２．ISEE International Joint Research Program 目次詳細

（所属・職名は平成31年3月現在）
(Affiliation and Department are correct as of March 2019)

研究代表者 Principal Investigator	所属機関 Affiliation	所属部局 Department	職名 Position	研究課題名 Project Title	頁 Page
Dr. Mahboubeh Asgari-Targhi	Harvard-Smithsonian Center for Astrophysics	High Energy Astrophysics	Astrophysicist	Comparison of the MHD modeling of solar wind with IPS observations	65
Koustov, Alexandre	University of Saskatchewan	Physics and Engineering Physics	Professor	Polar cap auroras and related ionospheric plasma flows	67
Valentina Zharkova	Northumbria University,	Department of Mathematics, Physics and Electrical Engineering	Professor of Mathematics	Multi-wavelength diagnostics of energetic particles in solar flares	69
Sergii V. Panasenko	Institute of ionosphere	Ionospheric Physics	Head of Department	Artificially induced traveling ionospheric disturbances inferred from GPS and radar data	71
Belakhovsky Vladimir	Polar Geophysical Institute	Labaoratory of Aurora	scinetific reseacher	The study of wave-particle interaction in a near-Earth space as observed by the ERG satellite and PGI ground-based instruments	73
Navin PARIHAR	Indian Institute of Geomagnetism	Upper Atmospheric Sciences	Reader	Study of the behaviour of the ionosphere over mid-latitude stations using OI 777.4 and 630.0 nm emission	75
Anukul Buranaprathe prat	Burapha University	Department of Aquatic Science	Assistant Professor, Faculty of Science	Detection and modeling of green Noctiluca bloom in the Gulf of Thailand using satellite ocean color	77
Nariaki Nitta	Lockheed Martin Advanced Technology Center	Solar and Astrophysics Laboratory	Senior Staff Physicist	Origins of Eruptive and Other Solar Flares as Diagnosed with Energetic Electrons	79
Michael J. Kosch	South African National Space Agency	Space Research and Applications	Chief Scientist	New radar method to observe thermospheric neutral density	81
Jośe Francisco Valdés Galicia	Instituto de Geofisica, Universidad Nacional Autonoma de Mexico	Space Science	Professor	Development of new and improved front end electronics for the SciBar Cosmic Ray Telescope.	82
Baolin Tan	National Astronomical Observatories, Chinese Academy of Sciences	Mingantu Observing Station	Professor	Study of coronal magnetic fields from the joint observations of MUSER and NoRH	84
Antonia Savcheva	Smithsonian-Astrophysical Observatory	High Energy Division	Astrophysicist	Data-Driven Simulations of Active Region Eruptions	86

Comparison of the MHD modeling of solar wind with IPS observations

PI: Mahboubeh Asgari-Targhi (Harvard-Smithsonian Center for Astrophysics)

Below is the description of the research that is currently being undertaken between the PI Dr Asgari-Targhi and the Co-I's Dr. Ken'ichi Fujiki at Nagoya University and Dr. Munehito Shoda at Tokyo University.

The fast-solar wind has velocities ranging from 500 to 800 km/s, and originates in low-density, open magnetic field structures in the solar atmosphere known as coronal holes. The fast wind is believed to be driven by Alfven waves that are launched in the photosphere and propagate outward along the open field lines. The mechanisms which heat and accelerate the fast-solar wind are not yet fully understood. Alfven waves are the most promising wave type for transporting energy over large distances in the corona and solar wind. However, it is not clear how the wave energy is transferred to the plasma. Using our recent Reduced Magnetohydrodynamic (RMHD) modeling of Alfven wave turbulence in open fields, we study the effects of wave turbulence in open magnetic field structures. A major significance of our modeling is that we include the effects of the solar wind outflow on Alfven wave propagation. The purpose of our collaboration is to test the hypothesis that reflection-driven wave turbulence can provide the energy needed for heating the coronal plasma in the acceleration region of the fast-solar wind. We use RMHD simulations to describe the wave turbulence in an open field stretching from the base of the corona into the heliosphere. We compare our simulated wave dissipation rates with those needed to sustain the background atmosphere. We consider the effects of density fluctuations, which may further boost the level of inward propagating waves and thereby the turbulent heating rate. A major aim of our project is to reveal key observational evidence of these density fluctuations at different positions in open field regions as well as looking for observational insights into the generation, dissipation and propagations of waves in the upper solar atmosphere and the inner heliosphere. We will be testing our modeling results against measurements of Inter-Planetary Scintillation (IPS) observations. This will aid us in implementing realistic values of density fluctuations in our modeling. IPS is the result of density fluctuations in the solar wind when the wind travels

across a line of sight and extends from the observer towards a radio source. Ground-based interplanetary scintillation observations provide estimates of the three-dimensional velocity structure of the inner heliosphere. We use the IPS observations of natural radio sources obtained with the Institute for Space-Earth Environmental Research (ISEE) system at Nagoya University in Japan. The ISEE system consists of the antenna at three sites inside Japan and the observations are obtained with a frequency of 327 MHz (wavelength of 0.92 m). Solar wind velocities are derived from a cross-correlation analysis of the IPS data measured at all three sites. The density irregularities are derived from the fluctuation level of radio frequency signal relative to the source intensity (1997-2009) or a power-spectrum analysis of the IPS data measured at the individual antenna (2010-).
We have identified a coronal hole of June 4th 2005. Using the time-series tomography developed by Fujiki et al.[2003], two-dimensional maps of the averaged solar wind velocity and density-irregularity in interplanetary space at distances 0.2-0.5 AU are derived from the observations.
The maps will be used to deduce the outflow velocity and density-irregularity measurements from observations at 40-100 R_sun. To compare the observations of density and outflow velocity with our modeling, we will be extending the open field in our modeling to larger heights to cover this interval.

Dr. Asgari-Targhi started her collaboration with Dr. Ken'ichi Fujiki at Nagoya University and Dr. Munehito Shoda at Tokyo University in March 2018 when they were awarded the ISEE international joint research program. The ISEE award made it possible for the PI to travel to Japan on 10th June 2018 for the duration of 10 days to stay at Nagoya University and collaborate with the Co-I's. The PI travelled to Nagoya University from 23rd February to 2nd March 2019 attending the International symposium "Recent progress in heliospheric physics by direct measurements of unexplored space plasmas" at Nagoya University.
The PI presented a talk titled "Modeling and observations of density fluctuations in the solar wind" at the Symposium where she showed the modeling results and out lined the comparison with the IPS observations. On both occasions, the PI held meetings with Drs. Kenichi-san and Shoda-san. Since this project consists of extensive modeling and observations, the collaborators involved in the project submitted a proposal to National Science Foundation in the US so the research can continue.

