022).

Christian Malacaria: What is the main advantage of being a Johannes Geiss Fellow @ ISSI?
Marco Velli: As a UCLA professor, I have several different official tasks and duties in addition to research, such as administrative, managerial, and teaching. All these are an essential part of each scientist's work but can become so cumbersome that eventually one is left with less and less time for the creative research process, or even just for enjoying in depth scientific discussions with colleagues and friends. The Johannes Geiss Fellowship (JGF) provides time away from the day-to-day hassle, allowing one to rediscover and enjoy pure research.
Being a JGF at ISSI offers numerous advantages, creating a highly favorable research environment. ISSI-Bern is a tranquil yet stimulating place, frequently visited by exceptionally interesting guests and featuring a vibrant atmosphere. Here, diverse scientists, both young and senior, from various backgrounds continuously come and go, providing opportunities for diverse brainstorming, which fosters innovative research projects. The peaceful environment and minimal mundane duties of ISSI allow me to feel comfortable and remain focused, free from distractions. Furthermore, ISSI provides a convenient apartment within a short walk of the institute, unlike my usual residence in Los Angeles, where I endure a one-hour traffic jam to get anywhere. In essence, as a JGF, the hassles of everyday life have been removed, making life at ISSI significantly easier. Moreover, at ISSI, I have been able to join several science teams and workshops, and even participate in meetings without being a formal team member. This opportunity is not available anywhere else in the world of space physics. Although my six-month Fellowship is coming to an end soon, I would reapply for the JGF experience right now. This experience has rekindled my enthusiasm for research, in ways that are impossible to replicate elsewhere.

C. Malacaria: What are the most important open questions in Heliophysics and how are they going to be addressed?
M. Velli: One of the most significant and fundamental problem is the existence of the heliosphere itself, closely linked with others: why does the Sun have a functioning dynamo and magnetic field? How is the solar corona heated and the solar wind generated? How are solar flares and coronal mass ejections triggered and solar energetic particles accelerated?
The main obstacles to answering these questions can be divided into two categories: the first is related to observations, the second to time-scales: to start from the second point, our knowledge of the basic mechanisms behind the solar dynamo is limited by the Solar cycle periodicity: we must base our statistics on the 11-year (22-year full) cycle, and though we have some observational proxies dating back centuries, routine measurements of the solar magnetic field from Earth is limited to about 10 cycles, while direct measurements of the solar wind and of the x-ray corona date to the space age (< 5 cycles), with the highest resolution measurements from SDO being only about a decade old. In addition, understanding the dynamo requires precise measurements of the magnetic fields and photospheric flows all the way to the solar poles, while we are limited from the ecliptic plane to

measurements around 60 degrees. Such observations would be key in understanding the solar magnetic field, and indeed the ongoing joint ESA-NASA mission Solar Orbiter will move out of the ecliptic plane within the next few years hopefully providing major new discoveries over the coming decade. Complementary to that, NASA's Parker Solar Probe is probing the solar corona directly and will be moving to a perihelion inside 10 solar radii from center within the next two years.
A predictive theory based on solid observations of the solar dynamo, solar coronal heating and solar wind acceleration is fundamental to understand the dynamics of magnetized plasmas well beyond Solar or Stellar physics, from the interstellar medium to galactic halos, pulsar wind nebulae and black hole magnetospheres, active galactic nuclei and the hot intra-cluster medium. Solar flares and coronal mass ejections are at the lower end of energetic bursty phenomena associated with magnetized plasmas throughout the universe that are associated with the generation and acceleration of cosmic rays and the X-ray and gamma-ray universe more generally. To progress in our understanding of the Heliosphere, key future missions should include a global constellation of observatories comprehensive of in ecliptic and out of ecliptic (polar) observations, allowing for a 3D reconstruction of the Heliosphere in its complexity and variability. Such a mission is of fundamental interest also in the context of space weather and of providing the plasma context and advance warning for future human exploration of the solar system.

