Proposal for an ISSI International Team Project:

Magnetic reconnection and particle energization: synergy of in situ and remote observations

Team leaders: Stuart Bale and Yuri Khotyaintsev

Abstract

We propose a team of 11 people to identify and study new ways how the knowledge about the magnetic reconnection process in astrophysical plasma environments can be significantly increased based on synergies between the observations of this process in situ in the near Earth space and remotely in the Solar corona. The major motivation is that both communities have reached a high level of understanding about the details of magnetic reconnection and such an approach finally is feasible. In addition, the launch within the last two years of Hinode, Stereo, and THEMIS, in combination with matured analysis of data from earlier spacecraft (RHESSI, Cluster, Wind, TRACE, SOHO) makes it very timely to address such questions as mechanisms of energetic particle acceleration in great detail. The support of theory and numerical simulations is crucial for the success. The first task of the team will be to review the fields of reconnection near the Earth, in the solar wind and in the solar corona to identify the most important questions where synergies can bring new important understanding and insights. The second part of the work will be to focus on one of the identified questions to carry out a detailed study utilizing all the important advantages of synergy. A possible scientific question for the detailed study might be the identification of particle energization mechanisms during the reconnection onset. This can require direct comparisons of the magnetic field reconfiguration, non-thermal particle distribution functions and their spatial and temporal evolution observed near the reconnection sites inside the Earth magnetosphere and the reconnection sites in the Solar corona. The expected outcome from this team is at least two papers - one review paper planned to be submitted in mid-2009 and a detailed study paper in mid-2010. A number of specialized study papers are anticipated in 2008-2010. For the goals of the proposal we would like to have three meetings: late 2008, early 2009, and early 2010.

Scientific rationale

Background reconnection . Magnetic reconnection is an important process in most astrophysical plasma environments leading to efficient, fast and often explosive-like conversion of magnetic energy into kinetic energy of plasma particles and rapid reconfiguration of magnetic topology. The most detailed studies of this process at the moment are possible using in situ measurements in the near Earth space, remote solar corona observations, numerical simulations and laboratory observations. There are limitations and advantages associated with each of these approaches. In situ observations can give a detailed single-point picture of local electromagnetic fields and particle distribution functions but they can not provide the overall context and integral properties of the process. In contrast, remote observations reveal the large-scale properties and context of the process but inherently suffer from line-of-sight limitations as well as have insufficient spatial resolution. Numerical simulations are a valuable tool when it comes to separating physical mechanisms that are important for reconnection under different conditions (for example guide field vs. antiparallel, turbulent vs. laminar reconnection) but there will be always limitations associated with current numerical capability of computers. Laboratory plasmas have the advantage of multi-point in situ measurements of electromagnetic fields but suffers from very limited system size, relatively high collisionality and limited charged particle diagnostics. Therefore cross-disciplinary studies can be very important in advancing our understanding of magnetic reconnection process and we would like to explore this road.

In situ measurements of reconnection. In situ observations allow for detailed measurement of reconnection phenomena at spatial and temporal scales ranging from electron scales and up to 1 AU. Here we list a few of recent highlights in the in situ studies of reconnection. Recent multispacecraft measurements by Cluster spacecraft have allowed to resolve detailed structure of the electron diffusion region [Phan et al., 2007], ion diffusion and separatrix regions [Vaivads et al., 2004, Khotyaintsev et al., 2006], look at details of ion and electron acceleration [Wygant et al., 2005, Catell et al., 2005, Imada et al., 2007, Chen et al., 2008], etc. At larger scales the two most important problems which have been addressed are continuity of reconnection and the role of guide field. A significant limitation of in situ measurements is that simultaneous observations are available only from a few spatial points, and in many cases it is necessary to use supplementary measurements which provide a more global view of the magnetosphere. Combining in situ observations of reconnection jets by Cluster spacecraft with global images of the aurora it was possible to show continuity of reconnection during many hours [Frey et al., 2002]. However, for a different solar wind conditions it has been shown that reconnection has a transient character [Khotyaintsev et al., 2004]. The possibility to have significant guide field at the reconnection site has been demonstrated using observations from time intervals showing a reversal in reconnection jet direction implying that the spacecraft is located close to an X-line [Retino et al., 2005]. Existence of X-lines in the solar wind plasmas as long as 390 Earth radii was demonstrated using simultaneous measurements by WIND, ACE and Cluster spacecraft [Phan et al., 2006]. At the same time recent in situ observations have shown the presence of reconnection in turbulent plasmas where large scale X-lines are not possible [Retinò et al., 2007, Gosling et al., 2007].

Remote observations of reconnection. Magnetic reconnection drives many important processes in the solar corona. Coronal mass ejections (CMEs) are believed to require magnetic reconnection to allow the emerging flux to escape. The presence of reconnection and its rate within the current sheet forming behind coronal mass ejections have been recently directly estimated using data from SOHO and RHESSI spacecraft [Lin et al, 2005]. Almost all solar flare models involve magnetic reconnection that allows both fast changes in the magnetic configuration and can lead to efficient particle acceleration [e.g. Benz, 2008; Vlahos et al., 2008]. A large fraction of the coronal heating is believed to be due to the reconnection in narrow current sheets which form when convective motions in the photosphere stress the magnetic field reaching into the corona. The feasibility of this explanation has been supported by numerical experiments [e.g. Gaslgaard 2006]. Also it has been suggested that solar wind source in the transition region can be due to reconnection between field lines of funnels and surrounding loops [Tu et al., 2005]. Significant advances in all those topics have been possible within last few years due to recent solar missions such as TRACE (1998 -), RHESSI (2002 -) and much more is expected due to very recent launches of Hinode (2006 -), Stereo (2006 -) and SDO (2008-).