Project Title

Polar cap auroras and related ionospheric plasma flows

Alexander V Koustov

Department of Physics and Engineering Physics, University of Saskatchewan, Saskatoon, Saskatchewan, S7N 5E2, Canada

Purpose: The purpose of the project was to advance our knowledge of plasma flows associated with polar cap aurora. There were 2 major goals for the project: 1) Investigate patterns of plasma flows and 2) Investigate microphysics of plasma structuring processes leading to SuperDARN echoes associated with the polar cap aurora. Although the projects targeted somewhat different aspects, they have one common underlying issue, reasons for occurrence of SuperDARN echoes inside the polar cap.

Methods:

Auroral images from the Resolute Bay camera (supported by ISEE, Prof. Shiokawa) have been mapped on geographic grid where the areas of the SuperDARN echoes have been shown as well. Auroral images were also plotted on standard SuperDARN convection maps built in magnetic coordinates. Significant preliminary analysis on the occurrence of such aurora in correlation with SuperDARN coherent echoes has been done, in the past in cooperation with Dr. K. Hosokawa of the University of Electro Communications (Tokyo), and more recently by the PI with his Graduate student K. Yakymenko. Several interesting events have been identified, but all are for very complex conditions in the interplanetary magnetic field so that the actual magnetospheric drivers of the flows was difficult to pin point.

Results:

Goal 1: The work on the polar cap arcs has not been completed, yet. Currently, more deliberate analysis of SuperDARN plasma flow maps is considered by developing a new method of flow mapping that can produce a pattern under limited data coverage. The hope is that this would allow one to quantify the flows. The work is currently ongoing.

Goal 2: The investigation showed that the number of SuperDARN echoes is extremely low whenever the aurora was seen. This is despite the fact that several years of joint radar-optical observations have been considered (2008-2013). This prompted the PI to expand the project on a more general problem of understanding why the SuperDARN echoes are not seen in the vicinity of optical forms and what controls the onset of echoes in this and other conditions. Expanding further in this direction, multi-year data collected by six polar cap SuperDARN radars, three in the Northern hemisphere and three in the Southern hemisphere, have been considered. Occurrence of echoes have been assessed versus solar cycle, season and time of the day. Among interesting findings is that the echo occurrence rate does not depend on the electric field magnitude during nighttime which might explain why echoes are not always occur near polar cap arcs in regions of enhanced electric field. The PI continues working on the reasons for polar cap echo occurrence with the thrust on joint observations with the incoherent scatter radar data in the Canadian Arctic.

Period of stay in ISEE:

October 3 – November 1, 2018

List of publications:

1. Occurrence of F region echoes for the polar cap SuperDARN radars, by **A.V. Koustov**, S. Ullrich, P.V. Ponomarenko, **N. Nishitani**,M.F. Marcucci, and W.A. Bristow (2019) Submitted to Earth, Planets, and Space, March 2019, 29 single-spaced manuscript pages including 8 Figures and 3 Tables.

Presentations at ISEE: (http://cicr.isee.nagoya-u.ac.jp/hokkaido/site1/workshop/h30.html)

1. A. V. Koustov, S. Ullrich, P. Ponomarenko, **N. Nishitani**, and F. Marcucci, Electron density as a factor affecting SuperDARN echo occurrence rates in the polar cap, Mid-Latitude SuperDARN Radar Workshop, Oct 16-17, 2018, ISEE, Nagoya University.

2. A. V. Koustov, D. Lavoie, P.V. Ponomarenko and S. Ullrich, Validation of Rankin Inlet electron density measurements with the RISR-C incoherent scatter radar, Mid-Latitude SuperDARN Radar Workshop, Oct 16-17, 2018, ISEE, Nagoya University.

3. A.V. Koustov, Contributions of coherent radars to studies of the near Earth's environment, ISEE colloquium #39, 12 October, 2018

http://cicr.isee.nagoya-u.ac.jp/site1/info_e/colloquium.html

Contributed to the work on referees' comments for the paper:

4. N. Nishitani, J. M. Ruohoniemi, M. Lester, J. B. H. Baker, **A. V. Koustov**, S. G. Shepherd, G. Chisham, T. Hori, E.G. Thomas, R.A. Makarevich, A. Marchaudon, P. Ponomarenko, J. Wild, S. Milan, W. A. Bristow, J. Devlin, E. Miller, R. A. Greenwald, T. Ogawa, and T. Kikuchi, Review of the accomplishments of mid-latitude SuperDARN HF radars, "Progress in Earth and Planetary Science", 6:27 https://doi.org/10.1186/s40645-019-0270-5

Multi-wavelength diagnostics of energetic particles in solar flares

PI: Prof. Valentina Zharkova
Northumbria University
Newcastle upon Tyne
NE1 8ST UK

PI V. Zharkova visited ISEE at Nagoya University from 10 January 2019 until 1 February 2019.

1. During the visit V. Zharkova has delivered a talk at the seminar ‘Particle acceleration in reconnecting current sheets of the Sun and heliosphere’ – 16 January 2019. VZ explained the results obtained with test particle and particle-in-cell codes, in order to follow individual trajectories of protons and electrons at acceleration at different parts of RCS and energy spectra of each kind of particles. We also will extract polarization and turbulent electric field effects from PIC results and investigate their effect on individual trajectories of each kind of particles for selected magnetic field topologies.

   The talk was well attended and led to fruitful discussions and some ideas of future collaboration as on interpretation of high energy particles observed during energetic events so for observing spectral signatures of flaring events via multi-wavelength observations (HXR, SHR, Ly-alpha, H-alpha and radio emission and seismic responses in flaring atmospheres. Using the simulations of realistic plasma heating functions by protons or/and electrons and the momentums delivered by particles to the lower atmosphere we simulated hydrodynamic responses of flaring atmospheres (with the two fluid 1D hydro-radiative code) to different kinds of particles (Zharkova and Zharkov, 2007, 2015; Matthew et al., 2011, Zharkov et al., 2011, Zharkov et al, 2013, Macrae et al, 2018). The simulated parameters (temperature, density, macrovelocity) are used to simulate the radiative models of flaring atmospheres and their spectral signatures from soft X-ray to optical emission and seismic response to shocks generated by the hydrodynamic response to the injection of energetic particles required to account for helioseismic responses in flares detected by using the time-distance diagram (TDD)

(Kosovichev and Zharkova, 1998) and holographic (H) (Donea et al., 1999). The outcomes are compared with those measured from soft X-ray (AIA/SDO), Hydrogen H-alpha emission (SST/CRISP), white light and seismic response (HMI/SDO). This will significantly advance quantitative interpretation of energy transport throughout the whole depth of flaring atmospheres with sunquakes.

We are working with Nagoya team (Prof. Kuzano and Dr. S. Inoue **on the paper** with a working title '**Unusual sunquakes and emission generated by mixed beams during the 6 September 2017 flare'**.