C. Malacaria: Given the importance of the social melting pot promoted by ISSI, what do you think is the role of science (and scientists) in society?
M. Velli: Science is experiencing an unprecedented pace of breakthroughs across multiple domains, and the approach to scientific research is also undergoing a significant transformation. Large collaborative teams are replacing the traditional romanticized notion of the lone scientist working at their table. However, the amount of time devoted to science and critical thinking has not improved, and science classes in schools remain limited. This is concerning, as it may lead to generations of scientists with exceptional technical skills, but a limited understanding of the big picture. The problem of "compartmentalized knowledge" can hinder scientific progress and our understanding of physics in several ways, including the limitations of our science, or the boundaries of our understanding. To prevent this, we need to apply scientific thought and critical reasoning to different environments, including everyday life. This would enable us to greatly expand the way science is practiced, and foster a more continuous form of education as opposed to the current discrete model.
Science no longer requires all-knowing gurus, as it did in the past. As science evolves, the role of "universalists" is fading, and team-based work is becoming the key to achieving groundbreaking goals. Each scientist is now part of a larger chain, and their responsibility is not solely to the advancement of science but also to a necessary knowledge of the limitations of the results and methodologies. This becomes even more paramount with the emergence of machine learning and artificial intelligence methodologies where understanding how a certain result has been obtained can become as difficult as the original question probed.

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 27th year:

Eric Gaidos, University of Hawaii at Manoa, USA, working period: 23.5-18.6.2022

Hans Huybrighs, Research Fellow ESA/ESTEC, working period: 22.8.-15.9.2022

Debora Lančová, Institute of Physics, Silesian University in Opava, Czech Republic, working period: 18.-23.1.2022

Piyush Marmat, Indian Institute of Technology Roorkee, Roorkee, India, working period: 1.9.-30.11.2022

Gabriele Morra, University of Louisiana, USA, Working: 16.11.-25.12.2022

Sabine Schindler, Johannes Geiss Fellow 2020, working period: 17.-31.7.2022

Yuri Skorov, working period: 27.4.-23.5.2022 and 25.7.- 3.9.2022

René Šprňa, Institute of Physics, Silesian University in Opava, Czech Republic, working period: 18.-23.1.2022

Marco Velli, Johannes Geiss Fellow 2022, working period: 10.10.2022-9.4.2023

Lenka Vozárová, Institute of Physics, Silesian University in Opava, Czech Republic, working period: 18.-23.1.2022

Frances Westall, CNRS, Orléans, France, working period: 1.-25.10.2022

Jun Yang, working period: 6.-18.6.2022

Adrian Glauser , Anne Verhamme, Pascal Oesch, Beatrice Kulterer, and Antonella Nota during their presentations (pictures taken by Guido Schwarz)

First Pictures James Webb Space Telescope

The James Webb Telescope – the most sophisticated space telescope to date – was launched in December 2021 and has acquired its first images and spectra in 2022. NASA, ESA and the Canadian Space Agency (CSA) released the first set of images and spectra of the James Webb Space Telescope (JWST) on 12th July 2022. ISSI celebrated the first release as the Swiss node of a worldwide network of events. Therefore several talks were organized with scientists involved in this spectacular mission.

After a short introduction by ISSI's Executive Director Tilman Spohn and Valerie Koller (Swiss Space Office), Swiss scientists involved in the JWST mission presented their talks: "JWST and the Swiss Contribution to the Mid Infrared Instrument (MIRI)" by Adrian Glauser (ETH Zurich), "From Dark to Light: The First Generations of Galaxies" by Pascal Oesch and Anne Verhamme (both University of Geneva), and "Making the Building Blocks of Life in Interstellar Ices" by Beatrice Kulterer (University of Bern).

Antonella Nota, Webb Project Scientist and former head of ESA office at the Space Telescope Science Institute explained to the audience "What to Expect from the Early-Release Observations" before the NASA/ESA/CSA ERO live broadcast during which where the first five images were presented.

Numerous Swiss space scientists such as astronaut Claude Nicollier (EPFL), Willy Benz (University of Bern), Jean-Paul Kneib (EPFL), all ISSI Directors as well as Swiss media representatives gathered to admire several spectacular data sets, from the cosmic cliffs and glittering landscape of the nearby star-forming region NGC 3324 in the Carina Nebula, to the deep near infrared imaging of early universe galaxies in the field of the lensing cluster SMACS 0723.

The dawn of a new era in astronomy has begun as the world gets its first look at the full capabilities of the James Webb Space Telescope. The telescope's first full-color images and spectra, which uncover a spectacular collection of cosmic features were released on 12th July 2022. (Credit: NASA, ESA, CSA, and STScI)

"It works!" concluded ISSI Honorary Director and former ESA Director of Science Roger-Maurice Bonnet with a smile, and Willy Benz added: "This will be *the* instrument everybody wants to use".