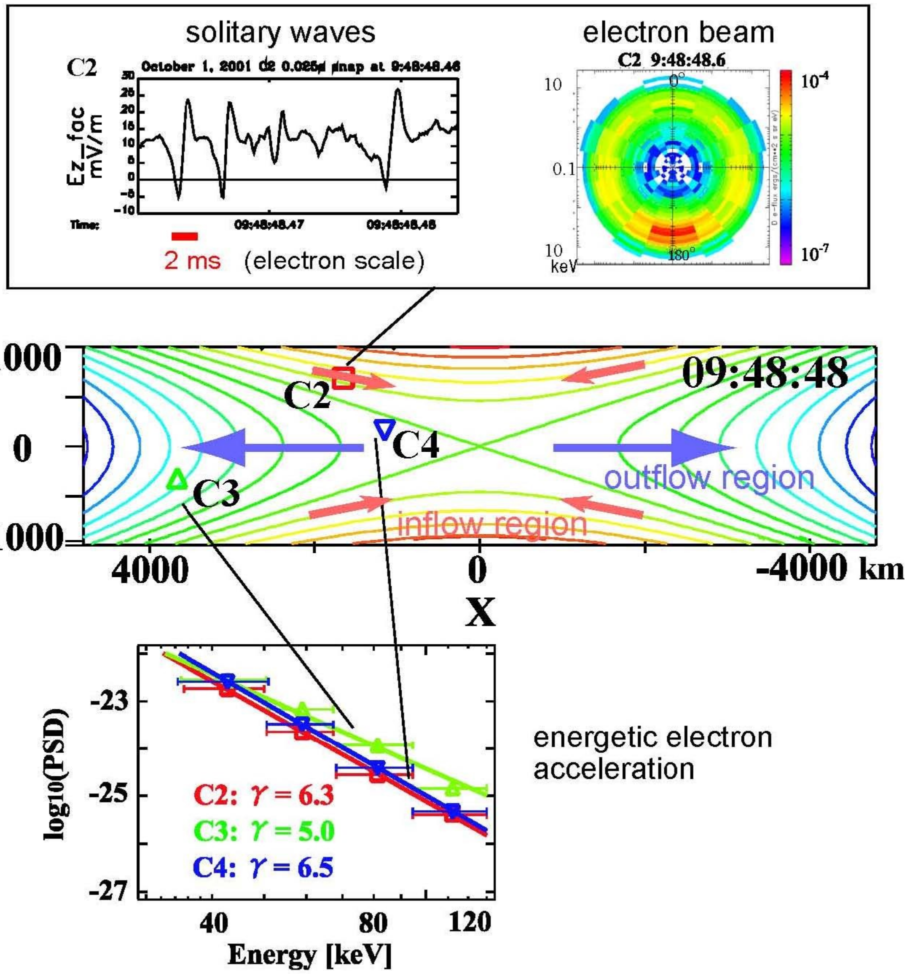

Figure 1. Electron acceleration within a reconnection region as seen in situ by the Cluster spacecraft. Top two panels show cold electrons that are accelerated to keV energies forming electron beam by very small timescale (millisecond) interactions with electric field solitary waves [Cattell et al., 2005]. Two bottom panels show the location of Cluster spacecraft. Further acceleration to non-thermal energies of 100’s keV involves non-adiabatic processes in the outflow region [Hoshino 2005; Imada et al., 2007].

Particle energization. It is important to identify those questions where a fruitful synergy between the studies using in situ and remote observations would be most likely. One such fundamental question is the particle energization. Both from in situ and remote observations it is known that reconnection is associated with both heating of plasma and non-thermal particle acceleration to energies of 10 and more times their thermal energy. We know that the large-scale characteristics of the solar reconnection results in more efficient production of energetic particles than the Earth's case but we do not know the reason why. Possible hints are emerging from recent large-scale particle simulations, such as electron acceleration in the magnetic island coalescence process where a harder energy spectrum is obtained via coalescence of larger magnetic islands. However it is also clear that not all magnetic reconnection is associated with efficient particle non-thermal acceleration, as for example has been shown by in situ measurements in solar wind [Gosling et al, 2005]. Therefore it is important to understand whether particle acceleration occurs during reconnection, or is it an after-effect of reconnection, for example a result of dipolarization in the tail or in the solar atmosphere. Also, it should be identified under what conditions reconnection produces non-thermal particle acceleration above and beyond the plasma bulk heating and acceleration. In order to facilitate the synergy among the studies, making clear the points of comparison among planetary magnetospheric observations, solar observations and simulation, should be one of the tasks of the ISSI team. We show in larger detail below what kind of synergies can be expected addressing the question of particle energization.