2. Attended a talk by Prof. B. Tan (China) on radio observations of solar flares and generation of zebra patterns. Discussion with prof. Tan of his and our previous results (Zharkova and Siversky, 2011, ApJ) led to the idea of a new paper offering an alternative mechanism of generation of zebra patterns via cascading Langmuir waves and their diagnostics from radio emission.

   The paper is in a working progress now, title of **the paper** '**Particle-wave interaction of electron beams with flaring atmospheres and generation of zebra patterns'**.

Artificially induced traveling ionospheric disturbances inferred from GPS and radar data

Sergii Panasenko (Department of Ionosphere Physics, Institute of ionosphere, Kharkiv, Ukraine)

1. Purpose

Traveling ionospheric disturbances (TIDs) being manifestations of acoustic-gravity waves (AGWs) or caused by electromagnetic forces and electromagnetic coupling between E and F-regions are responsible for energy transfer and one of the important sources of ionospheric variability. At present, TIDs and AGWs are thought to be ubiquitous and have plenty natural origins such as geomagnetic storms, solar terminators and eclipses, meteorological fronts, etc. There is increasing evidence that rocket launches and powerful radio waves can also generate ionospheric disturbances covering a wide range of periods and scales. The energetics of such man-made sources reached the values where releasing energy should be taken into account during the analysis of dynamical processes in the atmosphere and the geospace. Since the parameters of these artificial disturbances appear to be close to the parameters of natural perturbations, the main problem is to separate these two types of events. For the time being, no detailed physical and mathematical models of the processes in the atmosphere and the ionosphere far away from the man-made source are created. The mechanisms responsible for disturbance generation and its propagation to large distances are not fully understood. It can be due to episodic observations, variety of artificial source effects as well as weak sensitivity of used techniques and methods applied for detection such disturbances.

The aim of this project is to identify and estimate the parameters of the TIDs induced by rocket launches from different spaceports and transmission of powerful radio waves during the operation periods of ionospheric heaters. For achievement of this aim, we will undertake nowcast and retrospective analysis of radar and GPS data using similar approaches and harmonized methods and routines.

2. Facilities and methods

We used the data of Kharkiv incoherent scatter radar (ISR) which was operated using transmitted pulses with 663 and 135 μs durations. Its frequency is 158 MHz and transmitted power is 1.8 MW. This ISR is the only such kind facility in mid-latitude Europe.

To determine temporal variations in the power of an incoherent scatter signal, its basic estimates in the time interval of 1 min were first done. Then, using the least squares averaging on 120 min interval, the trend was estimated followed by its subtraction and the normalization to this trend. We also applied band-pass filtration procedure for studying the behavior of wave process with definite periods.

The deployment of dense GPS receiver networks over many regions of the Earth (Europe, North America, Japan) has enabled investigations of ionospheric perturbations on spatial scales down to several hundreds of kilometers. The differential TEC maps for European region were also involved to trace the horizontal propagation of TIDs, accompanying EISCAT Tromso heating facility.

3. Results

The main results obtained within collaborative project can be summarized as follows.

1. Large-distance (1000 – 2500 km) wave disturbances in the electron density were detected in the ionospheric F region with Kharkiv ISR and GPS receiver network during the operation of Sura and EISCAT heating facilities. The effect of high power HF radio waves transmitted far from heated region manifested itself in increasing of relative amplitudes of wave disturbances with periods of 30 – 60 min in the altitude range from 150 to 350 km as well as in appearance wave structures in differential TEC over Europe with apparent horizontal velocity of 300 – 350 m/s.

2. Observed disturbances are likely caused by acoustic gravity wave propagation originated by periodic HF modification of the ionosphere. The most effective mechanism for their generation is shown to be the modulation of ionospheric currents in the upper hybrid resonance region by high power radio waves.

3. It is important to use dense GNSS receiver networks to identify the horizontal propagation of these waves and detect their sources during artificial high energy releases.

We intend to publish a joint paper devoted to the wave-like processes induced by high-energy artificial sources. We also plan to apply the developed method for detection of possible ionospheric response on rocket launches. In particular, we will analyze the parameters of TIDs accompanying launches of “Soyuz” and “Proton” rockets from “Plesetsk” spaceport. For analysis, we will use data provided by a combination of techniques including GNSS receivers, EISCAT ISRs and ionosondes.

4. Period of stay in ISEE and activities

I have visited ISEE and worked with Dr. Yuichi Otsuka during August – September, 2018. During staying in Japan, I took part in seminar, symposium and conference and met with team members for discussion of methods and obtained results. I would like to express my gratitude to ISEE staff for hospitality and creating excellent conditions for my work as well as to all team members for assistance in further method development and result obtaining and interpretation.

5. List of publications and presentations

1. Panasenko S.V. Results of joint ionospheric measurements with Kharkiv incoherent scatter and MU radars during near-equinox and solstice periods / S.V. Panasenko, D.V. Kotov, O.V. Bogomaz, Y. Otsuka, M. Yamamoto, H. Hashiguchi, L.Ya. Emelyanov, I.F. Domnin // 12-th MU Radar / Equator Atmospheric Radar Symposium. – September 5 – 6, 2018. – RISH, Kyoto University, Uji Campus. – Uji, Kyoto, Japan, 2018.

2. Panasenko S. Detection of travelling ionospheric disturbances accompanying artificial high-energy source effects on the ionosphere using radar and GPS techniques / S. Panasenko, Y. Otsuka, L.F. Chernogor, I.F. Domnin // Mesosphere-Thermosphere-Ionosphere (MTI) Research Conference. – September 10 – 14, 2018. – NICT. – Tokyo, Japan, 2018.

The study of wave-particle interaction in a near-Earth space as observed by the ERG satellite and PGI ground-based instruments

Belakhovsky Vladimir (Polar Geophysical Institute)

The purpose of the project is to study charge particle dynamics and wave-particle interaction in the Earth magnetosphere and ionosphere with using the ERG satellite observations and conjugate ground-based observations of Polar Geophysical Institute (PGI).

Period of stay: 14 October – 18 November 2018.

Methods:

The experimental base of the project is the ERG satellite data. The ERG (Exploration of energization and Radiation in Geospace) satellite was developed by the Institute of Space and Astronautical Science of JAXA (Japan Aerospace Exploration Agency) for radiation belt studies. The data of other modern satellite projects (GOES, RBSP, THEMIS) was used as well. The ground support of this project is a geophysical observation of PGI at Kola Peninsula. The main observatory is Lovozero – LOZ (64.22N, 114.6E). For the analyses was chosen the time intervals when the ERG satellite was geomagnetically conjugate to the LOZ station. The ERG satellite flies near the LOZ station during approximately 1 hour. So using these instruments we have an opportunity to study in detail fast processes like high-frequency geomagnetic pulsations, VLF waves. The magnetometers, VLF receivers, all-sky cameras of PGI were used.

