

IAU Post Report – IAUS 372

■ Program: see also <https://nso.edu/iau-symposium-372/>

Aug 2, 2022

10:30 **G. Cauzzi & A. Tritschler** Welcome

Session 1: Early Results from Major Facilities (chair: G. Cauzzi)

10:40 **Robert Allen** Parker Solar Probe in the Multi-Spacecraft Era (*Invited*)

11:05 **Bin Chen** Recent Results of Solar Microwave Imaging Spectroscopy (*Invited*)

11:30 **Durgesh Tripathi** The Aditya-L1 Mission of the Indian Space Research Organization (*Invited*)

13:30 **Sami Solanki** The early Science Phase of Solar Orbiter (*Invited*)

13:55 **Thomas Rimmele** The Daniel K. Inouye Solar Telescope: status update and first results (*Invited*)

Session 2: Magnetic fields – Generation, Activity and Instabilities (chair: S. Solanki)

14:30 **Hindegaki Hotta** Generation of the solar magnetic field (*Invited*)

15:15 **Allan Sacha Brun** Powering solar-type stars magnetism: how are magnetic cycles established and driven?

15:30 **Ilya Usoskin** Solar cyclic activity reconstruction now extends to cover the last millennium

15:45 **Hanna Strecker** Tracking active regions from the near-Earth to the solar far side by combining SDO/HMI and SO/PHI data

16:00 **Bhuwan Joshi** Origin of extreme solar eruptive activity from the active region NOAA 12673 and the largest flare of solar cycle 24

16:15 **Ting Li** Solar flare-CME association (*Invited*)

16:45 *Afternoon posters, e-talks*

Aug 3, 2022

09:45 *Morning posters, e-talks*

Session 3: Structure and heating of the outer atmosphere (chair: D. Tripathi)

10:30 **Tim Bastian** Solar Observations with ALMA: a New Frontier (*Invited*)

10:55 **Maryam Saberi** MHD waves in chromospheric fibrillar structures as observed with ALMA

11:10 **Devoiyoti Kansabanik** Estimating physical parameters of quiet Sun corona using low-frequency spectro-polarimetric radio images

11:25 **Yajie Chen** Forward Modeling of Solar Coronal Magnetic-field Measurements Based on a Magnetic-field-induced Transition in Fe X

11:40 *Posters & e-talks flash presentations*

Session 4: Magnetic connectivity: from the star to the astrosphere (chair: S. Gibson)

13:30 **Aline Vidotto** How has the solar wind evolved to become what it is today? (*Invited*)

13:55 **Adam Finley** Stirring the Base of the Solar Wind

14:10 **Vishal Upendran** Exploring the formation of solar wind, switchbacks and Quiet Sun heating

14:25 **Marco Romoli** First science with Solar Orbiter Metis coronagraph

14:40 **Frederic Auchere** Solar Orbiter/EUI very wide field observations of the EUV corona

15:15 **Christian Moestl** The heliosphere in 3D from multi-spacecraft observations (*Invited*)

15:40 **Roksoon Kim** CME-CME interaction in the interplanetary space: Observation and simulation

15:55 **Juan C. Martinez Oliveros** 2Pi steroradian radio observations of the 28-10-2021 solar flare

16:10 **Jinhye Park** A revisit to the source regions of solar energetic particles by the synchronic potential field source surface model

16:25 **Tingyu Gou** Complete restructuring of a magnetic flux rope during a solar eruption

16:45 *Afternoon posters, e-talks*

Aug 4, 2022

09:45 *Morning posters, e-talks*

Session 5: Turbulence and reconnection at small scales (chair: H. Eklund)

10:30 **Elena Khomenko** Understanding solar local dynamo (*Invited*)

10:55 **Jin-Yi Lee** Plasma heating along a current sheet in nonequilibrium ionization and non-Maxwellian electron velocity distribution

11:10 **Gwangson Choe** Why Are Solar Prominences Filamentary?