The ISSI staff look forward to hosting many JWST related science activities in the coming years. This event showed how much interest JWST is generating already from day 1 and was pleased that this event organized at ISSI featured prominently in the Swiss news.

Mark Sargent and Andrea Fischer

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 general public via its members, who are mostly laypeople, but often represent universities, industry, politics, and public administration. The Association organizes public lectures and publishes several SPATIUM issues per year. The Pro ISSI Association, which consists presently of 118 members, also meets once per year for its general assembly. The Board of Pro ISSI currently consists of Prof. Christoph Mordasini (President), Dr. Annette Jäckel (Treasurer), Dr. Yasmine Calisesi (Secretary), Dr. Anuschka Pauluhn (Editor SPATIUM), and PD Dr. Andreas Verdun (Editor SPATIUM).

Public Lectures

In 2022, the Association Pro ISSI was relieved to be able to return to its normal in person modus after the pandemic. This meant that the three Pro ISSI talks took again place in person. To increase the international reach, the life online streaming was, however, continued. The talks are also recorded and available via the ISSI homepage. The in person meetings made it again possible to have the important personal interactions between the Pro ISSI members and the speakers.

On 30th of March 2022, Prof. Dr. Sabine Schindler (Innsbruck University) gave a presentation on the cosmic history of the universe. In 2020, she had been awarded with the Johannes Geiss Fellowship. Prof. Schindler summarized the current status of knowledge of our universe' past and future evolution. She also presented the constraints that are expected from the next generation of observational facilities like the JWST or the ESO ELT.

On 11th of May 2022, Prof. Dr. Thomas Schildknecht gave a talk on "Space Debris – Providing the Scientific Foundation for a Sustainable Use of Outer Space". Prof. Schildknecht (AIUB, Bern) is the director of the Zimmerwald Observatory that is involved in the study of space debris. He is also involved in numerous international committees on the use of outer space. As became clear in his talk, compared to other fields of space research, this subject has a strong political and strategic component. The perspective of satellite constellations with thousands of satellites, which could have many important effects was also discussed in his interesting lecture.

Finally, on 2nd November 2022 the General Assembly took place, followed by the talk of Prof. em. Dr. Ruedi von Steiger on "The First 25 Years: Genesis and Evolution of ISSI". His talk gave a first-hand account of the unique way how ISSI came into existence thanks to Prof. Johannes Geiss' exceptional initiative and ingenuity and how the institute has evolved ever since. Using many original documents from the time, Prof. von Steiger gave a captivating talk with many insights into the key elements of the success story of ISSI and the underlying principles. The talk was a lecture in the best sense for everybody interested in how a leading institution like ISSI can be founded and maintained.

In 2022 the SPATIUM No. 49, 50 and 51 have been published by the Association Pro ISSI.

SPATIUM

The Association's magazine SPATIUM elaborates on selected Pro ISSI lectures. During the reporting period, the first issue No. 49 was published in May 2022, entitled "Exploring the Earth's time-variable gravity field using satellite observations." It was prepared by Prof. Adrian Jäggi (AIUB, and former president Pro ISSI), based on his Pro ISSI talk in March 2021. Number 50 "Cosmographia Bernensis – ISSI's place in the history of Bernese cosmography" by PD Dr. A. Verdun and Dr. A. Pauluhn is clearly a highlight in the SPATIUM series to date. Appearing in October 2022, it is a special jubilee edition twice the length of a normal volume to celebrate the 50th SPATIUM. Starting with an editorial by Dr. Hansjörg Schlaepfer, it draws an fascinating and attractive visual history from the beginnings of modern astronomy in Bern to ISSI. It is a new reference for all interested in the history of astronomy, astrophysics and related subject in Bern. It also formed the larger historical frame for the talk of Prof. von Steiger. This volume was also intended to compensate the Pro ISSI members for the reduced (only virtual) activates during the pandemic. Thereby it used up the reserves that the association had amassed during the pandemic because of the lack of in person talks and associated costs. This very beautiful oeuvre also obtained special financial supported by the ISSI directorate. The 3rd SPATIUM (No. 51) in 2022 is "From the Present into the Past and Future – the Evolution of the Universe" by Prof. S. Schindler. It appeared in December 2022. These publications together with all previous issues of SPATIUM can be found on Pro ISSI's homepage www.issibern.ch/association-pro-issi/spatium/