In situ measurements of energetic particles. High energy particles observed in the Earth's magnetosphere often originate from reconnection sites. For example Cusp energetic particles [Chen and Fritz, 1998] have ion composition characteristic of the solar wind which suggests acceleration (at least partly) by reconnection at the magnetopause. High energy electrons are also often observed in relation to reconnection in the Earth's magnetotail [Baker and Stone, 1977; Øieroset et al., 2002, Imada et al., 2007]. Such electrons are injected into the inner magnetosphere where they are further accelerated and contribute to the radiation belts [Horne 2007]. Thermal electrons get accelerated to keV and higher energies on their way to X-line along the separatrices. This can be due to interaction with a very short timescale (millisecond) electric field solitary waves [Cattell et al., 2005] or lower hybrid drift waves, which are often very intense in the separatrix region [Bale et al., 2002, Vaivads et al., 2004a] and can efficiently accelerate electrons [Cairns and McMillan, 2005]. Further acceleration to non-thermal energies of 100’s keV involves non-adiabatic processes in the outflow region [Birn and Hesse, 1994; Hoshino 2005; Imada et al., 2007]. Electrons with energies up to ~300 keV were detected directly inside the reconnection diffusion region in the Earth's magnetotail by the Wind spacecraft [Øieroset et al., 2002]. The fluxes had a peak in the center of the diffusion region and showed strong field aligned anisotropy. Imada et al., 2007 reported observations of energetic electrons from a vicinity of an X-line and showed using multispacecrfat data that the spectrum becomes harder with distance away from the X-line (further into downstream region), see Figure 1.

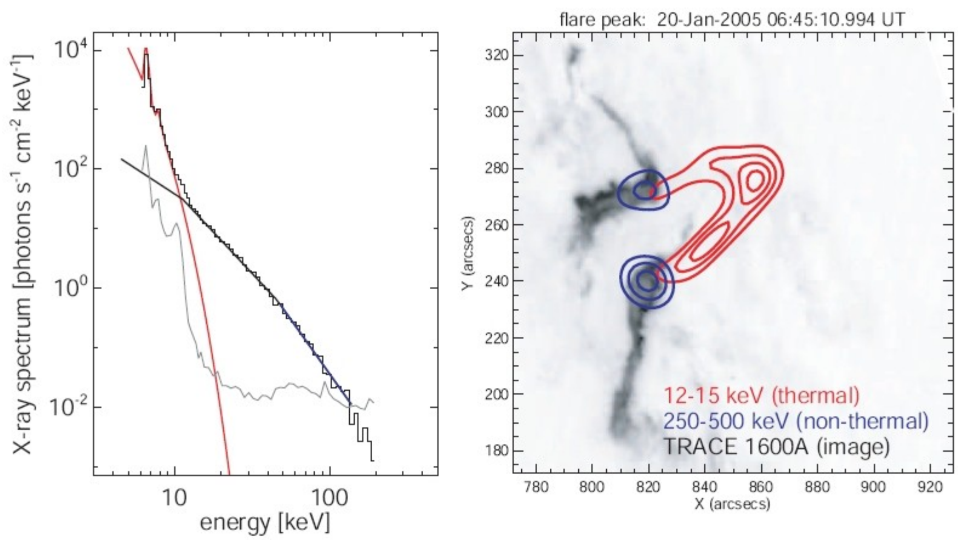

Figure 2. Spectroscopy and imaging in X-rays during the peak of solar flare. Left: X-ray spectrum is fitted with thermal (red) and non-thermal power law (blue) components. Grey line shows instrument background. Right: X-ray imaging. [Vlahos et al., 2008].

Steady vs. unsteady state reconnection. There is a wealth of knowledge accumulated on the energetic particles that most probably have been accelerated by magnetic reconnection processes in the solar corona, such as flare-accelerated electrons [e.g. Kontar and Brown, 2006; Krucker et al., 2007; Vlahos et al., 2008]. Much of information is obtained by direct measurements of particles at large distances from the Sun, however to derive detailed properties of processes inside corona one needs to rely on indirect measurements, e.g. X-rays and electromagnetic emissions [Krucker et al., 2007a]. Figure 2 shows an example of both spectral observations and X-ray imaging corresponding to non-thermal particle acceleration during solar flare. As an example, such results from the remote observations could be compared with the observations from the Earth magnetosphere (such as shown in Figure 1) where direct observation of non-thermal accelerated electron spectra can be obtained in different phases and locations of the reconnection site. One aspect that can be addressed directly is that correlated studies of energetic particle fluxes and the configuration of magnetic flux tubes during energetic particle acceleration events have shown that the most energetic particle acceleration is in the initial stages of the reconnection process when flux tube configuration dynamically changes [Asai et al., 2004; Sui et al., 2008]. Once the geometry is stabilized the reconnection slows down making particle acceleration and plasma heating less efficient [Sui et al., 2008]. This indicates that large scale quasi-stationary reconnection is not an efficient particle accelerator. This result is supported also by in situ measurements showing absence of energetic particles in reconnecting current sheets within solar wind [Gosling et al., 2005] while at the same time energetic non-thermal electrons are observed to correlate with magnetic islands characteristic for dynamic reconnection processes [Chen et al., 2008]. This is a possible topic that could be addressed in large details within the ISSI team - a typical solar flare case in the solor corona and a typical reconnection onset case in the magnetotail being compared from the point of view of particle energization dynamics.

