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2023　03)ISEE / CICR International Workshop
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＊所属・職名は2024年3月現在

＊Affiliation and Department displayed are current as of March 2024.

研究代表者 Principal Investigator	所属機関* Affiliation	所属部局 Department	職名* Job title	研究課題名 Project Title	頁 Page	備考 Remarks
Lina Hadid	CNRS – LPP– École Polytechnique – France	Space plasma physics	Researcher	Study of interplanetary coronal mass ejections propagation in the inner heliosphere combining MHD modeling, ground based observations,and in–situ multi–spacecraft data	75	
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Study of interplanetary coronal mass ejections propagation in the inner heliosphere combining MHD modeling, ground based observations,and in-situ multi-spacecraft data

Lina Hadid (Laboratory of Plasma Physics, CNRS, Éole Polytechnique, France)

Our Sun emits continuously a supersonic wind of charged particles called the solar wind. This solar wind plasma, flowing at speeds ranging from 300 to 700 km/s, extends far beyond Earth's orbit. Fortunately, Earth's magnetic field acts as a shield, deflecting most of the solar wind away. However, some solar wind particles still manage to sneak in, especially during intense bursts of activity called Coronal Mass Ejections (CMEs). CMEs are giant clouds of plasma and magnetic field erupting from the Sun. They can significantly impact Earth's magnetosphere, triggering spectacular auroras and potentially disrupting satellites, power grids, and other technology. To predict and prepare for these space weather events, we need a deeper understanding of the solar wind and its dynamic relationship with CMEs. While we have spacecraft and ground observatories monitoring the solar wind, there are still significant gaps in our knowledge. We especially lack information about how CMEs evolve and interact with the solar wind close to the Sun. This limited understanding hinders our ability to predict space weather accurately and protect our technology from its harmful effects.

From January 22 until January 26 2024, we held the international workshop “Study of interplanetary coronal mass ejections propagation in the inner heliosphere combining MHD modeling, ground based observations, and in-situ multi-spacecraft data”at ISEE. The workshop was a great success as 19 participants could join the discussions (online and in-person) - incuding Professors, reasearchers and students - from renowned institutes across different countries: South West Reasearch Insitute/USA, Lockheed Martin Solar and Astrophysics Laboratory/USA, University of Helsinki/Finland, University of Turku/Finland, European Space Agency/Spain, Space Physics Institute/Austria, Laboratory of Plasma Physics/France, Laboratory of Astrophysics,

Bordeaux/France, University of Leceister/UK, University of Tokyo/Japan, University of Nagoya ISEE/Japan and ISAS/JAXA/Japan.

During the workshop we could dicuss CME events in the inner heliopshere observed by multi-spacecraft at different heliocentric distances and cover additional various topics including: updated results of BepiColombo cruise observations (both Mio and MPO), coordinated observation with other spacecraft (e.g., Akatsuki, Parker Solar Probe, and Solar Orbiter), ground based observation (interplanetary scintillation), and simulation (SUSANOO). We have also discussed the collaborative studies across the above topics which were initiated during the first edition of ISEE workshop we had in November 2022. We have also updated the list of potential publications and discussed the submission plan of our special issue to Earth, Planets, and Earth. Moreover, we continued working on the overview paper, which we are planning to submit by Fall 2024. Additonal dedicated papers are planned to be submitted in the special issue: e.g., cross calibration between Mio's and MPO's radiation monitors, solar wind measurements by BepiColombo, heliospheric current sheet in comparison between BepiColombo and SUSANOO, coordinated observation by BepiColombo, Akatsuki, and Hinode, and multi-spacecraft observation of each SEP and CME event. The follow-up meetings will be held approximately every two months online. Finally we plan to hold a final workshop in 2025 before the orbit insertion of BepiColombo around Mercury, a good timing to close the science observations during the cruise phase of BepiColombo.

(Form03-2)

Origin of High-Energy Protons Responsible for Late-Phase Pion-Decay Gamma-Ray Continuum from the Sun

Nat Gopalswamy (NASA Goddard Space Flight Center)

The Fermi mission's large area telescope (LAT) has accumulated a wealth of data on the Sustained Gamma Ray Emission (SGRE) from the Sun. These data have resurrected the debate on the origin of >300 MeV protons responsible for SGRE. The Fermi/LAT SGRE events have a perfect combination of related data from SOHO, STEREO, SDO, Wind, and GOES to help perform in-depth analysis. In addition, there are numerical modeling and theoretical efforts that are brought to bear on the issue at hand. Many publications in the past few years indicate the significance of the science behind the SGRE events. The ISEE international project on SGRE builds upon these results involving particle acceleration at, and transport from, CME-driven shocks.