Christoph Mordasini

Financial Overview

The 27th financial year of ISSI resulted of the year is a surplus of almost 9 kCHF as opposed to a budgeted deficit of 18 kCHF. This positive result is largely due to the fact that, particularly in the first half of 2022, some scientists participated in teams or workshops online at no cost to ISSI due to uncertainties related to Covid-19. However, the surplus could have been somewhat higher if the ex-change rate of the euro against the Swiss franc had developed more favorably over the past twelve months. On a positive note, the Swiss National Bank decided in July 2022 to end the era of negative interest rates, which lasted for around eight years.

On the revenue side the contributions from ESA (Directorates of Science and 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. Additionally, the Lunar and Planetary Institute (LPI) supported the attendance of US planetary scientists at ISSI meetings.

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 27th Financial Year (1.1.2022-31.12.2022)

	Expenses	Revenues
ESA Science Directorate		1'261'320.00
ESA Earth Observation Programme		304'185.00
Swiss Confederation		1'020'000.00
Swiss Academy of Sciences (SCNAT)		215'000.00
ISSI Partners: ISAS/JAXA		24'686.00
Salaries and related costs [1]	1'135'953.77	
Fixed costs	282'031.20	
Operating costs [2]	286'891.71	
Investment (depreciated)	219'603.30	
Workshops, Working Groups, Teams, Visitors [3]	947'411.38	
Other income or cost [4]		55'520.26
Result of the year	8'819.90	
Total	2'880'711.26	2'880'711.26

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 organizational, 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 due to variations in monetary exchange rates.

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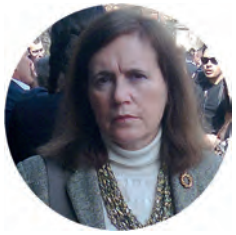

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The list shows the status at the end of the 27th business year on 31st December 2022.

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(as of 1st January 2023)

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The list shows the status at the end of the 27th business year on 31st December 2022.

Staff Activities

Listed are activities in which ISSI staff scientists participated in 2022. This includes presentations given, meetings attended, outreach, honors received, and chairmanships held.

Presentations

January 7, 2022 – L. Moreira: Sea-Level Fingerprints Due to Present-Day Water Mass Redistribution in Observed Sea-Level Data, Laboratory for Ocean Physics and Satellite remote sensing (LOPS) Seminar, Plouzané, France (online)

February 16, 2022 – M. Sargent: "Extragalactic continuum science at high angular resolution: Key contributions to understanding galaxy growth and quenching", invited review talk at the conference "VLBI in the SKA Era" (online)

February 25, 2022 – M. Falanga: "Das erste Bild eines schwarzen Lochs", Seminar, Seniorenuni, University Bern, Switzerland

March 25, 2022 – L. Moreira: Origin of the Regional and Interannual Variability in Sea Level, Institute of Applied Physics (IAP) Seminar, University of Bern, Switzerland.

May 11–12, 2022 – M. Falanga: two series of lectures on "Current and future European space projects" and on "The first image of a black hole" Foundation ONAOSI Perugia, Italy

May 13, 2022 – M. Falanga: Das erste Bild eines Schwarzen Loches, Seminar "Physik am Freitag Uni Bern", University of Bern, Switzerland

May 24, 2022 – M. Sargent: "Galaxies at cosmic noon: What will SKA1-MID see?", contributed talk at the SKACH Consortium Meeting, Zürich, Switzerland

31 May – 2 June 2022: M. Rast: EUMETSAT User Days: Focus on Next-Generation Satellite missions Meteosat Third Generation (MTG) and EUMETSAT Polar System Second Generation (EPS-SG), Darmstadt, Germany: Panel presentation/discussion: "R&D perspectives, and Next-Generation Satellite Missions MTG and EPS-SG".

