March 30th, 2012

Proposed Investigation to the ISSI 2012 call for International Teams in Space Science

Understanding Solar Jets and their Role in Atmospheric Structure and Dynamics

Research Domain: Solar and Heliospheric Physics

Team Members:

Nour-Eddine Raouafi[*] (JHUAPL, USA): X-ray and EUV observations of jets and plumes

Etienne Pariat[*] (LESIA, France): Magnetic field observations; 3D modeling of jets and plumes

Spiros Patsourakos (Univ. Ioannina, Greece): EUV and WL observations

Spiro K. Antiochos (NASA/GSFC, USA): Magnetic fields, 3D modeling of jets, flares and eruptions

Vassilis Archontis (Univ. St-Andrews, UK): 3D modeling of jets & magnetic flux emergence

Edward DeLuca (SAO, USA): Magnetic fields, X-ray and EUV observations

Suguru Kamio (MPS, Germany): EUV spectroscopy and stereoscopic observations of jets

Helen E. Mason (Univ. of Cambridge, UK): EUV and SXR spectroscopy, atomic physics

Fernando Moreno-Insertis (IAC, Spain): 3D modeling of jets and magnetic flux emergence

Masumi Shimojo (Nobeyama/NAOJ, Japan): Magnetic fields, X-ray and EUV observations

Alphonse C. Sterling (NASA/MSCF, USA): Magnetic fields, spicule & jet observations

Tibor Török (PredSci, USA): 3D modeling of jets, eruptions and magnetic flux emergence

[*] Team Leaders

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Abstract

Chromospheric and coronal jets represent important manifestations of ubiquitous solar transients, which may be the source of significant mass and energy input to the upper solar atmosphere and the solar wind. While the energy involved in a jet-like event is smaller than that of "nominal" solar flares and Coronal Mass Ejections (CMEs), jets share many common properties with these major phenomena, in particular, the explosive magnetically driven dynamics. Studies of jets, therefore, can provide critical insight for understanding the larger, more complex drivers of the solar activity. On the other side of the size-spectrum, the study of jets could also supply important clues on the physics of transients close or at the limit of the current spatial resolution such as spicules. Furthermore, the jet phenomenon may be a basic process for heating the corona and accelerating the solar wind; consequently their study gives us the opportunity to attack a broad range of solar-heliospheric problems.

Over the last decade, observations from space (Yohkoh, SOHO, STEREO, Hinode, and SDO) and from ground-based observatories have inspired an ever-growing interest in transients like jets. However, many aspects of these jets remain elusive: discrepancies between observations and models remain unresolved; driving mechanisms have not been clarified; some of their physical properties are at best known for limited samples, etc. Recent discoveries suggest also that different types of small-scale active events (e.g., spicules, EUV- and X-ray jets, bright points, and plumes) may be closely related. However, the exact nature of these inter-relationship(s), the plasma properties, the magnetic structure, and the magnetic topology of these features, as well as their formation process and evolution still remain unclear. The aim of the proposed team is to consolidate and enhance our knowledge on the properties of chromospheric and coronal jets from both observational and modeling points of view.

The objectives of our team include:

1. Advance our understanding of the triggering and driving mechanisms of solar jets;
2. Determine the physical properties and the magnetic set-ups of jets through statistical studies using data from SDO, Hinode, STEREO, IRIS, …;
3. Compare, constrain, and drive numerical models using observational measurements;
4. Study the nature of inter-relationship between jets and other solar structures such as plumes and bright points;
5. Determine their net role in producing and maintaining the observed upper solar atmosphere and solar wind.

Our team has pioneered several of the topics addressed by this proposal. This provides us with a unique perspective in our understanding of the problems and the approaches to resolve them. We have extensive expertise in data analysis and MHD simulations to achieve the objectives of this research.

I. Scientific Rationale

I.1. Introduction

The unceasing improvement in quality of data recorded over the last decade by different space missions (e.g., Yohkoh, SOHO, STEREO, Hinode, and SDO) reveal intense dynamical activity in the solar atmosphere, in particular in the chromosphere and lower solar corona. In particular, jet-like events, i.e. transient collimated mass outflows, are ubiquitous in the solar atmosphere. Such events are present over a wide range of sizes, from the small-scale "spicules" embedded in the solar chromosphere, to features that extend a few solar radii from the solar surface (e.g., jets and plumes). Jets occur in many different environments: coronal holes, active regions, intergranular lanes, and other areas (Shibata *et al.* 2007).

Observations from the Yohkoh Soft X-ray Telescope (SXT) led to the discovery of the largest, most energetic category of these events: the X-ray jets (Shibata *et al.* 1992; Strong *et al.* 1992). Such events present many characteristics shared by standard solar flares – the impulsive nature, the link with intense magnetic fields, strong X-ray emission – and hence are likely to be driven by similar mechanisms. Studies of jets are thus instrumental in improving our understanding of solar activity. Despite the major advances made on both the observational and theoretical fronts, the underlying physical mechanisms, which trigger these events, drive them, and explain their observational properties have not been clarified.

The small-scale magnetic activity with its diverse aspects (e.g., surges, spicules, jets, and plumes) may be a main powering source that sustains the hot corona and the solar wind, particularly in quiet sun and coronal hole regions. The high-occurrence rate of such events may provide a significant mass and energy input to the corona and the solar wind. For instance, Haggerty & Raouafi (in preparation) found evidence for jets as source of significant energetic particle fluxes at 1 AU. The precise mass and energy contributions of jet-like features to the corona and solar wind are not well characterized.