11:25 **Jongchul Chae** Detection of Propagating Alfvénic Waves in the Solar Chromosphere

11:40 **Sneha Pandit** Formation of activity indicators in a 3D model atmosphere

Session 6: Databases and Machine Learning (chair: J. Chae)

13:30 **Yong-Jae Moon** Application of Deep Learning to Solar and Space Weather Data (*Invited*)

13:55 **Neal Hurlburt** Heliophysics Events Knowledgebase support for Multi-Messenger Solar Physics

14:10 **Henrik Eklund** Deep neural network estimator for image refinement and estimation on radiation formation heights

14:25 **Andrea Diercke** Automatic Extraction of Solar Filaments Using Machine Learning Techniques

14:40 **Bendict Lawrance** Generation of coronal white light images from SDO/AIA EUV images using deep learning

Session 7: The Multimessenger challenge: combining data and facilities (chair: V. Martinez Pillet)

15:15 **Clementina Sasso** Modeling efforts for multi-mission science (*Invited*)

15:40 **Andrew Walsh** Coordinating Solar Orbiter Operations: The Story so far and What to Expect Next (*Invited*)

16:05 **Alexandra Tritschler** DKIST Coordination: Status and Current Strategies (*Invited*)

16:30 **Yang Su** Progresses of ASO-S mission

Aug 5, 2022

Plenary Session

08:15 **Valentin Martinez Pilet** Challenges and opportunities in solar and heliospheric physics at the dawn of the multi-messenger era

09:15 Discussion

IAU Post Report – IAUS 372

- Number of female/male invited speakers and contributed talks:

Oral Type	F	M	Non-Specified
Invited	5	9	0
Contributed	8	16	0

IAU Post Report – IAUS 372

■ Summary of the scientific highlights of the meeting:

IAU Symposium 372 spotlighted novel results from recently operative missions and facilities. Among many, we point out the first observations of the magnetic fields of active regions on the “hidden” face of the Sun, obtained with Solar Orbiter/PHI (Strecker et al.), and the spectacular data acquired with the Daniel K. Inouye Solar Telescope (shown by T. Rimmele), which are revealing details on scales of 20-30 km at the solar surface. Of note, the DKIST data were acquired during a campaign to support Parker Solar Probe encounter #12, with the main goal of providing the magnetic configuration for the source region of PSP’s in-situ measurements. This perfectly introduced the topic of the Symposium. The power of combining observations of various kinds was well illustrated by C. Sasso, with her talk on modeling efforts for multi-mission science: she showed how we can maximize the likelihood of linking in-situ data to their source region at or near the Sun with careful predictions, that can direct remote sensing instruments to on-disk targets at the right time. A. Walsh and A. Tritschler detailed the extensive planning that is necessary to fully exploit the science enhancing synergy of these large facilities.

Solar activity at a variety of spatial and temporal scales was the focus of many talks. The review of H. Hotta showed how modern MHD simulations of the solar interior, coupled with enhanced helioseismology techniques, are now enabling important insights into the working of the solar dynamo. T. Li introduced a new method to estimate the magnetic non-potentiality of active regions, which helps predicting whether they will produce eruptive flares, while B. Chen discussed how these events can now be routinely observed by microwave facilities like EOVS, providing precious information on the local coronal magnetic fields, as well as on the acceleration of energetic particles. The resulting Coronal Mass Ejections (CMEs), their magnetic configuration and interaction, as well as the propagation of solar particles in the inner heliosphere were the subject of the review by C. Moestl, who described how an amazing fleet of spacecrafts at our disposal is starting to explain how the Sun shapes its environment, and help our understanding of similar phenomena at other stars. A. Vidotto reviewed the long-term evolution of the solar wind, arguing how the study of exoplanetary systems could improve our understanding of the evolution of the solar wind and how it affected the young Earth. Of course the proximity of our star allows us to obtain exquisitely resolved observations: these motivate sophisticated numerical investigations of mechanisms such as turbulence and magnetic reconnection, or the role of small scales in the creation of larger structures. One such a case is the local dynamo, the process responsible for the appearance of the magnetic fields of the quiet Sun and their variation with the cycle, reviewed by E. Khomenko. The talk by A. Finley showed how small-scale vortex motions in the lower atmosphere could be the ultimate cause for the patchy nature of switchbacks in the solar wind, a conclusion supported observationally by the work of Upendran et al.

Finally, the enormous amount of data produced by modern solar instruments and simulations requires a variety of approaches to efficiently parse them to derive physical results. In particular, the use of deep learning techniques is rapidly developing, and multiple applications were presented in the review by Y-J. Moon and other talks. These include generation of solar farside magnetograms, global field extrapolations, generation of solar UV/EUV images starting from magnetograms, etc., that are rapidly filling gaps in our observational baseline, and improving our models of solar activity and space weather.

The plenary talk, presented by V. Martinez Pillet, summarized the Symposium by highlighting several science cases that will critically depend on the optimal coordination among multiple facilities, making a profound case for multi-messenger solar physics. Other new missions presented during the Symposium, like the Chinese ASO-S (talk by Y. Su), the Indian Aditya-L1 (review by D. Tripathi), or ground based facilities like ALMA (review by T. Bastian) or the proposed FASR will further complement our capabilities. This is indeed a golden age for studying the Sun.