Results:

It is studied the physical nature and generation mechanism of monochromatic Pc4 pulsations with using ERG satellite data. Such type of the pulsations is exited during very low geomagnetic activity; these pulsations are not seen on the ground magnetometers due to damping in the ionosphere. The question about the generation mechanism of these pulsations is still open. For the event 4 May 2017 according to the ERG satellite data the wave packet of Pc4 pulsations was registered after midnight at 08-10 UT. The pulsations are mostly seen in radial component and also in azimuthal component of the magnetic field; its frequency is about 13 mHz. On GOES-13 satellite located on higher L-shell than ERG satellite the frequency of these pulsations is about 11.5 mHz. This property (decrease of the frequency of geomagnetic pulsations with the increase of L-shell) testifies about the resonance nature of the pulsations. The Pc4 pulsations are accompanied by the pulsations in electron fluxes (in phase) and in proton (anti phase) fluxes. During appearance of the Pc4 pulsations on ERG satellite the injection of electrons (mostly seen in 10-80 keV energetic cannels) are registered. This injection is coincide with the small increase of AE index up 200 nT. So this injection is caused by the small substorm. Thus it is found the experimental evidence that injection of electron cloud into the morning sector can be reason of the excitation of monochromatic Pc4 geomagnetic pulsations. There are some theories which can explain this mechanism.

The simultaneous QP emissions registered on ERG satellite and Lovozero station is investigated. There are two types of QP emissions: the type1 of QP emissions is accompanied by the simultaneous ground geomagnetic pulsations with the same frequency, the type2 of QP emissions is not accompanied. It was found that small-scale geomagnetic pulsations which do not propagate to the ground due to damping in the ionosphere can produce QP emissions. We deeply investigate the event of 28 August 2017. The simultaneous QP emission on the ground and in space was observed during about 70 minutes in the evening sector of MLT. There is very high correlation between QP elements on the ground and in space. The QP emissions was registered in a frequency range 1-2 kHz, the period of QP emissions was approximately 40 seconds. Inside the QP emissions the higher frequency fine structures were observed. It is interesting that according to the ERG satellite data QP emissions are observed only in electric field, in magnetic field QP emissions are not observed. The QP emissions are not accompanied by the geomagnetic pulsations with the same period on the ground-based magnetometers. But according to the magnetometer data of ERG satellite with using spectral analysis it is identified the frequency very close to the frequency of QP emissions. The appearance of these QP emissions can be associated with the small-scale Pc3 pulsations which seen in space and does not seen on the ground due to its damping in the ionosphere. So these QP emissions should be attributed to the QP1 class. Thus even if we don’t see geomagnetic pulsations on the ground it does not necessarily indicate that this is QP2 class of QP emissions.

It was done the comparison of aurora substorm activity with the VLF wave activity in the magnetosphere registered by the ERG satellite and on the ground at Lovozero station for the events in March 2017. It was found the decrease of VLF intensity on the ground during appearance of the aurora which can be caused by the damping of the VLF waves in the ionosphere.

Unfortunately there is no digital data for the EFD instrument on ERG satellite. So we can’t do the conjugate Pc1/Pi1 studies on ERG satellite and Lovozero station as we plan in application.

It was done attempt to describe the VLF magnetosphere activity with using ERG satellite data (PWE instrument) to find the contribution the VLF mechanism to the electron acceleration up to the relativistic energies. The growth of VLF power is well correlate with the growth substorm activity (AE index). So it’s not easy to find at what stage the VLF mechanism have main contribution to electron acceleration.

List of presentations:

Belakhovsky V.B., Shiokawa K., Matsuoka A., Wang S.-Y., Kazama Y., Tam S., Kasahara S., Yokota S., Keika K., Hori T., Shinohara I., Miyoshi Y. The study of the generation mechanism of monochromatic Pc4 pulsations with using ERG satellite data // Physics of auroral phenomena. 42th annual seminar, 11-15 March 2019. Book of abstract. P. 29. 2019.

Belakhovsky V.B., Shiokawa K., Matsuoka A., Kasahara Y., Shinohara I., Miyoshi Y. The conjugate observations of QP emissions on ERG satellite and Lovozero station // Physics of auroral phenomena. 42th annual seminar, 11-15 March 2019. Book of abstract. P. 29. 2019.

Belakhovsky V.B., Shiokawa K., Miyoshi Y. The study of the generation mechanism of monochromatic Pc4 pulsations with using ERG satellite data // 14 conference “Plasma physics in Solar system”, 11-15 February 2019. Space Research Institute, Moscow, Russia. P. 271. 2019.

Belakhovsky V.B., Shiokawa K., Miyoshi Y. The conjugate observations of QP emissions on ERG satellite and Lovozero station // // 14 conference “Plasma physics in Solar system”, 11-15 February 2019. Space Research Institute, Moscow, Russia. P. 276. 2019 (in Russian).

Study of the behaviour of the ionosphere over mid-latitude stations using OI 777.4 and 630.0 nm emission

Navin Parihar
Indian Institute of Geomagnetism, India

Research Summary

Purpose & Methods:

Ground-based airglow observations have been successfully used to derive physical parameters of the emitting region. Firstly, emission intensities are monitored using ground-based photometers or imaging systems, and then different parameters are derived from their intensity information. Using an empirical approach by Makela et al. (2001), OI 777.4 nm emission intensity (I_{7774}) measurements have been used to derive the electron density maximum of the F-layer (Nm) and its critical frequency (foF2) at Sata (31.0º N, 130.7º E, modified dip angle (modip.) ~40.1º), Shigaraki (34.8° N, 136.1° E, modip. ~43.3°) and Rikubetsu (43.5° N, 143.8° E, modip. ~49.8°) in Japan during 2014-2015. We then compare airglow derived foF2 ($foF2^{AIR}$) with that of co-located ionosonde for the first time to explore the trustworthiness of this technique. On individual nights, we performed one-to-one comparison using pure visualization and relative deviation module mean technique. We then examined the percentage deviation of two measurements at different intervals in the night using entire database.