Additional questions. There are other questions that can be efficiently addressed from inter-disciplinary collaboration. One example is reconnection rate estimates. It is of interest to compare both the large scale average reconnection rates during different stages of the reconnection process, as well as temporal/spatial variations of the reconnection rate that can be responsible for forming complicated magnetic geometry and dynamics around the reconnection sites. Another closely related questions is reconfiguration of the magnetic field. Such reconfiguration can be observed both during solar flares and during substorms (reconnection in the Earth magnetotail). The correlation of different phases of magnetic configuration changes with other physical processes, such as particle energization, can allow much better understanding of the physical mechanisms leading to the energization. Another example is radio emissions. Much of the information on reconnection processes in the solar corona are derived from observations of electromagnetic radio emissions that in most cases are generated by energetic electrons. What are the necessary conditions for the emission generation are not clear and here to large help can be observations of the similar emission sources in situ in the near Earth space. The list of problems of high interests can be continued - the role of anomalous resistivity, reconnection under strong guide fields (can be often the case in solar wind and solar corona), reconnection in turbulent plasmas, shock formation in reconnection jet regions, etc.

Workshops. To encourage the inter-disciplinary collaboration we expect to present the results of the team work in different community workshops - plasma, solar, Earth magnetosphere. Example meetings are EGU 2009/2010, IPELS 2009 (bringing together lab and space people), Cluster workshops, Hinode Science Meetings, and STEREO SWG meetings. We also plan to discuss the possibility of suggesting sessions for some workshops/conferences that would address physical questions of magnetic reconnection and encourage inter-disciplinary participation.

Context. It is important also to view the current team effort as a contribution to the current spirit of the future space programs of ESA, NASA, JAXA as well as other space agencies. One particular line of development is the need to combine in situ and remote observations to progress in the field, particularly understanding solar corona. Examples are current mission STEREO, upcoming missions Solar Orbiter, SDO, Sentinels and Solar Probe. Also important are attempts to understand basic underlying physics such as upcoming MMS and possible future mission Cross-Scale.

Expected Output

During the first half of our ISSI program we expect to write one "research review" paper where we would identify a list of several important issues in the reconnection physics that can be addressed using close interdisciplinary collaboration between the scientific communities studying reconnection processes in situ in the near Earth space and the one doing it remotely in the Solar corona. The planned submission time would be one month after second team meeting (before summer 2009). The important focus at the paper would be to identify the strength and weaknesses of both approaches allowing to clearly see how the knowledge can be combined in the most efficient way. An example of one such question is energetic particle acceleration. The paper should be useful as a guideline identifying the most feasible sceintific questions where overlap between communities is big enough to bring important results from combined efforts.

In the second part of the program we are planning one focused study where the approach of interdisciplinary attack of the problem is validated. The results of the study would be submitted to the interdisciplinary journal before summer 2010.

We also expect that this activity will stimulate further development of close collaboration and synergies between the fields. The results of the study will be presented both at the space and solar meetings/workshops showing the large potential of interdisciplinary studies.

ISSI Implementation

The ISSI facility is ideal for this kind of workshop. The team leaders are familiar with the arrangements, and the team itself contains good and balanced representation from the solar and magnetospheric community at the same time covering expertize on observational methods, numerical simulations and theory. We expect to proceed with minimal overhead on a clearly-defined program of substantial scientific importance.

Short summary of expected meeting focus

- 1st meeting (fall 2008) - introductory presentations, brainstorming, outline of review, assignments
- 2nd meeting (spring 2009) - review paper finalization, identification of focused studies, assignments
- 3rd meeting (spring 2010) - finalization of at least one detailed study, brainstorming of future

List of Participants

The following participants have confirmed their willingness to participate in the proposed projects (CVs are attached):

1. Ayumi Asai (Nat. Astronom. Obs., Japan): Hinode observations
2. Stuart Bale (U. California, USA): STEREO observations, in situ observations
3. Masaki Fujimoto (ISAS, JAXA, Japan): Numerical simulations
4. Jack Gosling (U. Colorado, USA): Wind observations, in situ observations
5. Yuri Khotyaintsev (IRF, Sweden): Cluster observations
6. Eduard Kontar (U. Glasgow, UK): RHESSI observations, theory
7. Säm Krucker (U. California, USA): RHESSI and solar imaging observations
8. Thomas Neukirch (U. St. Andrews, UK): theory space and astrophysical plasma
9. Vladimir Semenov (U. St.Petersburg, Russia): theory
10. Andris Vaivads (IRF, Sweden): Cluster observations
11. Loukas Vlahos (U. Thessaloniki, Greece): theory

The team has extensive experience covering essentially all aspects of the proposal.