June 22–24, 2022 – M. Rast: "Contributions from Imaging Spectroscopy towards 2030", 12th EARSeL Workshop 2022 on Imaging Spectroscopy, Potsdam, Germany

July 19, 2022 – M. Falanga: "Pointing Robertson effect in Astronomy", Lecture, Silesian University, Opava, Czech Republic

July 22, 2022 – C. Malacaria: "Accreting on the Edge: A Luminosity-dependent Cyclotron Line in the Be/X-Ray Binary 2S 1553-542 Accompanied by Accretion Regimes Transition", COSPAR virtual solicited talk, (online)

August 3, 2022 – M. Falanga: "Reason to get scientific married in space", Lecture, International Space University (ISU) SSP22, Oeiras, Portugal

September 19–23, 2022 – T. Spohn: "Land/Ocean Surface Diversity on Earth-like Exoplanets" and „Using the HP3 Mole as a Thermal Probe on Mars", European Planetary Science Congress, Granada, Spain

September 23, 2022 – M. Rast: "The International Space Science Institute ISSI in Bern – a 'Think-Tank' and its activities in Earth Sciences", ISSI meets UZH Space Hub, University of Zürich, Switzerland

September 28, 2022 – M. Rast: "The International Space Science Institute ISSI and its activities in Earth Sciences", International Centre Earth Simulation ICES Biennial Workshop IV, Energy-, Climate-, Computing, Geneva, Switzerland

October 13, 2022 – M. Falanga: "Relativistic Iron Line Emission from the Neutron Star Low-Mass X-Ray Binary", RAGTime conference, Opava, Czech Republic

October 19–21, 2022 – M. Rast: "Imaging Spectroscopy Missions from Space - Cooperation, Requirements and Opportunities since Frascati 2019" 2nd Workshop on International Cooperation in Spaceborne imaging Spectroscopy.

November 7–10, 2022 – C. Malacaria: "The unaltered pulsar: GRO J1750-27, a supercritical X-ray neutron star that does not blink an eye", Athena Conference (poster)

December 6, 2022 – R. Hohensinn: "Estimation of tropospheric parameters from GNSS smartphones in a differential approach", AHORN 2022, Switzerland

December 12–16, 2022 – T. Spohn: "Land/Ocean Surface Diversity on Earth-like Exoplanets", AGU Fall Meeting 2022, Chicago, USA

December 14, 2022 – R. Hohensinn: "Sensitivity analysis of Western U.S. Velocities from daily GNSS displacements", AGU 2022, Chicago, USA (poster presentation)

December 14, 2022 - T. Dudok de Wit: "A Comprehensive Catalogue of Switchbacks: Evidence for a Generation in the Lower Corona", AGU Fall Meeting 2022, Chicago, USA

Meetings

January 19–20, 2022 – M. Sargent: Science with the DSA-2000 Radio Camera: Workshop I (online)

January 24–28, 2022 – M. Falanga: Compact-Object Astrophysics in the Era of Multi-Messenger Astronomy, Member of the organizing committee of the 51th "Saas-Fee Advanced Course" of the Swiss Society for Astrophysics and Astronomy (SSAA), Saas-Fee, Switzerland

February 14–18, 2022 – M. Sargent: VLBI in the SKA Era (online)

March 2–4, 2022 – T. Spohn: InSight Science Team Meeting 23 - Report on HP3 status and science

March 14–17 March 2022 – S. Wenger: COSPAR Bureau Meetings, Paris, France

April 1, 2022 – M. Rast: The Environmental Mapping and Analysis Programme – EnMAP, Geo Forschungs Zentrum - GFZ Potsdam, Germany

May 4, 2022 – M. Sargent: GNOSIS Workshop on Space Situational Awareness in Astronomy (online)

May 23, 2022 – T. Spohn: Stiftungsrat Planetarium Berlin, Germany

May 23–27, 2022 – M. Rast: ESA Living Planet Symposium 2022, Conference Centre Bonn, Germany

May 24, 2022 – M. Sargent: SKACH Consortium Meeting, Zürich, Switzerland

June 1, 2022 – T. Spohn: ISSI New Mars Underground (online)

June 14–17, 2022 – T. Spohn: InSight Science Team Meeting 24 - Pasadena and online - Report on HP3 status and science

July 11, 2022 – M. Falanga: A&A Journal Board of Directors meeting, Paris, France

July 11, 2022 – T. Spohn: ISSI New Mars Underground (online)

July 16–24, 2022 – S. Wenger: COSPAR 2022 - 44th Scientific Assembly, Athens, Greece