Recent data and modeling progress are very promising in the quest to address the open questions concerning these structures. Our team aims to tackle the most outstanding questions related to the physics of solar jets that are presented hereafter.

I.2. What triggers coronal jets?

As for the triggering mechanism, jets have been observed to form under different conditions: magnetic cancellation, emerging field regions, and locations of photospheric shearing motions (Shimojo *et al.* 1998, Chifor *et al.* 2008). Three-dimensional models of jets triggered by flux emergence (Moreno-Insertis *et al.* 2008, Török *et al.* 2009, Gontikakis *et al.* 2009, Archontis *et al.* 2010) and by shearing motions (Pariat *et al.* 2009, Rachmeler *et al.* 2010) have been developed. However, many of these models are initiated from ideal magnetic configurations, which may lack solar realism.

In active regions the magnetic twist included in the pre-jet structure seems of particular importance. Raouafi *et al.* (2010) studied several X-ray and EUV bright points and found evidence of small-scale sigmoidal structures at the base of jets. Nisticò *et al.* (2009) analyzed a sample of 61 jets and showed that about 50% show helical motions (Shimojo *et al.* 1996, Patsourakos *et al.* 2008). We need to understand how twist is generated and eventually transferred to the jet.

Observations and simulations both show a latency period between the applied forcing at the footpoints on the pre-jet configuration and the actual onset of the jet, likely the start of reconnection. The precise relation between the constraint (e.g., flux emergence, shearing or canceling motions) and the trigger of the jet is another field to be explored. Key parameters of the plasma and magnetic field configurations and boundary conditions leading to the formation of the different classes of jets must be explored to understand their triggering mechanism(s).

I.3. How are coronal jets driven?

Coronal jets occur almost everywhere on the solar disk and are particularly prevalent in coronal holes. They are characterized by their transient nature and often appear as collimated emission beams guided by open magnetic field with outflow velocities ranging from ~100 to ~1000 km s^{-1} (Shimojo *et al.* 2000; Savcheva *et al.* 2007, 2009). Multi-wavelength observations show that jets are complex multi-thermal events whose morphology depends on the observed temperature domain (Chifor *et al.* 2008, Kamio *et al.* 2010). Evidence for an Alfvénic component along with thermal outflow velocities has been revealed (Cirtain *et al.* 2007, Liu *et al.* 2011). Outflows velocities are particularly central as they can discriminate the driving mechanisms that allow the acceleration of jets.

The transient nature of jets and their relation with multipolar magnetic fields (Shimojo *et al.* 1998, 2009) has suggested that magnetic reconnection, as for flares and possibly for CMEs, is the central mechanism involved in the generation of these events. This has been confirmed by numerical simulations (Yokoyama & Shibata 1996, Moreno-Insertis *et al.* 2008, Nishizuka *et al.* 2008, Rachmeler *et al.* 2010). However, three main mechanisms have been put forth to explain the observed outflows: the reconnection jet itself, the evaporation of plasma heated during reconnection, and the driving action of non-linear Alfvénic waves (Shibata *et al.* 1997, Shimojo *et al.* 2001, Pariat *et al.* 2009). These mechanisms are likely to be acting concomitantly, possibly with a different balance depending on the external conditions, and leading to different observational signatures that could explain the diversity of jets. Though, the exact impact of the environment on the driving mechanisms is left to be determined.

Recently, Moore *et al.* (2010) have suggested that some of the jets, referred to as "blowout jets" (which may represent about one third of the jet population), could contain closed magnetic structures, i.e. magnetic flux being ejected. No numerical simulations of jets have yet reproduced such a scenario. One must therefore clarify if blowout jets exist, i.e. represent mini-CMEs involving a complex scenario of magnetic reconnection, or if their observed properties are the consequence of a peculiar distribution of the heated plasma. Synergic comparison of advanced numerical models with detailed observation will be required to address this question.

I.4. How are jets related to other dynamical features of the solar corona?

Coronal jets often occur in conjunction with other phenomena that are also likely due to magnetic reconnection, such as Hα surges (Canfield *et al.* 1996), polar plumes (Raouafi *et al.* 2008), coronal bright points (CBPs) and chromospheric emission (Sterling *et al.* 2010).

CBPs are believed to form through local heating and chromospheric evaporation. The fact that CBPs are associated with photospheric magnetic dipoles (Brosius *et al.* 2008) suggests that these structures are the result of coronal magnetic reconnection. Most coronal jets and plumes are closely related to CBPs (Shimojo *et al.* 2000). Raouafi *et al.* (2010) used Hinode/XRT and EIS, and STEREO/EUVI observations to show that the structure of bright points is more complex than simple bipolar regions. They showed examples of small-scale sigmoids as the source of multiple jets and argue that these sigmoidal structures may be the source of helicity in jets. It is thus important to constrain the key parameters (densities, temperatures, bulk and non-thermal velocities, etc.) in CBPs, which are potential sources of jet activity.