Timeliness

The time of project is very appropriate. The level of detailed understanding within both communities, studying reconnection in situ near the Earth and remotely in the Solar corona, has matured enough to allow and strongly benefit from interdisciplinary cooperation. A sufficient time has passed to accumulate the understanding of the data from earlier missions (Cluster, RHESSI, Wind, TRACE, SOHO), particularly Cluster and RHESSI are important for the current team project. Also recently launched STEREO, Hinode and Themis missions have entered their peak scientific phase thus making available their data that are of high use to the current project.

Facilities requires

No special facilities are required besides the usual ISSI workshop facilities: one meeting room with projector and internet access.

Financial requirements

No additional financial support is required but the standard ISSI financial support. ISSI is asked to provide the living expenses of team members while they reside in Bern. For the three week-long meetings (6 days maximal stay per week), at most 198 person days is required for the 11 team members. Funding to cover travel costs is the responsibility of the team members.

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Recent Papers

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1992-1996 Research Assistant, Nagoya University,
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Research themes:
- Multi-scale nature of fundamental space plasma phenomena such as shocks, vortices and reconnection: Data analysis and numerical simulations
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Current Status:
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Curriculum Vitae

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Dr. John (Jack) T. Gosling is a Senior Research Associate at the University of Colorado's Laboratory for Atmospheric and Space Physics. He is also a retired Laboratory Fellow at Los Alamos National Laboratory. He received his PhD in physics from the University of California Berkeley in 1965. He has extensive research interests in solar, solar wind, and magnetosphere physics, and has published more than 450 papers in these areas of research. He has worked extensively with plasma and magnetic field data from Vela 2 and 3, IMP 6, 7, and 8, ISEE 1, 2, and 3, Ulysses, and the Advanced Composition Explorer (ACE) and with coronagraph data from Skylab. He was the Principal Investigator for data analysis for the Los Alamos plasma experiments on IMP 6, 7, and 8 and ISEE 1, 2, and 3. He has served as secretary for Solar-Heliospheric physics within the American Geophysical Union, as Chair of the SPA/AGU Awards Committee, as a member of the AGU Fellows and Bowie Medal committees, and as President-elect and President of the Space Physics and Aeronomy section of the American Geophysical Union. He has twice served as an Associate Editor of the Journal of Geophysical Research. He served as Chair of the Solar-Heliosphere Physics panel of the National Research Council's Decadal Survey of Solar and Space Physics and as Chair of NASA's Science Definition Team for the Living With A Star Targeted Research and Technology program. He is a Fellow of the American Association for the Advancement of Science and of the American Geophysical Union, has received the National Center for Atmospheric Research Technology Achievement Award, two Los Alamos National Laboratory Distinguished Performance Awards, and five Editor's Citations for Excellence in Refereeing from AGU journals. He has been recognized as a Highly Cited Researcher by ISI, was the year 2000 recipient of the American Geophysical Union's John Adam Fleming Medal, and delivered the Parker/Bowie Lecture at the Spring 2004 AGU meeting.

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2004 Assistant Professor (Docent), Uppsala University, Sweden
1998 PhD. Space Physics, Umeå University, Sweden
1992 B.A. Physics, University of Latvia, Latvia

EMPLOYMENT
2007- , Senior Researcher, Swedish Institute of Space Physics
2003-2006, Researcher, Swedish Institute of Space Physics
2000-2002, Postdoctoral Fellow, Swedish Institute of Space Physics
1998-2000, Postdoctoral Fellow, Max Planck Institut fur extraterrestrische Physik

TEACHING EXPERIENCE
supervision of 5+ PhD students (main supervisor to 1, assistant to 3).
2004, Lecturer, Reconnection (graduate course)
1993-2007 Lecturer or Teaching Assistant in 6 different undergraduate courses
1992, Jan-Jun, Lecturer, Physics (high-school)

SCIENTIFIC WORK
50+ refereed publications (13 as the 1st author), 3 popular science articles.
10+ invited talks in international conferences/workshops
Member of
- organiz. commit. at many national and 8 international workshops/conferences
- ESA Solar System Working Group
- ESA CrossScale Science Study Team
- Review committees for NASA
- 2 working groups of International Space Science Institute
- evaluation committees on 2 PhD thesis, 1 master thesis.
Opponent to 2 PhD thesis defenses
Review of 20+ articles

Curriculum Vitae
Eduard P. Kontar
Department of Physics and Astronomy, University of Glasgow
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EDUCATION:

02/07/1999 PhD, Plasma Physics, Dept. of Physics and Technology, "Propagation and radio emission of electron beams in the solar corona" *Kharkov State University*, Ukraine

01/03/1995 MSc diploma with distinction, Theoretical Physics, *Kharkov State University*, Ukraine

EMPLOYMENT AND RESEARCH VISITS TOTALLING OVER A MONTH:

10/2005 - now Lecturer in Astronomy & PPARC Advanced Res. Fellow, *University of Glasgow*, Scotland, UK

04/2002-09/2005 Postdoctoral Research Associate, *University of Glasgow*, Scotland, UK

04/2000-04/2002 Postdoctoral Research Fellow, *University of Oslo*, Norway

03/1999-09/1999 Visiting Scientist, *University of Surrey*, Guildford, UK

1996 -1997 Research assistant (part-time), *Kharkov State University*, Ukraine

2004/2005 Visiting Researcher (~2 months), *Centre for Advanced studies at the Norwegian Academy of Sciences and Letterers,* Oslo, Norway