Results & Conclusions:

At Sata, one-to-one comparison suggests a good to reasonable agreement between two measurements only in ~12 % of the nights, and the two measurements are generally in poor agreement at all the three stations. We noted an inverse relationship between their deviation and the value of $foF2^{ION}$. A good to reasonable agreement was seen when $foF2^{ION}$ higher than ~8 MHz. When $foF2^{ION}$ was less than 6 – 7 MHz, the deviations exceeded ~41%. Sata wherein the ionosonde station lay the closest (~24 km) showed better agreement in comparison to those noted over Shigaraki and Rikubetsu (~325 and 245 km, respectively). This indicates the importance of limiting the comparison to airglow and ionosonde stations almost co-located like Sata and Yamagawa. Based on scatter-plots of the correspondence between foF2 and $\sqrt{I_{7774}}$, we determine new empirical coefficients of the linear relationship between foF2 and $\sqrt{I_{7774}}$ for I_{7774} ranging between 6 and 22 Rayleigh and Nm higher than ~1.8 x 10^{11} m^{-3}. Scatter plot analysis suggests (i) an enhanced contribution of ion-ion recombination to OI 777.4 nm emission intensity, and (ii) the possible contamination due to Q-branch lines of OH (9,4) Meinel bands. We noted the nocturnal and seasonal variation of discrepancies. An important assumption while formulating these empirical equations was that the state of the ionosphere is well-defined by the Chapman's function [Makela et al., 2001] which may not be true depending upon the time, season and location. Ambipolar diffusion above the F-layer peak and both the production and recombination rate below its peak determine the ionospheric plasma density profile. As such temporal, seasonal and spatial deviation from this standard ionosphere will lead to discrepancies between the two measurements. Scale-height of neutrals, plasma, ions

and electrons significantly define the shape of the electron density profile. Makela et al. [2001] used a constant scale height (that of atomic oxygen viz. ~50 km) in their empirical formulations. However, due to ambipolar diffusion, the plasma density decreases exponentially with altitude with the plasma scale height [viz. k(Ti+Te)/mg], which is almost twice of the neutral scale height during nighttime. Below the F-layer peak, the recombination rate decreases with the scale height of NO and O_2. And the scale heights above and below the F-layer peak are different. We noted an increase of discrepancies as the night progressed. During the night, temperature decreases and so does the scale-height, and could possibly be linked to an increase in discrepancies with time. Seasonal variation of discrepancies indicates lower deviations during the spring-summer months and the highest deviations during winter. Again, plasma temperatures are higher in summer than in winter; thus, scale-height is comparatively higher in summer and its variations during different seasons could be reason behind the seasonal variability of discrepancies. We have not taken into consideration the complex ionospheric chemistry involving ions, electrons and neutrals that lead to the charge exchange, ion-ion recombination, dissociative recombination, quenching of the excited states by neutrals, etc.. These limitations need to be addressed for a potential reevaluation and use of this technique to study the ionosphere.

Periods of stay in ISEE: 15th January – 30 March 2019

List of publications:

Based on this study, the following draft has been finalized for submission:

Statistical comparison of foF2 inferred from OI 777.4 nm emission intensities with the co-located ionosonde measurements in Japan

(Navin Parihar[1], Kazuo Shiokawa[2], Sandro M. Radicella[3], Yuichi Otsuka[2], Takuya Tsugawa[4], Bruno Nava[3], Yenca Olivia Migoya Orue[3])

[1]Indian Institute of Geomagnetism, Navi Mumbai, India; [2]Institute for Space-Earth Environmental Sciences, Nagoya University, Nagoya, Japan; [3]International Centre for Theoretical Physics, Trieste, Italy; [4]National Institute of Information and Communications Technology, Tokyo, Japan

Future Work:

Based on the success of the above-mentioned study, the following research problem has been undertaken:

Airglow derived Total Electron Content (TEC) and its statistical comparison with GPS measurements

Detection and modeling of green *Noctiluca* bloom in the Gulf of Thailand using satellite ocean color

Anukul Buranapratheprat (Burapha University)

Background

The harmful algal bloom (HAB) of green *Noctiluca scintillans*, a dinoflagellate containing a symbiotic green algae named *Pedinomonas noctilucae*, frequently occurs in the Gulf of Thailand nowadays. *N. scintillans* in high density can change seawater color from deep blue to dark green. It is often reported with fish kills due to hypoxia and tourism disruption due to dirty sea water and foul odor. Although the bloom is supposedly related to eutrophication and climate change, little is known about the mechanism of the blooms. It is necessary to understand the behavior of green *Noctiluca* bloom and other HAB species in the Gulf of Thailand to minimize the problems affecting coastal ecosystems and human well-being.

Purposes

1. To investigate the physical, biological, chemical, and optical properties of the green *Noctiluca* bloom and other species blooms.
2. To examine the performance of detecting green Noctiluca bloom on satellite ocean color data.
3. To investigate the transport of the green *Noctiluca* blooms.

Methods

Field observations near the main river mouths in the Gulf of Thailand were conducted in the northeast and the southwest monsoon season during July - August and December 2018, respectively. The RAMSES hyperspectral radiometer (320 nm - 950 nm) was used to measure remote sensing reflectance (R_{rs}) at the sea surface to investigate the spectral characteristics of phytoplankton blooms considering with chlorophyll-a, phytoplankton pigment composition and absorption. Satellite data were retrieved within ± 24 hrs. time difference from the sampling periods to examine the boundary of green *Noctiluca* blooms. Sea surface temperature, salinity, dissolved oxygen, pH, and transparency were also measured to understand the environmental conditions of the occurrence.

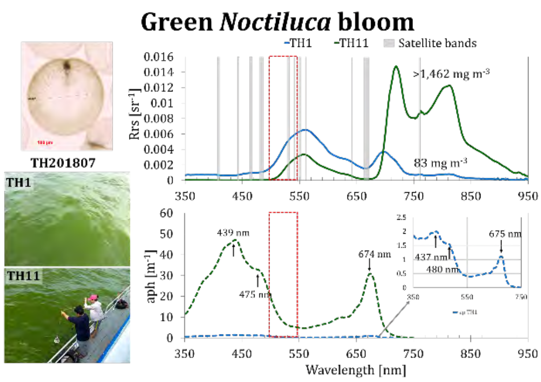


Figure 1 Remote sensing reflectance and absorption coefficient of green *Noctiluca* blooms during field observation in July 2018

Results

The super bloom of green *Noctiluca* occurred along the north-eastern coast of the upper Gulf of Thailand between the end of July to the

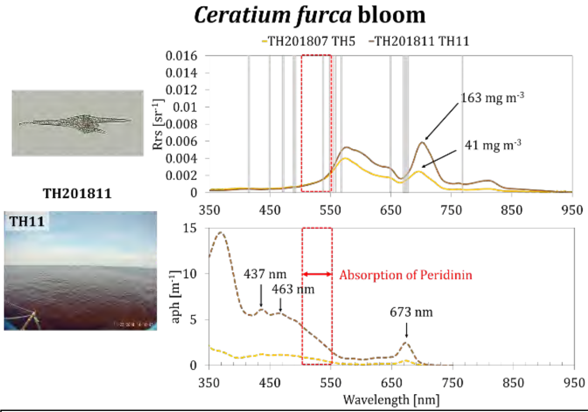


Figure 2 Remote sensing reflectance and absorption coefficient of *C. furca* blooms during field observation in November 2018

early of August 2018. *In situ* R_{rs} spectra of the high cell density (>1,500,000 cell L^{-1}) revealed that the R_{rs} was relatively low reflectance in blue wavelength (350 – 500 nm) and extremely high in red to near-infrared (NIR) wavelengths in the region from 700 nm to 900 nm (Figure 1). The rise of R_{rs} in the NIR bands, possibly caused by high content of suspended particulates (i.e., green *Noctiluca* cells), affects the criteria of satellite pixel removal. Those pixels will be masked based on the maximum iterations of NIR algorithm and atmospheric correction processing.