Coronal plumes are quiescent, hazy features, which are particularly prevalent at the solar poles. They can also appear as spike-like or sheet-like structures (Wang *et al.* 1997) and are visible in white light, in EUV, and also in soft X-rays. Spectroscopic studies show evidence for plumes to be denser and cooler than the background coronal holes (inter-plume regions; see Wilhelm 2006). The relation of polar plumes to coronal jets remained unclear until recently. Raouafi *et al.* (2008) have shown evidence for jets as precursors of plumes and suggested that jets may be the source of disturbances observed in plumes. The sample of this study concerns 28 events. Pariat *et al.* (2010) showed that two regimes of reconnection could be present during the jet and before/after the event. This could possibly explain the tight link between jets and plumes. In any case the jet-plume relationship must be investigated through larger data samples and more realistic theoretical modeling. This would constrain the processes leading to the formation and evolution of jets and plumes and their mass and energy inputs to the corona and the solar wind.

Finally, at smaller-scales, there are different classes of chromospheric jet activity (e.g., Hα-surges, Hα- and EUV-macrospicules, spicules). Most of these features have similar morphology and may share common properties with larger coronal jets. However, most of these events are eruptions of cool material that are followed by down-flows. It remains to be explained how these structures are formed and to which extent their generation mechanism is similar to coronal jets. Large-scale coronal jets have a significant chromospheric emission, which appears as jetting structures (Sterling *et al.* 2010, Liu *et al.* 2011). Models have shown that within the course of reconnection both hot and cold ejecta could be generated simultaneously (Nishizuka *et al.* 2008). The exact relationship between the transient chromospheric and coronal large-scale activities needs to be explored in more detail.

II. The Objectives of the Project

Despite the present observational evidence and the noticeable progress made in numerical simulations of coronal jets, there are still many aspects of both approaches that require further study: mechanisms of formation and evolution of jets, their relationship with other structures (e.g., spicules, plumes), and their mass and energy input to the corona and the solar wind. It is important to constrain the key parameters (magnetic field configuration, densities, temperatures, velocities, waves, etc.) in jets and their related phenomena (plumes, CBPs, chromospheric emission). This can be achieved through multi-temperature diagnostics of Hinode/EIS, SDO/AIA observations, and the future IRIS that will launch on December 1st, 2012. We expect to use the available instrumental capabilities to extract most of these parameters.

This information will be the building elements to develop more realistic theoretical and numerical models of jets. To gain more realism, models of jets must be based on configuration/set-ups that are as close as possible to the observations. Key parameters of the plasma and magnetic field configurations will be used as initial and boundary conditions for improved models of jets. Many current simulations are too simple in their treatment of the underling physics. The outputs of numerical simulation may not be directly comparable to observable data. Interplay between observations and models is necessary to define the key ingredients. Observers and modelers in our team will collaborate closely to benefit from each other expertise and achieve the goal of the project: understanding solar jets and their role in atmospheric structure and dynamics.

To focus on the generation mechanism, our team of experts will exploit the outstanding observations that are now available and state-of-the-art numerical models to address the key questions listed below. In addition to the existing data, we plan to design new observational programs when needed (particularly spectral data of jets) and execute improved numerical simulations. New observations can be designed through interactions between observers and modelers in order to determine the plasma key parameters and the "magnetic" configurations needed to bring more realism to models. Hinode/EIS and IRIS will be instrumental in gathering spectroscopic data to determine plasma properties of jets such as densities, velocities, temperatures, etc. We expect to learn a great deal about the magnetic configurations of jets through the high cadence magnetograms from SDO/HMI and also Hinode/SOT (see Moreno-Insertis *et al.* 2008). Jet topological aspects and their relationship with other structures will be characterized using multi-instrument observations: Hinode/XRT, SDO/AIA, STEREO/EUVI, -COR1 and -COR2). We plan to assemble a decent statistical sample (few dozen for small FOV instruments , i.e. EIS and IRIS, and several dozen for full disk coverage by AIA and SECCHI) of jets from spectroscopic and imaging observations. We expect that detailed analysis of diverse types of observations together with state-of-the-art numerical simulations will allow us address the following outstanding questions:

1. Advance our understanding of the triggering and driving mechanisms of solar jets;
2. Determine the physical properties and magnetic set-ups of jets through statistical studies using data from SDO, Hinode, STEREO, IRIS, and other sources;
3. Study the nature of the inter-relationship between jets and other structures such as plumes and bright points;
4. Determine their combined role in producing the observed upper solar atmosphere and solar wind.
5. Make progress on constraining the energy balance in jets.

The output of observations will be used to compare, constrain, and drive analytical and numerical models developed and used by several of the team members. Numerical models will benefit from the input of the observations to improve their boundary and initial conditions and to derive meaningful quantities that can be directly tested against observational data.

This will allow us to advance our understanding of the triggering and driving mechanisms of jets. The objective is to foster close collaborations between observers and modelers. This will help us to identify key problems and ways to address them. The ISSI environment is an ideal setting for close interaction between members of small teams.

III. Timeliness of the Project

Prior to the Hinode and SDO era the quality of solar observations in both terms of temporal and spatial resolution was not sufficient to study in depth the formation and evolution of solar jets. It was not possible to acquire near-simultaneous, multi-wavelength, high-resolution observations. We believe that these obstacles can now be alleviated thanks to the unprecedented spectral and imaging data and the temperature coverage allowed by the current generation of space missions enable us to provide insights into the mechanisms of formation and evolution of jets. Spectral and imaging observations will allows us to provide important constraints for the different theoretical models of jets that witnessed great popularity in the last few years. Advances in numerical modeling and computer technology allowed the recent development of more complex, 3D models of jets over the recent years and an important number of papers have been published on this topic from different international teams.