July 18–22, 2022 – M. Falanga: Visiting the "Silesian University in Opava", Czech Republic

July 22, 2022 – M. Sargent: Joint Workshop of the SKA Extragalactic Continuum and HI science working groups (online)

August 8–12, 2022 – M. Falanga: Lecturer at the International Space University, SSP22, Oeiras, Portugal

September 6, 2022 – T. Spohn: ISSI New Mars Underground (online)

September 12–13, 2022 – T. Spohn - Evaluation European Space Resources Exploration Center Luxembourg

September 27, 2022 – T. Spohn: Evaluation of the Mars Rover Testsite art DLR Oberpfaffenhofen

September 30 – October 4, 2022 – T. Spohn - meeting - ISSI New Mars Underground

October 3–4, 2022 – M. Sargent: Swiss SKA Days 2022, Lugano, Switzerland

October 10–14, 2022 – M. Falanga: RAGTime conference, 24th Relativistic Astrophysics Group Meeting, Opava, Czech Republic

October 18–21, 2022 – M. Sargent: IAA Severo Ochoa Meeting - Addressing Key Astrophysical Questions from Granada, Granada, Spain

November 5, 2022: M. Rast: Topping out ceremony Space Eye - Observatory for space and environment, Niedermuhlern, Switzerland.

November 14–18, 2022 – T. Spohn - InSight Science Team Meeting 25 - London and online - Report on HP3 status and science

November 22–25, 2022 – M. Sargent: SKA Pathfinder Radio Continuum Surveys (SPARCS) Meeting XI (online)

November 23–24, 2022 – T. Dudok de Wit: Science Council for Astronomy and Astrophysics, Paris, France

November 25, 2022 – M. Rast: Wissenschaftliches Symposium - Doppeljubiläum 100 Astronomisches Institut der Universität Bern, 200 Jahre Uraniae, AIUB, Bern, Switzerland

December 12–16, 2022 – T. Dudok de Wit, R. Hohensinn, T. Spohn: AGU Fall Meeting 2022, Chicago, USA

December 13, 2022: Michael Rast: Launch event: The Meteosat Third Generation – MTG-I 1 launch, ESA Centre Spatial Guyanais, Kourou, French Guyana.

January – December 2022 - Tilman Spohn - monthly author team online meetings ISSI Workshop and Book "Venus Evolution Through Time", monthly online meetings InSight mission leadership, bi-weekly online meetings ImSight mission Near Surface Working Group

ISSI Scientists in the Media

January 11, 2022 – How much Did the Moon Heat Young Earth?, Article with T. Spohn by J. Japelj, EOS Journal

March 2022 – Interview with M. Falanga: "Die Schweiz spielt in der obersten Liga" by P. Stehlin, touring Magazine

June 15, 2022 – "Gefrässiges Schwarzes Loch entdeckt" Article with M. Falanga by I. Dietschi, SRF News Online

July 25, 2022 – M. Sargent: "Probing the physical processes in the interstellar medium of galaxies at 'Cosmic Noon' with SKA", press release (IPM Teheran and MPIA Heidelberg)

July 26, 2022 – M. Sargent: "Möglicher Blick auf das Ende der kosmischen Mittagszeit", Press Release of the MPI for Astronomy, astronews.com

November 24, 2022 – Interview with R. von Steiger. "Es ist wichtig, dass die Schweiz einen Esa-Astronauten hat", SRF News Online

Chairperson- and Memberships, Honors

Roger-Maurice Bonnet
- President of IFHE's Aubinière Price Award, France
- Member of Institut Français d'Histoire de l'Espace, France
- Member ISSI-BJ Board of Trustees
- Member Royal Swedish Academy of Sciences
- Member Academia Europaea
- Member Royal Society of Sciences, Liège, Belgium
- Member International Academy of Astronautics (IAA), Van Karman Awardee 2009
- Member Academy of Air and Space
- "Hall of Fame" National Air and Space Museum, Washington DC, USA
- Asteroid 18627 1998DH33 named ROGERBONNET