Dinoflagellate *Ceratium furca* blooms were found to occur in both surveys near the Tha Chin River mouth (the west of the central coast). R_{rs} spectra of the *C. furca* blooms between 500 nm and 550 nm were lower than the spectra of green *Noctiluca* blooms (Figure 2) due to high absorption of peridinin, a specific accessory pigment of dinoflagellates. These crucial features would be used as a criterion to develop the algorithm to distinguish green *Noctiluca* from other species in the future work.

Simulated surface circulation during field observations (Figure 3) is used to explain the distribution and accumulation of green *Noctiluca* or *Ceratium* blooming. Extremely strong *Noctiluca* bloom near the east coast in July (red circle in Figure 3) occurred because of surface advection from high cell density water located in the middle of the north coast and surface convergence near the east coast. *Ceratium* blooming near the Tha Chin River mouth (green circle in Figure 3) was located where the influence of river discharge was high and water salinity was low.

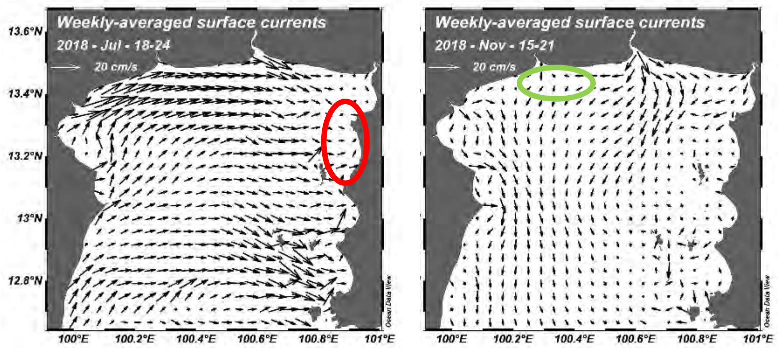


Figure 3 Simulated surface circulation during field observations in the northeast and the southwest monsoon season during July and December 2018, respectively.

Periods of stay in ISEE: 8th – 14th March 2018

List of publications: none

Origins of Eruptive and Other Solar Flares as Diagnosed with Energetic Electrons

Nariaki Nitta (Lockheed Martin Advanced Technology Center)

The main purpose of this proposed investigation is to understand the eruptivity of solar flares in terms of the observed signatures of nonthermal electrons. Solar flares may be associated with different types of eruptions that may produce shock waves or compression regions that are responsible for particle acceleration. Without apparent eruptions, however, electrons are accelerated presumably in magnetic reconnection, producing hard X-ray emission through interaction (bremsstrahlung) with ambient ions (mostly protons) especially from the footpoints of the reconnected loops. Away from the Sun, typically at 1 AU, electrons are observed in situ, in similar energy ranges to those that emit hard X-rays. It is those electrons that can be traced back to eruptions in the solar corona, where we also observe radio bursts. In particular, type II radio bursts signify shock or compression waves, likely related to coronal mass ejections, and type III bursts result from electrons escaping along open field lines that may delineate jets and narrow CMEs.

We have studied a handful of flares that show different eruptive activities (including apparently non-eruptive flares) as found in EUV coronal and white-light coronagraph images. Their hard X-ray spatial and spectral properties were analyzed with RHESSI data, in comparison with Nobeyama Radio Heliograph data when available. To probe their origins further, we also studied magnetograms, magnetic field extrapolations and even numerical simulations. We discussed the possibility of electron acceleration in CME-driven shocks with an emphasis of shock geometry and threshold energies. Lastly, we tried to evaluate the magnitude of CMEs en route to near-Earth space using IPS data. As of writing this report, we are still interpreting what the analysis so far conducted tells us. There was at least one interesting event in our list, which launched a geoeffective CME with a clear flux rope, produced both relatively strong hard X-ray emission and in situ protons and electrons. But this event occurred in an environment where the magnetic field was not strong enough for extrapolations to produce meaningful results. We plan to continue this collaboration, including attempts to use different magnetic field models, until a few papers are published, hopefully within this year.

The PI, Nariaki Nitta, made two trips to Japan, October 13-24 and December 5-18, 2018, and worked with the Japanese collaborators at ISEE, Kyoto University, ISAS and University of Tokyo. He is grateful to the host, Prof. Masuda, for his hospitality during his stay at ISEE, where he also benefited from discussion with Prof. Kusano, Prof. Leka, Prof. Iwai, Dr. Inoue, Dr. Park, Mr. (now Dr.) Muhamad, Ms. Lin, etc.

New radar method to observe thermospheric neutral density

Prof. Michael Kosch (South African National Space Agency)

Prof. Kosch visited ISEE from 19 November to 7 December 2019 for 4 weeks. He was hosted by Prof. N. Nishitani. The purpose of the visit was to further analyze radar data for a "New radar method to observe thermospheric neutral density" that was developed theoretically using the ion-momentum equation by Prof. Kosch for the SuperDARN coherent-scatter radar observing perpendicular to the magnetic field line. A similar approach had previously been successful and published using the EISCAT incoherent-scatter radar observing parallel to the magnetic field line.

The main activity at ISSE was: (a) selecting a data set from the Syowa radar (completed, selected 00-04UT 25/03/2017), (b) performing the spectral analysis on the EISCAT Dynasonde data to find atmospheric gravity waves (completed, 1.3 milli-Hertz waves found), (c) including the Horizontal Neutral Wind (HWM) model data into the calculation of thermospheric neutral density for the Hankasalmi and Longyearbyen radars (now completed), (d) finding and reading papers on heat flux for the theoretical development (now completed), and (e) writing the manuscript for publication (half completed).

Outstanding tasks include: (a) Performing the spectral analysis on the estimated thermospheric neutral density variability (currently underway), (b) analyzing the Syowa radar data set at both high (0.1s) and low (1s) temporal resolution, and (c) completing the manuscript. These tasks are expected to be completed in May 2019.

Prof. Kosch has presented at conferences on this research topic before, during and after his stay at ISEE (see report form 2-1). He also presented at a research seminar at ISEE on sprites (see report form 2-1). A publication is half written and will be completed for publication (target is May 2019) when the spectral analysis is completed and the analysis of the Syowa radar data is completed.

M. Kosch

Development of new and improved front end electronics for the SciBar Cosmic Ray Telescope.