NASA's Living With a Star Targeted Research and Technology (LWS/TR&T) has a running program on the focused science topic: "Jets in the Solar Atmosphere and their Effects in the Heliosphere." Two members of our team are proposal PIs in the TR&T program (i.e., E. DeLuca [*team leader*] and A. Sterling). We believe that the present ISSI project would be an appropriate complementary approach to the NASA LWS program.

The proposing team is composed of international experts in different studies of diverse type of solar jets (e.g., spicules, jets, plumes, etc.) and theoreticians who developed different approaches to explain different observational aspects of jets. Indeed the theorists of our team are working on every proposed main-stream jet model. Some members of the team are highly involved in the different space missions (e.g., Hinode, STEREO, SDO, IRIS, etc.) and have broad expertise in multi-wavelength data. This will help with planning new observational programs when needed.

The actual project will allow a close interaction and collaboration between observers and theoreticians, which will enable important progress in our understanding of coronal jets.

IV. Expected Output

The proposed project is motivated by the recent advances at both observational and theoretical ends in understanding the formation and evolution of coronal jets together with their relationship to other structures like chromospheric spicules and coronal plumes. Several aspects of jets, including discrepancies between observations and models, need to be addressed, taking advantage of the availability of high-quality data and models. In addition, the solar conditions over the last few years have favored the study of small-scale solar activity. The properties of the source regions of jets are not well known, nor their mass and energy input to the corona and the solar wind. We plan to foster close collaborations between experts (both observers and modelers) working on coronal jets to elucidate the conditions and processes of formation of the different classes of coronal jets and their relationship with other coronal structures. The objective is to address existing questions concerning the physical properties of jets through statistical studies using data from SDO, Hinode, STEREO, IRIS, and other sources; compare, constrain, and drive analytical and numerical models using observational measurements; advance our understanding of the triggering and driving mechanisms of jets; study the nature of inter-relationships between jets and other structures such as plumes and bright points; and determine their combined role in producing the observed upper solar atmosphere and solar wind.

The results from existing collaborations between members of the team and new collaborations that will be established during the meeting will result in several peer-reviewed papers. We also expect to publish the first comprehensive review paper on the nature of jets and related coronal structures, which will summarize our present understanding on this topic.

V. Added Value from ISSI for the Implementation of the Project

We believe that the International Space Science Institute (ISSI) provides an excellent working environment for small groups of experts to concentrate on a well-defined project and to discuss and confront their results, views, and theories. Most of our team members have participated in previous ISSI teams and appreciate the importance of the ISSI environment allowing for small group of experts with common interests to make significant progress on a focused topic and to foster fruitful collaborations.

VI. Schedule

We plan two meetings with 4 to 5 day durations at ISSI within 12 months from the date of the first meeting:

Meeting 1: Dec. 2012 - Feb. 2013 ***Meeting 2:*** Sep. - Dec. 2013

VII. Facilities Required

The standard ISSI workshop facilities are required, i.e. a meeting room for 15 people (12 team members and 3 students), equipped with data projection facilities, wireless internet access and some limited printing facilities. We expect that most team members will use their own laptop computers.

VIII. Financial Requirements

The standard support, i.e. per diem and lodging, for 12 team members is required two times for 5 days, as well as travel support for one of the team leaders.

IX. References

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X. Team Relevant Expertise

The proposing team is composed of international members with extensive expertise in diverse type of studies of jets in the solar atmosphere. This team will enable a synergistic collaboration between observers (spectroscopy, imaging, image processing, etc.) and modelers (3D numerical simulations, theory of magnetic reconnection, etc.). Our team will also include two or three young scientists and will invite outside experts as guests when needed.

Members of the proposed team are involved in different space missions:

- **N.-E. Raouafi:** member of SDO/FFT team;
- **E. DeLuca:** US PI Hinode/XRT, Co-I on SDO/AIA, Co-I on IRIS, and member of SDO/FFT team; SAO project scientist on IRIS (Launch Dec 2012).
- **H. E. Mason:** member of the Science Team for Hinode/EIS;
- **S. Patsourakos:** Co-I of the SECCHI coronal suite of instruments for the STEREO mission;
- **M. Shimojo:** member of the Hinode/XRT and the Nobeyama Radioheliograph teams;
- **A. C. Sterling:** NASA Chief Planner for the Hinode satellite mission.

Annex: Curricula

Dr. Nour-Eddine RAOUAFI

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Dr. Raouafi contributed to different research topics in solar physics. He studied on the plasma dynamic properties in the coronal holes (fast solar wind) and polar plumes through spectroscopy. He also worked on the relationship between coronal jets and plumes and the roles played by X-ray and EUV jets in driving the formation and evolution of coronal plumes. He also studied the structure of bright points that are sources of coronal jets.

In addition, Dr. Raouafi has interest in several other research topics such as the coronal polarimetry and the measurement of the coronal magnetic field, solar magnetic fields, CMEs and coronal shock waves, and coronal spectroscopy. Since he joined the JHUAPL he is a member of the Science Team of the Solar Probe Plus and a member of the Solar Dynamic Observatory Feature Finding Team (SDO/FFT).