The international workshop "Origin of High-Energy Protons Responsible for Late-Phase Pion-Decay Gamma-Ray Continuum from the Sun" was organized from 16 – 20 October 2024 at ISEE (Research Institute Building 2) for analyzing Fermi/LAT data. We had 19 participants who are active researchers with diverse background and expertise (solar physics, heliospheric physics, plasma physics, high energy physics, radio astronomy). The participants had a combined expertise in observations, theory, and modeling suitable for tackling the problems involved in the production of SGRE on the Sun.

The primary purpose of this workshop is to understand the origin of SGRE from the Sun that last for hours, and sometimes almost a day after the end of the impulsive phase of the associated flare. The scientific objectives of this workshop are: (i) to determine why all large solar energetic particle events are not associated with SGRE, (ii) to determine why all type II radio bursts in the decameter-hectometric wavelengths are not associated with SGRE; (iii) to check if the spatial distribution of SGRE with respect to the source active region is compatible with the interplanetary shock source for the required high-energy protons; (iv) to come up with a realistic model of particle acceleration and transport to the Sun that accounts for the physical conditions in the ambient medium (turbulence, seed particles, magnetic mirroring). In order to achieve these objectives we analyzed Fermi/LAT data (https://umbra.nascom.nasa.gov/fermi/lat/) in conjunction with data on hard X-rays from RHESSI, and low-energy gamma rays from Fermi Gamma-ray Burst Monitor (GBM), interplanetary type II radio bursts from Wind/WAVES and STEREO/WAVES (https://cdaw.gsfc.nasa.gov/CME_list/radio/waves_type2.html), CME data from SOHO/LASCO, and STEREO/SECCHI (https://cdaw.gsfc.nasa.gov/CME_list/), and GOES solar energetic particle (SEP) data (https://cdaw.gsfc.nasa.gov/CME_list/sepe/). Type II bursts at higher frequencies (metric) were used to identify shock formation closer to the Sun. The modeling experts (theory and numerical

simulation) worked with the team to develop a realistic model noted above. One of the important outcomes of the workshop is the development of an annotated SGRE catalog that has links to plots, movies, and images of the related phenomena.

The workshop discussed the flare and shock sources of energetic particles responsible for the SGRE. One of the issues that received significant attention was the relation between the number of protons involved in the gamma-ray event derived from the gamma-ray flux and that derived from the observed SEP event. The correlation between these two numbers has been questioned. However, the correlation need not be perfect because there is a third population of particles trapped in the shock. It was decided to revisit the number problem making use of the new observations and properly taking into account of all SEP populations. Another problem that received attention was the importance of CME interactions. We decided to investigate whether the presence of the preceding CMEs enhances the likelihood of the following CME to produce an SGRE event at the Sun. In order to understand the source extent of SGRE events, it was decided to investigate the chromospheric response of energetic particle precipitation that may be able to distinguish the precipitation of flare and shock particles based on the extent of such signatures. Finally, most of the problems involving shock particles can be revisited using sophisticated MHD simulations that capture the propagation of shocks. It was decided to publish a review paper and several research papers in the Springer Journal Solar Physics.

(Form03-2)

Science Objectives of SOLAR-C and Numerical Modeling Workshop

Shinsuke Imada (University of Tokyo)

SOLAR-C Mission is designed to comprehensively understand the energy and mass transfer from the solar surface to the solar corona and interplanetary space, and to investigate the elementary processes that take place universally in cosmic plasmas. The proposed mission is a fundamental step for answering how the plasma universe is created and evolves, and how the Sun influences the Earth and other planets in our solar system. The two primary science objectives for Solar-C are : I) Understand how fundamental processes lead to the formation of the solar atmosphere and the solar wind, II) Understand how the solar atmosphere becomes unstable, releasing the energy that drives solar flares and eruptions. Solar-C will, A) seamlessly observe all the temperature regimes of the solar atmosphere from the chromosphere to the corona at the same time, B) resolve elemental structures of the solar atmosphere with high spatial resolution and cadence to track their evolution, and C) obtain spectroscopic information on the dynamics of elementary processes taking place in the solar atmosphere. In this workshop, we will first discuss the science target of the Solar-C and summarize to the journal paper.