2002/2003 Research visits (~2 months), University of Alabama in Huntsville, USA

PROFESSIONAL RESEARCH-RELATED ACTIVITIES:

Panellist, NASA Heliospheric and Solar Physics Proposal Review Panel, 2007

Proposal referee, Science, Technology and Facilities Council (formely PPARC), UK; NASA, USA; Academy of Sciences, Czech Republic;

Member, LOFAR:UK Consortium, 2006-now;

Co-organizer, Series of Topical RHESSI/NESSI workshops, (06/2003, 03/2004, 03/2005 in Glasgow, UK; 03/2006 in Paris; 10/2006 in Berkeley, USA); UK Solar Physics Theory Meeting, February 25-27, 2008

Referee (3-4 papers per year), *Solar Physics, Astrophysical Journal, Astrophysical Journal Letters, Physics of Plasmas, Astronomy and Astrophysics, Advances in Space Research;*

Local Organizing Committee Member, *The Community of European Solar Radio Astronomers (CESRA) meeting,* Sabhal Mor Ostaig, Isle of Skye, UK, (June 2004);

Member, Team "The RHESSI Mission: X-ray Spectra and Image Analysis by Means of Inversion Methods" (2005-2006), Team "The Rhessi Mission: Inversion Methods for Imaging Spectroscopy" (2006-), ISSI, Bern, Switzerland

Fellow, Royal Astronomical Society (2005 -);

Member, American Physical Society (2000-2006), International Astronomical Union (2004-), American Geophysical Union (2004 -);

Selected relevant publications:

Kontar, E.P. and Brown, J.C., Stereoscopic electron spectroscopy of solar hard X-ray flares with a single spacecraft, 2006, *Astrophysical Journal Letters*, 653, L149-L152.

Kontar, E.P. and Brown, J.C., Solar Flare Hard X-ray Spectra Possibly Inconsistent with the Collisional Thick-Target Model, 2006, *Advances in Space Research*, 38, 945-950.

Kontar, E.P., et al., Determination Of Electron Flux Spectra In A Solar Flare With An Augmented Regularization Method: Application To RHESSI Data, 2005, *Solar Physics*, 226, 317-325

Kontar, E.P., Dynamics of electron beams in the solar corona plasma with density fluctuations, 2001, *Astronomy & Astrophysics*, 375, 629-637.

Stuart Douglas Bale

Education
1989: B.A., Physics, B.A. Mathematics, University of Minnesota
1994: Ph. D., Physics, University of Minnesota

Career
1994-1997: Postdoctoral Fellow, Queen Mary College, University of London, UK
1997-2004: Asst/Assoc Research Physicist, University of California, Berkeley
2004-2006: Assistant Professor of Physics, University of California, Berkeley
2006-present: Associate Professor of Physics, University of California, Berkeley
2004-present: Associate Director, Space Sciences Laboratory, UC Berkeley

Awards
1993 AGU Outstanding Student Presentation Award
2001 Mâitre de Conférence Invité, Université Paris VII
2004 Presidential Early Career Award for Scientists and Engineers (PECASE)

Research Activities:
Prof. Bale is interested in plasma waves and particle energization in astrophysical and heliospheric plasmas, in particular, in situ observations of magnetic reconnection, collisionless shocks, turbulence, and radio emission and nonlinear plasma processes. He also has interests in solar and low frequency radio astronomy, plasma wave and electric field instrumentation and antenna design and signal processing techniques.

Project related responsibilities:
• Co-Investigator and Institutional PI on the STEREO/WAVES experiment (antenna design/fab)
• Co-Investigator on MAXIS II balloon campaign (AC search coils experiment)
• Member, Solar Orbiter Payload Technology Working Group (ESA)
• Member, NASA Sentinels Science and Technology Definition Team

Selected Publications (more than 60 in refereed journals)
• Bipolar electrostatic structures in the shock transition region: Evidence of electron phase space holes, S. D. Bale, P. J. Kellogg, D. E. Larson, R. P. Lin, K. Goetz, and R. P. Lepping, Geophys. Res. Lett., 25, 2929, 1998.
• Antenna-plasma and antenna-spacecraft resistance on the Wind Spacecraft, P. J. Kellogg and S. D. Bale, J. Geophys. Res., 106, 18,721, 2001.
• Evidence of diffusion regions at a sub-solar magnetopause crossing, F. S. Mozer, S. D. Bale, and T. Phan, Phys. Rev. Lett., 89, 015002, 2002.
• Observation of lower hybrid drift instability in the diffusion region at a reconnecting magnetopause, S. D. Bale, F. S. Mozer, and T. Phan, Geophys. Res. Lett., 0.1029/2002GL016113, 2002.
• Evidence for electron acceleration up to ~300 keV in the magnetic-reconnection-diffusion region of Earth's magnetotail, M. Oieroset, R. P. Lin, T. D. Phan, D. E. Larson, and S. D. Bale, Phys. Rev. Lett., 89, 195001, 2002.
• Measurement of the electric fluctuation spectrum of magnetohydrodynamic turbulence, S. D. Bale, P. J. Kellogg, F. S. Mozer, T. S. Horbury, and H. Reme, Phys. Rev. Lett., 94, 215002, 2005.