Education

2000 Ph.D., University of Paris XI, Orsay, France
1997 Master in Astrophysics, University Paul Sabatier, Toulouse, France
1996 Master in Fundamental Physics, University Tunis II, Tunisia

Selected Publications

- Wilhelm, K. et al., "*Morphology, dynamics and plasma parameters of plumes and inter-plume regions in solar coronal holes*," ARA&A, 2011, in press
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Born 1980 July 5 in Paris, France

Dr. Pariat has 8 years experience in solar physics. His fields of expertise include theoretical and observational solar physics. His work consists primarily of coupling theoretical models with observations. It relies heavily on magnetohydrodynamic (MHD) theory, on large-scale numerical simulations and on the exploitation of the latest spectroscopic and spectropolarimetric observations.

Positions Held

Since 10/2009	CNRS Research scientist (CR2), LESIA, Meudon, France
12/2006 - 10/2009	Research Assistant, George Mason University, Fairfax, USA
09/2004 - 11/2006	Research and Teaching Assistant, Universities Paris 6 & 7, France

Education

09/2006	PhD Thesis *"Injection of magnetic energy and helicity in the solar atmosphere",* Université Paris 7 – Denis Diderot, Paris, France
07/2003	Master, Astrophysics and associated methods, U. D. Diderot, Paris, France

Awards

12/2010	Recipients of the CNRS *"Prime à l'excellence scientifique".*

Relevant Publications

- Masson, S., Aulanier, G., Pariat, E., & Klein K.-L.; *"Interchange Slip-Running Reconnection and Sweeping SEP Beams",* Solar Physics, 276, 199, 2012
- Rachmeler, L., Pariat, E., DeForest, C., Antiochos, S. K., & Török T; "*Symmetric coronal jets: a reconnection-controlled study*," ApJ, 715, 1556, 2010
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Curriculum Vitae

Diploma, Department of Physics, University of Thessaloniki, Greece (1996)
Master in Plasma Physics, University Paris XI, France (1997)
Doctorate (Ph.D.), University Paris XI, France (2000)
2000-2001 Post Doctoral Research Assistant, MSSL, University College of London, UK
2001-2009 Research Professor, George Mason University, USA
Presently: Assistant Professor, Department of Physics, University of Ioannina, Greece

Professional

Dr. Patsourakos has more than 10 years of experience in Solar Physics. His research interests include coronal heating and structuring, Coronal Mass Ejections and Flares and Space Weather. He has extensive experience in data analysis of multiwavelength data from a series of space-borne instruments: OSO8; SUMER, CDS, EIT and LASCO on SOHO; TRACE; SXT on YOHKOH; SXI on GOES12; EIS and XRT on Hinode; SECCHI on STEREO, AIA on SDO as well from the VAULT suborbital rocket experiment. He served as scientific planner of the operations of the SUMER and CDS instruments on SOHO during several intervals in the period 1997-2001. He participated in assessment studies for various instruments on future missions like Solar-Probe, Solar-Orbiter and Hinode. He is presently:

- Co-I of the SECCHI coronal suite of instruments for the STEREO mission.
- Guest Investigator of the SWAP instrument of the PROBAII mission.
- Scientific collaborator of the ASPIICS coronagraph on-board the PROBAIII mission.

Relevant Publications

- Patsourakos, S., Pariat, E., Vourlidas, A., Antiochos, S., & Wülser, J.-P., "*STEREO SECCHI Stereoscopic Observations Constraining the Initiation of Polar Coronal Jets*," ApJ, 680, 73, 2008
- Nistico, G., Bothmer, V., S. Patsourakos, & Zimbardo, G., "*Characteristics of EUV Coronal Jets Observed with STEREO/SECCHI*," Sol. Phys., 259, 87, 2009
- Nistico, G., Bothmer, V., S. Patsourakos, Zimbardo, G., "*Observational features of equatorial coronal hole jets*," Annales Geophysicae, 28, 687, 2010
- Podladchikova, O., Vourlidas, A., Van der Linden, R.A., Wülser, J.P., & Patsourakos, S., "*Extreme Ultraviolet Observations and Analysis of Micro-Eruptions and Their Associated Coronal Waves*," ApJ, 709, 369, 2010

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BA McGill University, 1970
PhD Stanford University, 1976

Biography

Since January 2008, Dr. Antiochos has been a senior scientist in the Heliophysics Division of NASA GSFC. Since January 2003, Dr. Antiochos has also been an Adjunct Professor in the Department of Atmospheric, Oceanic, and Space Sciences at the University of Michigan. His fields of expertise include theoretical solar physics and plasma physics. His work consists primarily of developing theoretical models to explain observations, and relies heavily on magnetohydrodynamic (MHD) theory, especially nonlinear equilibria and instabilities, and on large-scale numerical simulations. During his career he has worked on a number of problems related to the Sun and Heliosphere, in particular, the physics of magnetic driven activity and heating, and the structure of the solar corona and transition region. Some of his most widely recognized contributions are his work on cool loop models for the transition region, on the thermal nonequilibrium model for coronal condensations, on the 3D sheared arcade model of prominence magnetic fields, and on the “breakout” model for coronal mass ejections and eruptive flares.

