

FY2012

JSPS Core-to-Core Program
Strategic Research Networks
Research Report

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| Project No. | 22001 |
| Research Theme | Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas |
| Duration of Project | 2012.4. 1 – 2015.3.31 |
| Core Institution in Japan | Graduate School of Frontier Sciences, University of Tokyo |

Implementing Organizations

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| Country | Japan |
| Core Institution | Graduate School of Frontier Sciences, University of Tokyo |
| Co-Chair (name and title) | Yasushi ONO, Professor |
| Number of Cooperating Institutions | 5 |
| Cooperating Institutions | Advanced Industrial Science and Technology National Astronomical Observatory of Japan Japan Aerospace Exploration Agency National Institute for Fusion Sciences Kyoto University |

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|------------------------------------|---|
| Country | United States of America |
| Core Institution | Princeton Plasma Physics Laboratory, Princeton University |
| Co-Chair (name and title) | Hantao JI, Principal Research Physicist |
| Number of Cooperating Institutions | 9 |
| Cooperating Institutions | University of Wisconsin University of Washington University of Chicago Swarthmore College University of New Hampshire University of Alabama Stanford University George Mason University University of California, Los Angeles |
| Matching Fund | COE Project: Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas (CMSO) |

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| Country | Italy |
| Core Institution | Padova University |
| Co-Chair (name and title) | MARTIN Piero, Professor |
| Number of Cooperating Institutions | 0 |
| Cooperating Institutions | |
| Matching Fund | Research on the Self-Organization of Magnetic Field in Laboratory Plasmas |

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| Country | United Kingdom |
| Core Institution | Culham Laboratory |
| Co-Chair (name and title) | GRYAZNEVICH Mikhail, Principal Research Physicist |
| Number of Cooperating Institutions | 1 |
| Cooperating Institutions | University of London |
| Matching Fund | Tokamak Science |

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| Country | Bundesrepublik Deutschland |
| Core Institution | Max Planck Institute for Solar System Research |
| Co-Chair (name and title) | SOLANKI Sami K., Principal Research Physicist |
| Number of Cooperating Institutions | 0 |
| Cooperating Institutions | |
| Matching Fund | Base research funds |

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|------------------------------------|--------------------------------------|
| Country | Spain |
| Core Institution | Instituto de Astrofísica de Canarias |
| Co-Chair (name and title) | TRUJILLO BUENO Javier • Professor |
| Number of Cooperating Institutions | 0 |
| Cooperating Institutions | |
| Matching Fund | Base research funds |

Result of Program Implementation

In fiscal year 2012, our CMSO (Center for Magnetic Self-Organization) group accepted about 20 foreign researchers and sent 23 research staffs and students to MAST(UK), MRX(US), MST(US), RFX(Italy) groups and two solar laboratories for joint studies of magnetic reconnection and self-organization and solar/ space observations. For magnetic reconnection study, we sent 9 members to the world largest reconnection experiment: MAST and documented 1) strong ion heating up to 1.2keV in the downstream and electron heating up to 1keV at the X-point as the first application study of reconnection heating to fusion plasmas. The collaborative experiments in TS and MAST revealed 2) the promising squared B scaling of reconnection heating in agreement with the outflow heating of ions observed in TS-3. We also sent 10 members to MRX to solve 3) two fluid extension of ion heating mechanism, especially formation of negative potential well in the downstream that accelerates unmagnetized ions. The TS-3 also found the transient effect of reconnection: 4) current sheet ejection, 5) plasmoid ejection and 6) 3D reconnection as a new fast reconnection mechanism. For self-organization study, we sent 5 members to MST and RFX for an active control of plasma self-organization by Neutral Beam Injection (NBI), revealing 8) suppression of magnetic self-organization and excitation Alfvén instabilities. As for On-site self-organization study, the joint laboratory-observation team simulated the light-bridge configuration using a spheromak plasma with center solenoid flux in TS-4 and confirmed the plasma jets formation along the periphery of the light-bridge in agreement with solar observation. As for our seminars, we sent 10 members to MR2011 conference to review the advanced researches of magnetic reconnection and also 6 members to Hinode6 science meeting to solve a variety of magnetic self-organizations of solar plasmas. These activities promoted the joint research of magnetic self-organization among laboratory experiment, observation and theory in Japan, US and Europe.

Achievements in FY2012 (Self Review)

In fiscal year 2012, we successfully doubled our international and interdisciplinary CMSO team, extending our collaborative plasma research among laboratory experiment, observation and theory/simulation to several new research fields such as on-site self-organization researches. Especially, MAST(UK)-TS collaboration documented the significant reconnection heating of ions up to 1.2keV by reconnection outflow and that of electrons up to 1keV by ohmic heating of sheet current, using 2D measurements. The promising squared B scaling of reconnection heating explored the new application of reconnection heating to fusion plasmas. Based on these results, we made the plenary talk in European Physical Society and wrote the invited paper in CCPF in addition to 20 invited talks (MR, IAEA etc.) and 40 publications (Astrophys. J., Phys. Plasmas etc.). The reconnection heating experiments were also reported in the commercial science magazine "Parity" as one of the most outstanding progress of physics 2012. Joint experiments in TS and MRX also studied kinetic interpretation of reconnection heating by electrostatic potential well. In the new on-site self-organization study, the simulation experiment of solar light-bridge solved the jet formation on its periphery, leading us to the press release by ISAS and Univ. Tokyo. This new style of joint-research was reported in several newspapers. As for our seminar activities, our two core meetings: MR2011 and Hinode 6 were made successfully as the No.1 meetings in the field of magnetic reconnection and solar observations, respectively. Just like MR2010, the main papers in MR2012 will be published in Special Issue of Physics of Plasma 2013. As for young scientist's activities, young scientists and students successfully extended our research field especially to the on-site observation of magnetic self-organization, by the help of our organized schooling system and young CMSO Seminars. Our program of overseas education has been good stimulations to young students, causing their winning prizes, such as PFR, IEEJ.

Future Plan (Measures toward Achieving Research Objectives)

Our primary research subjects will be 1) to solve the whole energy conversion effect of magnetic reconnection in MHD and kinetic regimes, 2) to establish the application of reconnection heating, 3) to solve the plasmoid reconnection as a fast reconnection mechanism and also as a key process of self-organization and finally 4) to bridge the magnetic reconnection to the magnetic self-organization through formation of magnetic configuration. We will obtain clear-cut conclusions of reconnection heating in the largest reconnection experiment MAST(UK) using 2-D imaging measurements developed in TS. We will make detailed comparisons of 1)-4) among solar/ space observations, theory/ PIC simulations and the experiments by organizing an interdisciplinary CMSO team. It will also be important to make active control of reconnection and self-organization in TS, MST(US) and RFX(Italy) using neutral beams and profile adjustments. As for seminars, we will host the IPELS2013 conference successfully for interdisciplinary research subjects to bridge magnetic reconnection to magnetic self-organization. The Hinode6 workshops will solve wider one-site observations of solar and astrophysical self-organizations by the help of the interdisciplinary CMSO team. The CMSO team will use the 20th Young CMSO Seminar and school to educate young students and will encourage experienced students to study abroad in the most suitable research team of magnetic self-organization.