Thierry Dudok de Wit
- Member of The European Space Weather and Space Climate Association (E-SWAN)
- Member of American Geophysical Union (AGU)
- Member of International Astronomical Union (IAU)
- Member of French Physical Society (SFP)
- Member of French Society of Astronomy and Astrophysics
- Member of Academy of Air and Space (AAE)
- Associate Editor of Journal of Space Weather and Space Climate
- Reviewer for Astronomy and Astrophysics, The Astrophysical Journal, Journal of Geophysical Research, Solar Physics, Scientific Reports, Geophysical Research Letters
- Evaluator and Rapporteur for The Research Foundation - Flanders (FWO)
- Evaluator for the Swiss National Science Foundation (SNF)
- Evaluator for the South African National Space Agency (SANSA)

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 (SCF
- 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 science team, scheduled for launch in 2023
- Member of the COSPAR Task Group to Develop an Actionable Plan for an International Constellation of Small Satellites (TGCSS)

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) - Board Member
- 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)
- Co-chair of the SKA Extragalactic Continuum science working group
- Ex-officio board member of the Swiss SKA Consortium (SKACH)
- Reviewer for Astronomy & Astrophysics
- Reviewer for European Research Council (ERC) grant proposals
- Reviewer for STFC Ernest Rutherford Fellowships

Tilman Spohn
- Fellow American Geophysical Union
- Full member Academy of Astronautics,
- Academy of Astronautics, Board of Trustees
- Member Academia Europaea
- European Astrobiology Inst. Management Committee
- Planetarium Berlin, Board of Trustees
- Principal Investigator for the Heat Flow and Physical
- Properties Package HP3 on the NASA InSight mission to Mars
- Asteroid 12062 1998FB10 named TILMANSPOHN

Staff Publications

Listed are all papers written or co-authored by ISSI staff members that appeared in 2022.

Algera, H. S. B. (incl. M. Sargent) et al. COLDz: Probing Cosmic Star Formation With Radio Free–Free Emission. Astrophysical J 924, 76 (2022).

Breuer, D. (incl. T. Spohn) et al. Correction to: Interiors of Earth-like planets and satellites of the Solar System. Surv Geophys 1–2 (2022) doi:10.1007/s10712-021-09687-9.

Brinkman, N. (incl. T. Spohn) et al. In Situ Regolith Seismic Velocity Measurement at the InSight Landing Site on Mars. J Geophys Res Planets 127, e2022JE007229 (2022).

Bult, P. (incl. C. Malacaria) et al. The Discovery of the 528.6 Hz Accreting Millisecond X-Ray Pulsar MAXI J1816–195. Astrophysical J Lett 935, L32 (2022).

Cassan, A. (incl. J. Wambsganss) et al. Microlensing mass measurement from images of rotating gravitational arcs. Nat Astronomy 6, 121–128 (2022).

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Chen, J. (incl. L. Moreira) et al. Applications and Challenges of GRACE and GRACE Follow-On Satellite Gravimetry. Surv Geophys 1–41 (2022) doi:10.1007/s10712-021-09685-x.

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Ghasemi-Nodehi, M. (incl. M. Sargent) et al. Evolution of thermal and non-thermal radio continuum emission on kpc scales – predictions for SKA. Mon Not R Astron Soc 515, 1158–1174 (2022).

Giessen, S. A. van der (incl. M.T. Sargent) et al. Probing star formation and ISM properties using galaxy disk inclination. Astron Astrophys 662, A26 (2022).

Giessen, S. A. van der (incl. M.T. Sargent) et al. Probing star formation and ISM properties using galaxy disk inclination III: Evolution in dust opacity and clumpiness between redshift $0.0 < z < 0.7$ constrained from UV to NIR. Arxiv (2022).

Gómez-Guijarro, C. (incl. M.T. Sargent) et al. GOODS-ALMA 2.0: Source catalog, number counts, and prevailing compact sizes in 1.1 mm galaxies. Astron Astrophys 658, A43 (2022).

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Zhao, G. (incl. M. Falanga) et al. NICER observations of the evidence of Poynting-Robertson drag and disk reflection during type I X-ray bursts from 4U 1636–536. Astron Astrophys 660, A31 (2022).

Visitor Publications

Listed are all papers written or co-authored by ISSI visitors, with acknowledgment to ISSI, that appeared for publication in refereed journals in 2022.

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Bellavita, C., García, F., Méndez, M. & Karpouzas, K. vKompth: a variable Comptonization model for low-frequency quasi-periodic oscillations in black hole X-ray binaries. Mon Not R Astron Soc 515, 2099–2109 (2022).