From June 1985 – December 2007, Dr. Antiochos was an Astrophysicist in the Space Science Division of NRL. From April 1980 – June 1985, Dr. Antiochos was a Senior Research Associate at the Center for Space Science and Astrophysics at Stanford University. From May 1978 – April 1980, Dr. Antiochos was a Research Associate at the Institute for Plasma Research at Stanford University. From October 1976 – April 1978, Dr. Antiochos held a Skylab Post-Doctoral Fellowship with the National Center for Atmospheric Research in Boulder Colorado.

Dr. Antiochos is a member of the American Geophysical Union (AGU), the American Astronomical Society (AAS), the American Physical Society, and the International Astronomical Union. He has served on many advisory/review committees including Chair of the Solar Physics Division of the AAS, Chair of the NASA Solar Management and Operations Working Group, Chair of the SOLAR-B Science Definition Team, and member of the Space Studies Board of the National Research Council. Dr. Antiochos has been elected Fellow of the AGU and the APS and Honorary Fellow of the Royal Astronomical Society, and has been awarded the George Ellery Hale Prize by the AAS and the E. O. Hulburt award by NRL.

Selected Bibliography

- J. T. Karpen, C. R. DeVore, and S. K. Antiochos, “*Reconnection onset and eruption takeoff in the breakout model for coronal mass ejections*,” ApJ, 2011, submitted
- S. K. Antiochos, Z. Mikić, R. Lionello, V. S. Titov, and J. A. Linker, “*A model for the sources of the slow solar wind*,” ApJ, 2011, in press
- J. K. Edmondson, S. K. Antiochos, C. R. DeVore, and T. H. Zurbuchen, “*Formation and dynamics of three-dimensional current sheets in the solar corona*,” ApJ, 718, 72, 2010
- E. Pariat, S. K. Antiochos, and C. R. DeVore, “*Three-dimensional modeling of quasi-homologous solar jets*,” ApJ, 714, 762, 2010

Dr. Vassilis ARCHONTIS

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Research interests

Solar Physics, Numerical Astrophysics, MHD

Education – Employment

1992--1996	Physics degree, Aristotle University of Thessaloniki, Greece.
1997--1999	PhD in Astrophysics, Niels Bohr Institute, Denmark (Marie Curie Fellow).
2000 -- 2002	Career-break: military service, Greece.
2002--2005	Post-doc, Instituto de Astrofisica de Canarias, IAC, Tenerife.
2006--2011	Post-doc, Mathematical Institute, University of St. Andrews.
2011	Royal Society Research Fellow (URF).

Research experience and professional activities (selected)

- Leading the research project '*Flux emergence: numerical simulations and analytical models*', funded by the STFC, UK. Mathematical Institute, St Andrews University (2007 – 2011).
- Leading the research project '*Discovering the nature of outstanding aspects of the solar magnetic activity',* awarded by the Royal Society (2011-2016).
- Serving in the SOC and LOC of international scientific meetings and workshops.
- Serving in the NASA 'Solar and Heliospheric' peer review panel committee.
- Serving in PhD panel committees as an external examiner.
- Member of the Greek Astronomical Society, International Astronomical Union, Royal Astronomical Society, Royal Society.

Recent publications (selected)

- **Archontis, V.**; Hood, A., ``Magnetic flux emergence: a precursor of solar plasma expulsion", A&A V537, A62, (2012).
- Harra, L.; **Archontis, V.**; Pedram, E.; Hood, A.; Shelton, D.; van Driel-Gesztelyi, L.,``The creation of outflowing plasma in the corona at emerging flux regions: comparing observations and simulations", Solar Physics (2011).
- **Archontis, V.**; Tsinganos, K., Gontikakis, C., ``Recurrent solar jets in active regions", A&A, 512L, 2A (2010).
- Gontikakis, C., **Archontis, V.**; Tsinganos, K., ``Observations and 3D MHD simulations of a solar active region jet", A&A, 506L, 45G (2009).

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EDUCATION
Ph.D. Astrophysics, 1986, *University of Colorado, Boulder, CO*
B.A. Astronomy, 1979, *Wesleyan University, Middletown, CT*

APPOINTMENT Smithsonian Astrophysical Observatory, Cambridge, MA

Senior Astrophysicist	2012 - present

PREVIOUS APPOINTMENTS

SAO, Cambridge, MA - Supervisory Astrophysicist	2006 - 2012
SAO, Cambridge, MA - Astrophysicist	1993 - 2006
IfA, University of Hawaii, Honolulu, HI - Astronomer	1990 - 1993
Dept. of Astronomy, University of Chicago, Chicago, IL - Postdoc	1987 - 1990
ASP, NCAR, Boulder, CO - Postdoctoral	1986 - 1987

COMMITTEES & HONORS

Hinode Science Working Group	2005 - present
LWS Targeted Research & Technology Steering Committee	2010 - 2011
Solar-C International Sub-Working Group Co-Chair for NGXT	2009 - 2011
NASA Advisory Council Heliophysics Sub-Committee	2006 - 2010
American Astronomical Society Solar Physics Division Chair	2003 - 2006
NASA Sun-Earth Connection Roadmap Team	2002
Compton Lecturer, University of Chicago	Spring 1989

RESEARCH INTERESTS

Theory of magnetic field generation in the Sun and stars; coronal heating via magnetic reconnection and MHD turbulence; magnetic flux emergence in the Sun and stars; the nature and origin of coronal fine structure; state-of-the-art X-Ray and EUV instrumentation.