IAU Post Report – IAUS 372

■ List of participants (including distribution by country and gender):

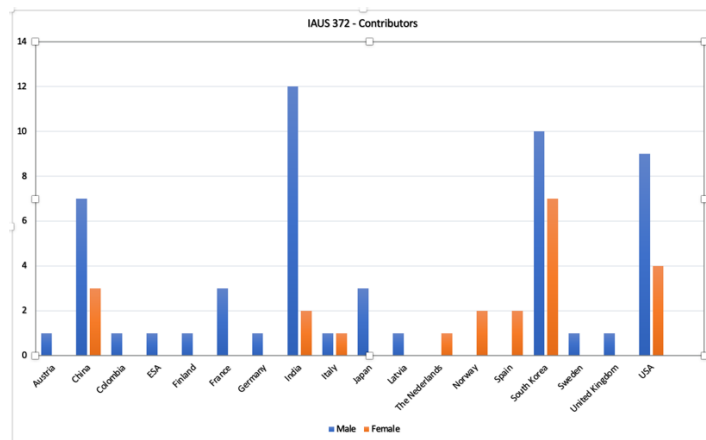
(as before, we list only the contributors; we have no info on people that visited the sessions, in person or remotely)

About 1/3 of the contributors were female; about 40% were young researchers (PhD students or early career).

1. Robert Allen
2. Frédéric Auchère
3. Suresh Babu Balaji
4. Dipankar Banerjee
5. Timothy Bastian
6. Allan Sacha Brun
7. Gianna Cauzzi
8. Jongchul Chae
9. Bin Chen
10. Hechao Chen
11. Yajie Chen
12. Kyung-Suk Cho
13. Gwangson Choe
14. Joao M. Da Silva Santos
15. Andrea Diercke
16. Henrik Eklund
17. Adam Finley
18. Sarah Gibson
19. Tingyu Gou
20. Hideyuki Hotta
21. Neal Hurlburt

22. Hyun-Jin Jeong
23. Bibhuti Kumar Jha
24. Bhuwan Joshi
25. Devojyoti Kansabanik
26. Yukio Katsukawa
27. Elena Khomenko
28. Roksoon Kim
29. Pankaj Kumar
30. Hannah Kwak
31. Bendict Lawrance
32. Harim Lee
33. Jin-Yi Lee
34. Kyoung Sun Lee
35. Ting Li
36. Daye Lim
37. Eun-Kyung Lim
38. Yukun Luo
39. Bhupendra Malvi
40. Juan Carlos Martinez Oliveros
41. Valentin Martinez Pillet
42. Christian Moestl
43. Yong-Jae Moon
44. Divya Oberoi
45. Sneha Pandit
46. Vemareddy Panditi
47. Jinhye Park
48. Sumiaya Rahman
49. Jack Reid
50. Thomas Rimmele
51. Marco Romoli
52. Maryam Saberi

53. Clementina Sasso
54. Arpit Shrivastav
55. Sami Solanki
56. Jihyeon Son
57. Shirsh Lata Soni
58. Anu B Sreedevi
59. Hanna Strecker
60. Yang Su
61. Durgesh Tripathi
62. Alexandra Tritschler
63. Vishal Upendran
64. Ilya Usoskin
65. Santiago Vargas Domínguez
66. Aline Vidotto
67. Arturs Vrublevskis
68. Andrew Walsh
69. Ruihui Wang
70. Haruka Washinoue
71. Yu Xu
72. Zihao Yang
73. Sibaek Yi
74. Zebin Zhang



IAU Post Report – IAUS 372

■ Executive Summary:

The IAU Symposium 372, “The Era of Multi-Messenger Solar Physics”, took place on August 2-5, 2022, during the first week of the XXXI IAU General Assembly in Busan, Republic of Korea.

The Symposium was structured in 7 Sessions, held on August 2-4. The first Session included invited talks on early science results from large solar missions and facilities that have recently come online or are approaching start of operation; this provided a comprehensive overview of the current international efforts in the field of solar physics. Worth of note is the fact that “emergent” countries like China and India are now entering the arena of space solar missions, testifying to the enormous progress of the field in these Countries. Talks were given on the US NSF 4-m visible/infrared Inouye Solar Telescope (DKIST); the NASA Parker Solar Probe, a mission to “touch” the Sun at 10-15 solar radii; the ESA/NASA Solar Orbiter, providing remote sensing observations at different positions along the ecliptic; the Indian mission Aditya-L1; the microwave arrays EOVAS and MUSER, among others.