SOLAR-C simultaneously observes the photosphere, chromosphere, and the coronal region. The chromosphere from the photosphere is optically thick, and it is necessary to consider radiative transfer in order to interpret the motion of these plasmas. It has been suggested that comparison with numerical calculations including radiative transfer is effective for the interpretation of these observations, and collaboration with numerical calculations is very important in the SOLAR-C project. In this workshop, we plan to discuss how to link each science objective with numerical calculation and summarize it in a paper. In addition, we plan to discuss the necessary functions of the SOLAR-C Science Center to be established at ISEE/Nagoya University.

Program of Science Meeting:

Day1 (3/5)

Mission Status (10:00-10:30)

10:00-10:15 Toshifumi Shimizu (Remote), "Mission Status"

10:15-10:30 Hirohisa Hara (Remote), "Instrument development status"

Coronal Heating and Solar Wind acceleration (10:30-11:45)

10:30-10:55 Patrick Antolin, "Synthetic EUVST observations from coronal rain modeling"

10:55:11:20 Clara Froment, "Thermal nonequilibrium and coronal rain"

11:20-11:45 Munehito Shoda, "Synthetic observations of the Alfven-wave turbulence in the coronal hole"

Solar Flare & Eruptions (11:45-17:00)

11:45-12:10 Xudong Sun, "Late-phase solar/stellar flares" (Remote)

12:10-13:30 Lunch

13:30-13:55 Andy To, "Spatially Resolved Plasma Composition Evolution in a Solar Flare" (Remote)

13:55-14:20 Kazumasa Iwai, "IPS observation and Solar-C"

14:20-15:00 Break

15:00-15:25 Krzysztof Barczynski, "SoSpIM measurements: affects of Solar Radiations to the Earth atmosphere"

15:25-15:50 Kyoko Watanabe, "SoSpIM Science"

15:50-16:15 Marie Dominique, "How can we use SoSpIM to help calibrate EUVST?"

Day2 (3/6)

MUSE & Ground-Based Observation Collaboration (09:00-15:15)

09:00-09:15 Bart DePontieu (Remote), "MUSE status"

09:15-09:40 Cosima Alexandra Breu (Remote), "MUSE observations of small-scale heating events"

09:40-10:05 Tiago Pereira, "MUSE Synthesis tools"

10:05-10:30 Peter Young (Remote), "CHIANTI and SOLAR-C"

10:30-11:00 Break

11:00-11:25 Ayumi Asai, "Ground-Based Observation Collaboration with SOLAR-C"

11:25-11:50 Yusuke Kawabata, "Observation with GREGOR/GRIS"

11:50-12:15 Yamasaki Daiki, "TBD"

12:15-14:00 Lunch

14:00-14:25 Dipankar Banerjee (Remote), "ADITYA update and possible collaboration"

14:25-14:50 Milan Gosic (Remote),

Numerical Simulation and Other technique

14:50-15:05 Yukio Katsukawa, "Application of the persistent homology to the solar data"

15:05-15:30 Break

15:30-15:45 Yokoyama, "Japanese strategy for virtual observation in SOLAR-C"

15:45-16:10 Takayoshi Oba (Remote), "EUV synthesis study of the solar transition region for SOLAR-C"

16:10-16:35 Hidetaka Kuniyoshi, "Quiet Sun small-scale brightening initiated by a magnetic tornado"

16:35-17:00 Haruhisa Iijima, "Radiative MHD modeling of magnetically open corona

Day 4-5 (3/7-8)

SOLAR-C SWG Board meeting (Buisiness meeting)

We are going to submit the paper discussing the Science Objectives of SOLAR-C to PASJ. The paper will discuss not only the Science Objectives of SOLAR-C but also the comparison of observational data and numerical modeling. We are also willing to submit several papers discussing the comparative study of observations and numerical modeling for specific topics of each science objective.

(Form03-2)

What is a Magnetic Flux Rope?
Would we know one if we saw it?

Dr. KD Leka (NWRA, US)
Dr. Bernhard Kleim (Potsdam U., Germany)
Prof. Kanya Kusano (ISEE/Nagoya U., Japan)

A group of approximately 20 scientists and graduate students gathered 29 May -- 02 June at the Institute for Space-Earth Environmental Research (ISEE), Nagoya University to participate in an International Workshop sponsored by the Center for International Collaborative Research. The goal was to address the topic of solar magnetic flux ropes, specifically whether we could establish a theoretical definition and describe unique expected observational diagnostics of their presence and evolution.