MANAGEMENT EXPERIENCE

US PI Hinode X-Ray Telescope (XRT). Hinode is a strategic solar mission in low earth orbit. It is an international collaboration between the US, Japan, UK and Norway. The XRT team includes scientists from nine different institutions in the US and Japan.

Co-I, Project Scientist pre-launch, Solar Dynamics Observatory (SDO) Atmospheric Imaging Array (AIA), NASA strategic mission. SDO launched in February 2010. Responsible for developing the testing program for entrance filters, SAO representative to the science working group, helped define the fundamental science questions that would be addressed by the mission. Helped to secure the SAO archive of SDO data.

Co-I, Project Scientist Interface Region Imaging Spectrograph, NASA Small Explorer. SAO has built the UV telescope feed for the spectrograph. Will help define the science goals for this mission. Will help develop the Mission Operations and Data Analysis (MODA) plans. Will organize the SAO contributions to science and operations.

Co-I SAO Project Scientist, Transition Region and Coronal Explorer, NASA Small Explorer. Responsible for entrance filter testing and installation, helped define the science goals for the missions, trained and organized the telescope operators, helped lead the science working group. TRACE images are still highest resolution images ever made of the solar corona.

RESEARCH GRANTS

PI & Team Leader Living with a Start Focus Science Topic - Jets & Plumes in the Solar Atmosphere. A four year research effort starting Fall 2011. NASA HQ requested that I lead a group of five independently funded groups to study physical processes that form jets and plumes in the chromosphere and corona. (2011 - 2015)

PI Non-Potential Structure of Active Regions, NASA Grant. A four year research effort has resulted in the most accurate magnetic models of active regions. (2007 - 2010)

PI Influence of Coronal Abundance Variations, NASA Grant. A three year research project exploring the relationship between the variable solar coronal abundances and imaging in narrow EUV and broad X-Ray passbands. (2005 - 2009)

Dr. Helen E. MASON

ASSISTANT DIRECTOR OF RESEARCH
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Centre for Mathematical Studies, Wilberforce Road,
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Nationality: British

Summary of Research Activities

My group has a very high international reputation in the field of solar physics with particular expertise in the field of Ultraviolet (UV) and X-ray spectroscopy. Over the past three decades, I have been involved in many other solar space projects: Skylab, Solar Maximum Mission, Spacelab, YOHKOH and SoHO. I am a member of the Science Team for the EUV Imaging Spectrometer (EIS) on Hinode. My group has produced many publications (first results, letters and other journal papers) on EIS data. Our work has focussed mainly on the nature of active regions, small flares, jets and micro-flares which can trigger filament eruptions. Hinode is providing some fascinating new results. We are combining observations from Hinode with those from other solar space observatories, TRACE, Stereo and more recently the Solar Dynamics Observatory, SDO. I am a founder member of the CHIANTI team - an atomic database for the analysis of astrophysical spectra. CHIANTI is now widely used by the solar physics communities (with over 1500 citations). In my group, we take an integrated approach to modelling solar physics phenomena, by linking our own theoretical models with atomic physics models (CHIANTI) to predict the observational characteristics of UV and X-ray spectra, for various instruments.

Publications and Presentations

My publication list is extensive (with over 120 papers in refereed journals), including several (20) invited reviews on spectroscopic diagnostics in the UV for solar and stellar plasmas. Two of my scientific papers have featured in the international press. A recent sample below.

- O'Dwyer, B., Del Zanna, G., Mason, H. E., Sterling, A. C., Tripathi, D., & Young, P. R., "*Hinode/EIS observation of a limb active region*," A&A, 525, 137, 2011
- Tripathi, D., H. E. Mason, H. E., & Klimchuk, J. A., "*Evidence of Impulsive Heating in Active Region Core Loops*," ApJ, 723, 713, 2010
- Dere, K. P., Landi, E., Young, P. R., Del Zanna, G., Landini, M., & Mason, H. E., "*CHIANTI: IX. Ionization rates, recombination rates, ionization equilibria for the elements hydrogen through zinc and updated atomic data*," A&A, 498, 915, 2009
- Del Zanna, G., Mitra-Kraev, U., Bradshaw, S. J., Mason, H. E., & Asai, A., "*The 22 May 2007 B-class flare: new insights from Hinode observations*," A&A, 526, 1, 2001

University Degrees

1970: **B.Sc**. (1st class, Honours), Queen Mary College, London.
1973: **Ph.D**. Atomic and Astrophysics, University College, London.
1978: **M.A**. (honorary) University of Cambridge

Other Academic Activities and Awards

- Fellow and Senior Tutor, St Edmund's College
- Taught for Cambridge University and the Open University
- Supervised 5 graduate students
- Engaged in many outreach activities and created the Sun|trek website
- Women of Outstanding Achievements, 2010

Dr. Suguru KAMIO

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Personal Information

Date of birth: 22 June 1976
Nationality: Japan

Career History

- Postdoctoral Fellow at MPS (2008 – present)
  Experimental study of the solar corona using UV spectrum recorded by Hinode/EIS and SOHO/SUMER
- Postdoctoral Fellow at Hinode Science Center, NAOJ (2006 – 2008)
  Conducting scientific operation and data analysis of Hinode spacecraft