Loukas Vlahos – Curriculum Vitae

Personal data
Name: Vlahos, Loukas
Born: Levadia (Greece) 22-04-1949
Nationality: Greek
Marital status: married, two daughters
Languages: English, Greek
Present position: Professor, University of Thessaloniki, Greece
Address: Dep. of Physics, University of Thessaloniki
54124 Thessaloniki, Greece
Tel.: +30-2310-998044, FAX: +30-2310-998354
E-mail: vlahos@astro.auth.gr
Website: www.astro.auth.gr/~vlahos

Studies
Feb. 1976 MSc, University of Maryland, USA
April 1980 PhD, University of Maryland, USA

Employment
1980 – 1985 Research associate , University of Maryland, USA
1985 – 1990 Assistant professor, University of Thessaloniki, Greece
1990-– present: Associate Professor , University of Thessaloniki, Greece

Research interests
Basic Plasma, Solar Physics and High Energy Astrophysics

Scientific publications 120
PhD supervision 3 completed (as supervisor) , and 2 underway
Referee for A&A, ApJ, MNRAS, Solar Physics
Collaboration P. Cargill(UK), K. Arzner (Switcher land), J.C. Brown(UK), RHESSI team
Teaching experience - 40 courses between 1976 and today on various topics in (astro)physics, both at the
introductory and advanced level;
- Supervision of 30 diploma theses;
-
Loukas Vlahos – recent articles
- Particle acceleration in multiple dissipation regions, Azner K., Vlahos L. Astroph. J. (Lett), 605, L69-L72 (2004)
- On the Self-Similarity of Unstable Magnetic Discontinuities in Solar Active Regions, Vlahos L., Georgoulis M. Astroph. J., 603, L61-L64 (2004)
- Anomalous transport of magnetized electrons interacting with EC waves, Tsironis C., Vlahos L., Plasma Physics and Controlled Fusion, 47, 131-142 (2005)
- Particle acceleration in stressed coronal magnetic fields, Turkmani R., Vlahos L., Galsgaard K., Cargill P. J., Isliker H., Astroph. J. (Lett), 620, L59-L62 (2005)
- Gyrokinetic electron acceleration in force-free corona with anomalous resistivity, K. Arzner and L.Vlahos, Ast. Astroph, 454, 957 (2006).
- Stochastic Acceleration in Turbulent Electric Fields Generated by 3D Reconnection, M. Onofri, H. Isliker and L. Vlahos, Phys. Rev. Lett., 96, 151102 (2006)

Säm Krucker

Personal Data:
Name: Samuel (Säm) Krucker
Date of birth: June 13, 1967
Nationality: Swiss

Education & Professional Status:
1987 - 1992 Study of experimental physics,
Swiss Federal Institute of Technology (ETH) Zürich, Switzerland
1993 - 1996 PhD student at the Institute of Astronomy, ETH Zürich (Prof. A. O. Benz)
November 1996 Ph. D. Thesis: "Small Solar Flares in Radio and X-rays: Micro
ares and Radio Bursts"
1997 - 2000 Post-doctorate position at the Space Sciences Laboratory,
University of California, Berkeley (with Prof. R. P. Lin)
2000 - 2006 Assistant research physicist at the Space Sciences Laboratory
2003 Named Co-Investigator of the NASA small explorer mission RHESSI
2006 to present Senior Fellow at the Space Sciences Laboratory

Experience relevant to the proposal:
Data analysis and interpretation of
• solar flare observations in radio waves, in the optical range, in EUV, and X-rays.
• iterplanetary in-situ observations of solar energetic particles.

Publications
I have published 65 papers in refereed journals, 20 as a first author.

Curriculum Vitae for **Yuri Khotyaintsev**

Born:
January 21, 1976 in Kyiv, Ukraine.

Education:
M. Sci. in Physics, 1997, Kyiv Shevchenko University.
Ph. D. in Space Physics, 2003, Uppsala University.

Employment:
1998 – 2003, PhD student at Swedish Institute of Space Physics, Uppsala.
2003 – 2008, Scientist, Swedish Institute of Space Physics, Uppsala. Analysis of the EFW data for the Cluster Active Archive (CAA).
2008 to present, Research Fellow, Swedish Institute of Space Physics, Uppsala.

Experience in Space Science Missions:
F1, F2, F4, F7 instruments, Freja (scientific analysis)
EFI, MFE instruments, Polar (scientific analysis)
EMMA, LINDA instruments, Astrid-2 (scientific analysis)
EFW electric field instrument, Cluster (scientific analysis)

Other relevant experience:
1999-2003 Development of Orbit Visualization Tool (OVT, http://ovt.irfu.se).
2005-2007 Member of a group at the International Space Science Institute (ISSI) studying relationship between the reconnection and turbulence.