Sessions 2-6 included both invited and contributed talks, presenting state-of-the-art observations and modelling, as well as an overview of outstanding scientific problems in solar physics that will be addressed with the novel facilities highlighted above. The sessions’ topics ranged from models of the solar dynamo and interior, to the surface solar activity, to the structure and dynamics of the extended heliosphere. Of particular relevance was Session 6, where we discussed a pressing problem in contemporary solar physics, namely the enormous amount of data produced by modern instruments and simulations. Maintaining and interrogating such large data volumes requires a multi-pronged approach, including the use of machine learning tools and techniques to efficiently parse them and derive physical results. Like in much of astrophysics, this is a rapidly developing field in solar physics as well, and illuminating examples were presented in this Session, as applied to both solar and space weather research.

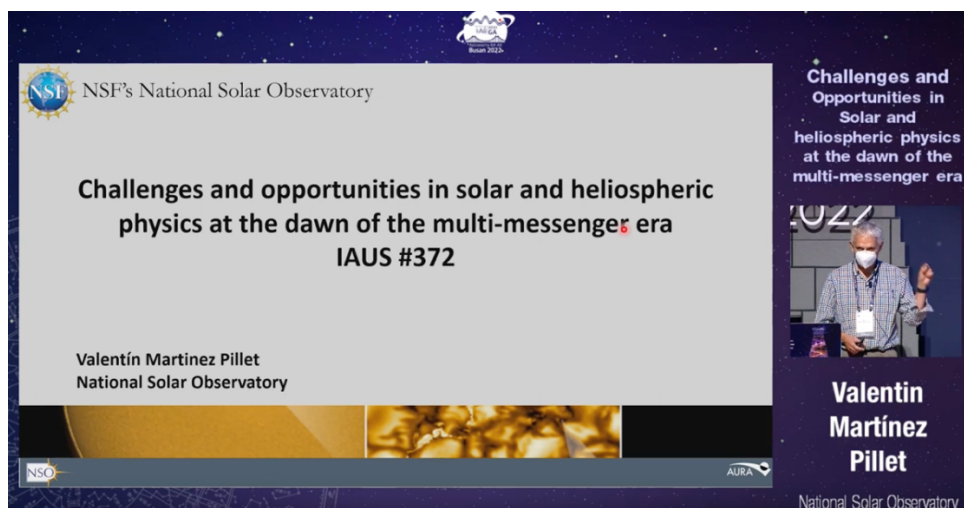


Left: the Symposium room during one of the sessions; right: Dr. C. Sasso delivering an invited talk on multi-mission science

Session 7 was devoted to the underlying theme of the Symposium: how to properly combine and coordinate observations from multiple facilities, in order to best exploit their remarkable synergy. In

particular, the combination of remote-sensing observations and in-situ measurements for individual events is becoming a powerful tool to understand how the Sun shapes and influences its immediate surroundings. Talks were given on how observations on space missions can be planned to maximize the likelihood of linking in-situ data to their source region near the Sun, directing remote-sensing instruments to specific targets on the solar disk with the proper temporal advance; and how ground-based observatories can play a crucial role in this effort providing unique physical parameters like the chromospheric magnetic field.

Finally, the Symposium concluded with the plenary talk on August 5, presented by NSO Director Valentin Martinez Pillet. His talk highlighted several science cases that will critically depend on the optimal coordination among multiple facilities, making a profound case for multi-messenger solar physics.



Dr. Martinez Pillet delivering the IAU S372 plenary lecture on August 5, 2022

Five out of the fourteen invited talks (including the plenary talk) were given by female researchers; and two were from early career researchers.

About 40 contributions on the topics of Sessions 1-7 were presented as e-talks or e-posters during the Symposium. Per past experience, posters at IAU General Assemblies do not receive the full attention of the participants, as multiple events are often organized in parallel. In Busan, this was exacerbated by the organizational decision to have only on-line posters, even for in-person participants. So, in order to enhance the visibility of these contributions, we organized them in different blocks, when the presenter would be available online to answer questions in real time (taking into account the presenter's time zone if remote). This effort had some mixed success, with the best exposure accorded to participants present in person, which could make use of the on-site screens.

Finally, 75 researchers contributed to the Symposium with invited, oral and poster presentations. A total of 18 countries were represented, with researchers originating from all continents apart Oceania. During the meeting, numerous other colleagues participated to the oral sessions in person; we estimate that an average of about 60-80 participants were present in the meeting room. We have no knowledge of how many colleagues were participating remotely.