Jose Francisco Valdes Galicia (Instituto de Geofisica, UNAM)

The SciBar Cosmic ray telescope (SciCRT) is installed on the top of the Sierra Negra volcano, in Mexico, with the main goal of observing solar neutrons to investigate the ion acceleration process during solar flares and cosmic ray muons to detect possible anisotropies due to solar interplanetary phenomena. The SciCRT uses scintillator bars to record both energy deposited and direction of the incoming particles with high resolution. The original Data acquisition system for the telescope does not meet the specific requirements for our goals and therefore, to achieve the full performance of the SciCRT as a Cosmic ray detector we need to develop new front end electronics with the following requirements:

- Increase the maximum transfer rate for ADC data read from multi-anode photo-multiplier MAPMT.
- Optimize the system to operate on severe environment conditions (4600 m above sea level).

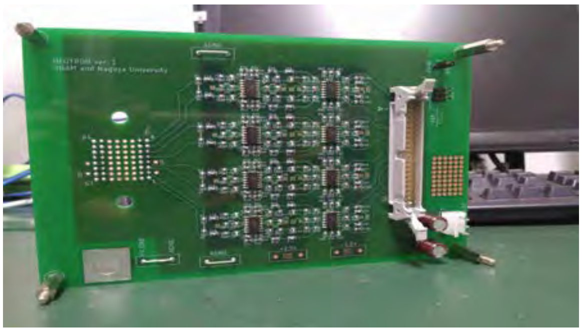
During the period of the stay, from July 23 to September 20, two students from UNAM worked on the design, construction and testing of a prototype version of the front end electronics, capable of reading 16 channels from one 64 channel MAPMT. This work is a joint research between UNAM and ISEE.

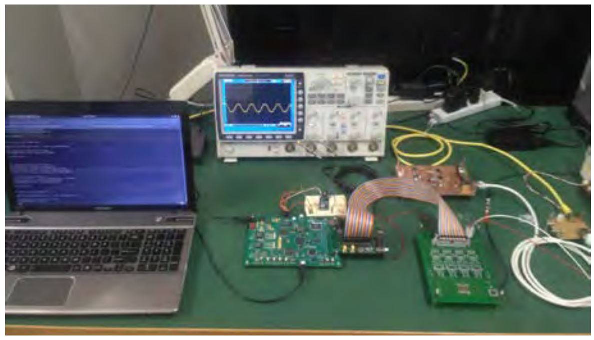
The design required the detailed simulation of the process of signal formation in the detector; for this goal Geant4 and other custom made software were used. Following the results of the simulation, the design of preamplifier circuits and system for distributing power supply in the SciCRT with other complementary circuits were done.

Some of the circuits were built at ISEE with help of technical staff, but the more complex circuit, the preamplifier board, was sent to a special company for manufacture.

Following the construction of the modules, we proceed with the testing. For this purpose, the students worked in the Cosmic ray laboratory at ISEE. The test of the modules was performed using one LED and one 64 MAPMT inside a dark box.

In the figures below it is shown the module built and the setup for testing.





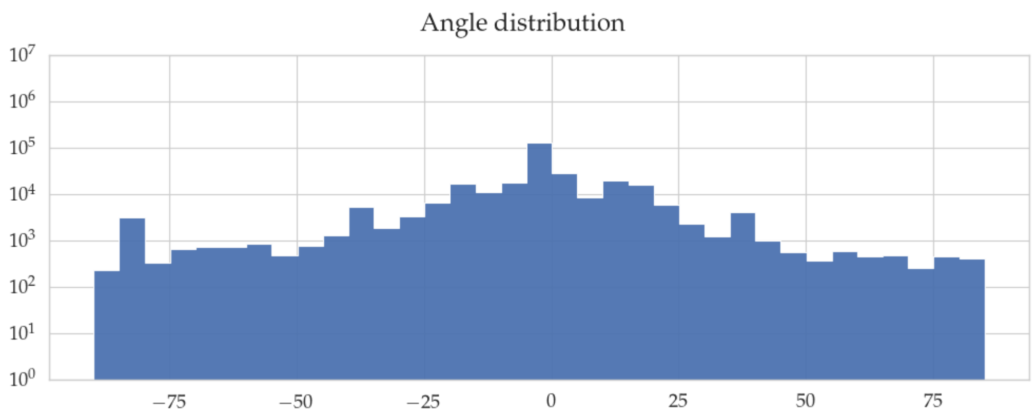
Preamplifer board

Setup for testing

The testing of the modules was successful and with this We achieve the final goal of our stay. We are now working on a full system for reading all the signals from the MAPMT and on a publication describing in detail the operation of the new system.

Aside from the work on the electronics, the students worked in the analysis of neutral particle data from the SciCRT. In general, they worked on a method to determine the incident angle distribution from the data using the Fourier transform. This method is useful to study the occurrence of a solar neutron events by analyzing if the incident angle distribution corresponds to the direction of the sun.

The following figure shows the corresponding angular distribution from neutral particle data obtained on November 14 2017. In this period of time we do not expect any excess related to Solar neutrons. Therefore the shape of the distribution corresponds to the expected shape from incoming incident radiation without any preferent direction.



Study of coronal magnetic fields from the joint observations of MUSER and NoRH

Baolin Tan (NAOC)

Please write your research summary including purpose, methods, and results, periods of stay in ISEE, and list of publications in maximum two pages.

Summary:

During this joint collaborating year, we mainly have done the research of coronal magnetic field diagnostics from the observation of MUSER and NoRH, especially on the theoretical analysis to derive the magnetic parameters from the solar radio observation parameters and other important issues in solar physics. We finished two papers and submitted to ApJ under review, and one paper is under preparing.

We have adopted the NoRH imaging observation to analyze the small bright points of a prominence on the microwave images in a flare event, and proposed that the small microwave bright points should be related to the small-scale energy releasing in the magnetic flux rope by kink instability. The result has been submitted to ApJ and is under the second review.

Another work is about the quasi-periodic pulsation (QPP) before and during a solar flare observed by MUSER and NoRH images and EUV intensity of AIA/SDO. In this work, we found that the period of QPP shifted from about 3 minutes in the preflare phase with EUV emission mainly in the edge zone to near 2 minutes during the flare impulsive phase with radio emission mainly the flare source region. These two QPP regions are connected by large coronal loops. We interpreted the results from LRC-model and proposed that the electric currents occurred in the active region before the onset of solar flare, which might play a key role to trigger the origin of solar flare.

Additionally, we also adopt the observations of the Japanese radio telescope IPRT (Iitate Planetary Radio Telescope) to study an event of radio spike burst group following a type III burst which occurred just at the beginning of a solar flare. This work is continued now.

Periods of stay in ISEE

We have two members visited ISEE of Nagoya University under the support of joint project:

(1) Prof. Baolin Tan, visiting ISEE during January 7-25, 2019

(2) Dr. Chengming Tan, visiting ISEE during January 31 – February 12, 2019.