Professional Societies:
Member of American Geophysical Union

Selected publications:

• Khotyaintsev, Yu. V., A. Vaivads, A. Retino, M. André, C. J. Owen, H. Nilsson, Formation of Inner Structure of a Reconnection Separatrix Region, Phys. Rev. Lett., Vol. 97, 205003, 2006.
• Vaivads, A., Yu. Khotyaintsev, M. André, R. A. Treumann, Plasma Waves Near Reconnection Sites, in Geospace Electromagnetic Waves and Radiation (Lecture Notes in Physics), 2006.
• Khotyaintsev, Y., A. Vaivads, Y. Ogawa, B. Popielawska, M. André, S. Buchert, P. Décréau, B. Lavraud, H. Rème, Cluster observations of high-frequency waves in the exterior cusp, Ann. Geophys., Vol. 22, pp. 2403-2411, 2004.
• Khotyaintsev, Y ., S. Buchert, K. Stasiewicz, A. Vaivads, S. Savin, V. O. Papitashvili, C. J. Farrugia, B. Popielawska, Y.-K. Tung, Transient reconnection in the cusp during strongly negative IMF By, J. Geophys. Res., Vol. 109, No. A4, A04204, 2004.
• Vaivads, A., Y. Khotyaintsev, M. André, A. Retinò, S. C. Buchert, B. N. Rogers, P. Décréau, G. Paschmann, T. D. Phan, Structure of the Magnetic Reconnection Diffusion Region from Four-Spacecraft Observations, Phys. Rev. Lett., Vol. 93, 105001, 2004.

Curriculum Vitae for **Thomas Neukirch**

Dipl.-Phys. (Bochum) Dr. rer. nat. (Bochum)
Solar Theory Group
School of Mathematics and Statistics
University of St. Andrews, St. Andrews
Fife KY16 9SS, U.K.

Education

February 1987- June 1991 Theoretische Physik IV, Ruhr-Universität Bochum, Dr. rer. nat. in Physics (sehr gut)
March 1986-January 1987 Astronomisches Institut, Ruhr-Universität Bochum, Diplom in Physics (summa cum laude)
October 1980-January 1987 Physics, Fakult¨at f¨ur Physik und Astronomie, Ruhr-Universit¨at Bochum (Vordiplom 1982, sehr gut)

Employment

- since October 2002 Reader in Applied Mathematics, Solar Theory Group, School of Mathematics and Statistics, University of St. Andrews
- October 1997-September 2002 PPARC Advanced Fellow, Solar Theory Group, School of Mathematics and Statistics, University of St. Andrews
    - Awarded a permanent Lecturership (Scale B) in June 1998 (start of contract October 2002)
- January 1995-September 1997 Postdoctoral Research Assistant, Solar Theory Group, School of Mathematical and Computational Sciences, University of St. Andrews
- January 1994-December 1994 ESA Research Fellow, Solar System Division, Space Science Department of ESA, ESTEC, Noordwijk, The Netherlands
- February 1987-December 1993 Wissenschaftlicher Mitarbeiter (Research Assistant), Institut für Theoretische Physik IV, Ruhr-Universit¨at Bochum, Germany
- October 1984-January 1987 Studentischer Mitarbeiter (Undergraduate Assistant), Astronomisches Institut, Ruhr-Universit¨at Bochum, Germany

Research Interests

My general research interests are in the area of plasma theory, in particular space, solar and astrophysical plasmas. I have published about 70 research articles in these areas, of which more than 50 have been published in refereed journals.

Vladimir Semenov

Professor, St.Petersburg State University

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E-mail: sem@geo.phys.spbu.ru

Birth: Feb 20, 1949

Career Summary:

1979 PhD in space physics: Problem of the solar wind flow around the magnetosphere in MHD approximation.

1987 Doctor Degree in space physics: Reconnection theory and solar wind - magnetosphere interaction.

1973 - 1996 research at the Institute of Physics, St.-Petersburg University

1997 professor at the Physical faculty of St.-Petersburg State University

Research themes:

- Space Plasma Physics, Astrophysics, Magnetohydrodynamics, Solar Physics,
- Black holes, Physics of Magnetosphere, Reconnection Theory

Publications: More than 190 in refereed journals

M. I. Pudovkin, and V. S. Semenov. Magnetic Field Reconnection Theory and the Solar Wind - Magnetosphere Interaction: a Review. Space Sci. Rev., vol. 41, pp. 1-89, 1985.

Semenov, V. , S. Dyadechkin, B. Punsly, Simulation of jets driven by black hole rotation, Science, vol. 305, pp. 978-980, 2004.

Semenov, V. S., T. Penz, V. V. Ivanova, V. A. Sergeev, H. K. Biernat, R. Nakamura, M. F. Heyn, I. V. Kubyshkin, and I. B. Ivanov, Reconstruction of the reconnection rate from Cluster measurements: first results, J. Geophys. Res.,Vol.110, A11217, doi: 10.1029/2005JA011181,2005.

Sergeev V., V. Semenov, M.Kubyshkina, V.Ivanova, W.Baumjohann, R.Nakamura, T. Penz, A. Runov, T. L. Zhang, K.-H. Glassmeier, V. Angelopoulos, H. Frey, J.-A. Sauvaud, P. Daly, J. B. Cao, H. Singer, and E. Lucek, Observations of repeated intense near-Earth reconnection on closed field lines with Cluster, Double Star and other spacecraft, Geophys. Res. Lett., vol. 34, L02103, doi:10.1029/2006GL028452, 2007.