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Benella, S., Consolini, G., Stumpo, M., Alberti, T. & Gjerloev, J. W. Markov property of the Super-MAG auroral electrojet indices. Chaos Solitons Fractals 164, 112736 (2022).

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Visitor Publications

England, S. L. et al. Vertical Shears of Horizontal Winds in the Lower Thermosphere Observed by ICON. Geophys Res Lett 49, (2022).

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Fargette, N. et al. The preferential orientation of magnetic switchbacks and its implications for solar magnetic flux transport. Astron Astrophys 663, A109 (2022).

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Jarvinen, R., Kallio, E. & Pulkkinen, T. ~I. Ultra-low Frequency Foreshock Waves and Ion Dynamics at Mars. Journal of Geophysical Research (Space Physics) 127, e30078 (2022).

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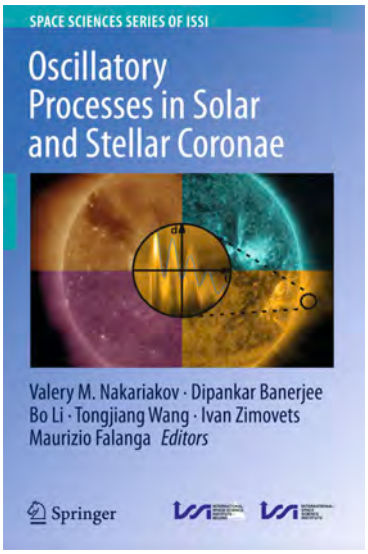

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International Space Science Institute Beijing

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.

The main mission of ISSI-BJ is to contribute to the achievement of a deeper scientific and technological understanding of future space missions as well as of the scientific results from current and past missions through multidisciplinary research, possibly involving whenever felt appropriate, ground-based observations and laboratory experiments, using similar tools as ISSI, i.e. Forums, International Teams, Workshops, Working Groups or individual Visiting Scientists. The Program of ISSI-BJ covers a wide spectrum of space science disciplines, including solar and space physics, planetary science, astrobiology, microgravity science and Earth observation from space. It offers a complement to the ISSI program with special emphasis on future scientific opportunities.

Because of the COVID-19 pandemic, all ISSI-BJ activities were limited to online seminars. Some International Teams and Workshops had organized webinars to carry on scientific discussions in lieu of in-personal meetings.

Forums

- Exploration of the Local Interstellar Medium Intruding in the Heliosphere
- Space Resources Forum
- For a fundamental improvement of the lunar crater chronology

International Teams

Chide B. (US) Planetary Acoustics: A Brand New Sense with which to Explore Atmospheres in our Solar System (ISSI - ISSI Beijing Team)

Neumann W. (DE): Timing and Processes of Planetesimal Formation and Evolution (ISSI - ISSI Beijing Team)

Kajdic P., Blanco-Cano X. (MX): Impact of Upstream Mesoscale Transients on the Near-Earth Environment (ISSI - ISSI Beijing Team)

Zhu X. (CN), Chifu I. (DE): Magnetohydrostatic Modeling of the Solar Atmosphere with New Datasets (ISSI - ISSI Beijing Team)

Workshops

Sino-ESA GNSS Reflectometry Joint Workgroup Annual Workshop

Outreach Activities

Because of the pandemic, ISSI-BJ organizes online seminars, including four series. "On Things to Come" focuses on current and future space missions; "1001 Space Nights" aims to introduce the research and result of outstanding Chinese and Japanese women scientists; and "Space Science Bazaar" is for young scientists presenting their work within international team program of ISSI-BJ; "Topical Review" aims to foster cooperation in space science and technology in the international academic community, and the talks are given by leading researchers in universities in China and France. In the given period, 41 lectures were organized.

Interviews

The interview series is aiming at scientists who are also senior administrators of major research organizations and space agencies for their views and suggestions on the strategy and program of ISSI-BJ.

Interview with Ms. Qi YU
Interview with Prof. Len Fisk
Interview with Prof. Guenther Hasinger
Interview with Prof. Saku Tsuneta
Interview with Prof. Clive Neal

All interviews and information about ISSI-BJ can be found on its webpage: http://www.issibj.ac.cn

Yinong Li and the ISSI Beijing Staff

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