Our Japanese Collaborating colleagues (Satoshi Masuda and Kyoto Shibasaki, and Tomoko Kawate, Ayumi Asai, Kyoko Watanabe) have visited the Mingantu Observing Station of NAOC during October 7-12, 2018. They have visited the new generation Chines Spectral Radioheliograph arrays, and discussed the details of the observation data, and make two presentations to our Chinese colleagues.

Publications:

(1) Huang J., Tan B.L., Mausda S., Cheng X., Bisoi K.S., & Melnikov V., The localized microwave and EUV bright structures in an eruptive prominence, ApJ, under 2nd review
(2) Tan B.L., Chen N.H., Yang Y.H., Masuda S., & Misawa H., The solar radio spike bursts following a type Ⅲ burst in an X1.3 flare on 2014 April 25, under preparing.
(3) Chen X.Y., Yan Y.H., Tan B.L., Huang J., Wang W., Chen L.J., Zhang Y., Tan C.M., Liu D.H., Masuda S., Quasi-periodic pulsations before and during a solar flare in AR 12242, ApJ, under 2nd review.

Presentations:

(1) Tan B.L., Solar radio spectral fine structures and diagnostics of nonthermal processes, Seminar in ISEE, Nagoya University, 21/01/2019
(2) Masuda K., Purely nonthermal solar flares observed with Nobeyama Radioheliograph, Mingantu Observing Station of NAOC, 09/10/2018
(3) Shibasaki K., Magnetic moment of thermal plasma: revisiting the Bohr-van Leeuwen theory, Mingantu Observing Station of NAOC, 09/10/2018
(4) Masuda S., Quarter Century of Nobeyama Radioheliograph and Its Contribution to Space Weather Research (invited talk), AP-RASC 2019, New Delhi, India, March 9-15, 2019

Please use A4 paper (210 x 297 mm) with margin (top and bottom 20 mm, left and right 20 mm).

Data-Constrained and Data-Driven Simulations of Active Region Eruptions and Time-Dependent Topology Analysis

Antonia Savcheva
(Smithsonian Astrophysical Observatory, 60 Garden st., Cambridge, MA 02138, USA)

Understanding the magnetic field structure, stability, and loss thereof of large-scale sheared and twisted magnetic fields in the solar atmosphere can prove critical to increasing our insight into the triggers and drivers of large space-weather events. It has been known that one option for producing filaments in the solar atmosphere is to collect cool chromospheric material in the dips of the twisted field lines of a magnetic flux rope. Since its field is twisted and sheared it is highly non-potential and hence great for storing magnetic free energy, which can be released to power an eruption like a coronal mass ejection (CME). Filaments have been observed in the solar atmosphere as dark features on a bright background from the smallest scales (at the bases of coronal jets) to the largest polar crown quiet sun filaments that can span more than one diameter of the solar disk out of the active region band.

In this collaboration we will model large active region filaments at the base of sigmoidal active regions since Inoue's MHD code is still Cartesian and is yet impossible to capture large-scale quiet sun filaments and properly model their 3D coronal magnetic field and its evolution toward eruption. We will analyze the topology and stability of the magnetic configuration and their evolution from formation to eruption for famous SDO and Hinode event of Sept 06, 2017. If Inoue's MHD code is extended to spherical geometry NLFFF models exist for two large quiet-sun filaments that erupt as CMEs (12 March 2012 and 19 April 2015) that can be used as initial conditions in the simulation. The challenge with modeling such events is that a precursor to the CME is rarely seen except when the filament is seen along its axis on the limb of the sun in EUV or X-rays and shows up as a tear-dropped cavity. The same inference has been made for active region flux ropes. Savcheva et al. (2012a, b, 2015, 2016) showed that an inverted-teardrop shaped cross section to active region flux ropes is a precursor to CMEs in several modeled sigmoids. On the underside of this inverted tear-drop shape of the current cross section of the flux rope we find a place, where reconnection can take place and can facilitate an eruption, i.e. a topological feature called a hyperbolic flux tube (HFT, Titov et al. 2002) – reminiscent of a generalized X-line in 3D.

In order to model these filaments over their evolution we will use the flux rope insertion method of van Ballegooijen (2004) (details of the current method are given in Savcheva & van Ballegooijen 2009, Savcheva et al. 2012, 2016). The method consists in creating a potential field extrapolation based on a LoS magnetogram and inserts flux ropes following the path of an observed filament in AIA 304A or 171A. Since we have no prior information on the poloidal and axial flux in the flux rope, we create a grid of models with different combinations of poloidal and axial flux, and let each model relax to a force-free equilibrium state by magnetofriction. The best fit model is chosen based on comparison with suitable loops, or the shape of the filament cavity at different moments in time. The group at the CfA has successfully modeled more than 20 regions using this most highly data-constrained method. The Sept, 2017 event has already been modeled by Inoue's NLFFF method, so a comparison between the two methods will be made. From the best fit-model at a given time we can estimate the free energy and helicity, poloidal and axial flux in the flux rope. Using our brand new unprecedentedly fast 3D magnetic topology tools (Tassev & Savcheva 2017, 2019) we will determine the axis of the flux rope, the distribution of twist, the boundaries of the flux rope, and the locations of any places where the flux rope is connected to the photosphere at a bald patch separatrix surface (BPSS; Titov et al. 1993) or probable sites of reconnection such as the locations of any null points or HFTs. Based on the 3D magnetic field information we can analyze the stability of the flux rope to kink and torus ideal MHD instabilities, which have been hypothesized to be essential in producing CMEs. In addition we will finish modelling the rest of the CMEs in the Feb 2009 region from the previous years of the project and integrate them in one study of how the parameters of the different consecutive eruptions evolved as the region kept rebuilding itself. This will be the final publications in a series of three that will be the culmination of the study of this region.

In addition we will finish modelling the rest of the CMEs in the Feb 2009 region from the previous years of the project and integrate them in one study of how the parameters of the different consecutive eruptions evolved as the region kept rebuilding itself. This will be the final publications in a series of three that will be the culmination of the study of this region. We also plan a collaboration with Toriumi-san (ISAS), where he produces initial conditions for Inoue-san's MHD code with his flux emergence codes in variety of configurations and use the MHD code to further follow the dynamics to see which of these configurations are stable and which are not. Savcheva will apply the 3D topology toolkit at each time step of these simulations to shed important understanding on the importance of topology in loss of stability.

Visit schedule:

The visits of Savcheva to Nagoya University from Boston, MA, USA are requested to be covered by the present collaboration proposal. We plan two visits – one 3 week visit in the fall (Sept-Oct 2019) with one week to visit ISAS for collaboration with Toriumi-san, and one 2 week visit in the spring (Feb-March 2020), during one of the weeks Savcheva will be accompanied by her Ph.D. student, who will assist in NLFFF modeling and topology analysis.