We prepared 4 data sets from numerical and analytic models for participants to examine as if they represented observational data. We also identified and curated data for 3 observational cases, for which we also provided nonlinear force free models of the solar coronal magnetic field. We asked each participant to prepare a short presentation answering specifically:

a) Who are you and why are you here? (relevant interest & expertise)
b) Your personal definition of a magnetic flux rope, and why/how you came to it?
c) An example that demonstrates why your definition is the best
d) An example that demonstrates why your definition maybe "needs some thinking..."

where 'example' above could be either an observational or theoretical case.

Figure 1: The emergence and formation of a (possible) magnetic flux rope from a numerical simulation

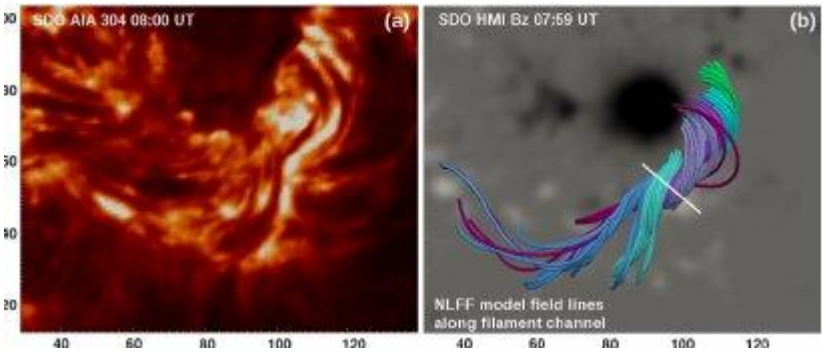

Figure 2: Observations of a proposed magnetic flux rope (left) and a

As the presentations progressed, each sparked new discussion; the theoretical presentations were first, and essentially occupied the majority of the first three meeting days. There was significant discussion focused on the differences between a sheared magnetic arcade and a magnetic flux rope, including the implications of

each for solar euptive events, and what (if any) observational signatures could distinguish between them.

The goal of defining "sufficient and necessary conditions" for a flux-rope formation and detection was an overall focus – with most participants agreeing that "twisted magnetic flux" was required, and that the presence of "photospheric magnetic bald patches along a polarity inversion line" were a strong indication, possibly a sufficient condition, but not a necessary condition (as evidenced by the evolution of multi-height observations of some active regions discussed briefly at the workshop). But questions remain regarding whether a single magnetic axis is required (and how to detect such a thing, observationally – with some tests proposed by participants that they may pursue), and the morphological structure of associated electric current systems theoretically providing some tests for observational investigations.

Most participants felt that we simply "did not finish". The observational-focused discussions were initiated late in the workshop, and insufficient time was available to bring the discussion to any detailed analysis questions. There was similarly no time to examine any of the prepared data-sets by the full group, although a few side-discussions were initiated and small sub-group analysis ensued.

The group did initiate an outline of a potential paper and what needed to be done for progress. Unfortunately, three things have conspired to inhibit progress:

1. Kliem and others on the team have been working very hard on a Review paper that was initiated by a separate ISSI Team, which has significant overlap with regards to the science and analysis, albeit somewhat indirectly. The topic is "coronal dimmings", but the magnetic topology implied by dimmings can be one of a magnetic flux rope. As such, those participants have not had time for MFR analysis per se, but have been working on related physics.
2. A Space Science Reviews paper by Patsourakos et al 2020 included a discussion of MFRs; however, few of our team found the definition proposed in that paper satisfactory. Still, we realized that it will take significant work to establish a more robust definition.
3. It was generally recognized that multi-height observational data of the solar magnetic field (which is not readily available) is required in order to constrain and test models of the coronal field that are such a key part of this question.
4. The group did discuss avenues for a follow-up workshop, and these may be pursued at some point. However, given point #1 and other commitments by the lead scientists, and the work involved, a funding source for support of the required effort (outside of the immediate workshop or meeting) is also needed.

The group does share a google-group "task and paper outline" file, and some of the early-career scientists are establishing investigations based on, or informed by, the discussions at our workshop. This workshop and CICR's support will be acknowledged in any follow-up publication that is produced.