Education

- *Ph.D. in Astrophysics* (2006)
  Thesis: "Spectroscopic study of dynamic phenomena in the solar atmosphere"
  Graduate School of Science, Kyoto University, Japan
- *Master of Science in Astrophysics* (2003)
  Thesis: "The temporal evolution of blue-shifted H® grains"
  Graduate School of Science, Kyoto University, Japan
- *Bachelor of Science* (2001)
  Department of Science, Kyoto University, Japan

Invited Talks

- The Fifth Hinode Science meeting in Boston, USA (2011)
  "*Quantitative study of microflares*"
- The Second Hinode Science Meeting in Boulder, USA (2008)
  "*Outflows from the Sun*"

Professional Services

- Contributions to EIS Science Nugget
  "*Temporal evolution of microflares in bright points*" (2011)
  "*Preparing EIS data with neural networks*" (2010)
- Peer review: The Astrophysical Journal
- Peer review: Solar Physics

Publication List

Available at: http://www.mps.mpg.de/homes/kamio/publications/

Dr. Fernando MORENO-INSERTIS

Professor of Astrophysics
Coordinator of the Solaire European Network (www.solairenetwork.eu)
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and Dept of Astrophysics, Univ La Laguna
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Current Position

Full Professor of Astrophysics at University of La Laguna (Tenerife, Spain) and Associate Senior Research Scientist at Instituto de Astrofisica de Canarias (Tenerife)

Doctorate

Max-Planck-Institut für Astrophysik (Munich, Germany).
DOCTOR DEGREE: University of Munich, March 1984.

Research Fields

Theoretical and Computational Astrophysics, Fluid Dynamics and Plasma physics, Solar Physics

Management of European Projects

General Coordinator of the SOLAIRE European Network, financed by the European Commission (June 2007-May 2011), with 13 participating institutions and about 170 researchers.
Team leader at the IAC of the European Research Training Network PLATON, financed by the European Commission (4 years)

Other Management and Advisory Positions held in the past

- Member of the Board of Directors of the scientific journal Astronomy & Astrophysics
- Scientific Advisory Committee of the Kiepenheuer-Institut, Freiburg
- Director of the Department of Astrophysics at University of La Laguna
- Head of the Postgraduate Studies Division of the Instituto de Astrofisica de Canarias
- Member of the Director's Board at the Instituto de Astrofisica de Canarias
- Member of the Board of the Opticon Consortium
- Steering Committee of the Spanish Astronomical Society
- Commission of the International Union for Pure and Applied Physics
- Commission of the International Astronomical Union

Publications

More than 100 scientific publications (40 of them as first author), with 1800 citations.

Dr. Masumi SHIMOJO

Assistant Professor
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Professional Experience

2000-Assistant Professor, Nobeyama Solar Radio Observatory,
National Astronomical Observatory of Japan, NINS
1999 Postdoctoral Fellow, YOHKOH Satellite Project,
Institute of Space and Astronautical Science, JAXA

Education

1999 Ph.D. in Astrophysics, The Graduate University for Advanced Studies (NAOJ), Japan. The title of the doctor thesis is "Studies of Solar X-ray Jets".
1996 M.S. in Physics, Tokai University, Japan
1994 B.S. in Physics, Tokai University, Japan

Recent Publication (Refereed Paper)

- Shimojo, M. & Tsuneta S., "*The Relation Between Magnetic Fields and Coronal Activities in the Polar Coronal Hole*," ApJ, 706, L145, 2009
- Shimojo, M. et al., "*Fine Structures of Solar X-Ray Jets Observed with the X-Ray Telescope aboard Hinode*," PASJ, 59, 745, 2007
- Shimojo, M. et al., "*One Solar-Cycle Observations of Prominence Activities Using the Nobeyama Radioheliograph 1992-2004*," PASJ, 58, 85, 2006
- Shimojo, M. et al., "*One-dimensional and Pseudo-Two-dimensional Hydrodynamic Simulations of Solar X-Ray Jets*," ApJ, 550, 1051, 2001
- Shimojo, M. & Shibata K., "*Physical Parameters of Solar X-Ray Jets*," ApJ, 542, 1100, 2000

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Among Dr. Sterling's current interests is a better understanding of the nature and cause of dynamic solar fine structures such as spicules and chromospheric jets, and also larger-scale solar eruptions and CMEs. He has studied these features extensively, both theoretically using numerical simulations, and observationally using data from ground- and space-based instruments. Currently he is in Japan, where in addition to continuing his research, he is also NASA's Chief Planner for the Hinode solar-observing satellite mission.

Education

January 1988. Doctor of Philosophy, Physics, University of New Hampshire,
NASA Graduate Student Researchers Fellowship (1985 -1987).
Thesis: "Dynamics of the Solar Atmosphere: Spicules and Fibrils." Thesis Advisor: Dr. Joseph V. Hollweg.
June 1981. Bachelor of Science, Physics, California Institute of Technology.

Employment

January 2007 - Present: Astrophysicist and NASA Chief Planner for Hinode satellite, NASA/JAPAN, and NASA/MSFC.
April 2004 - present: Astrophysicist, NASA/MSFC.
September 2001-April 2004: Senior Staff Scientist, United Applied Technologies, Inc. (UAT). Contracted out to NASA/MSFC. Posted in Japan for to work with the Solar-B satellite.
September 1999-September 2001: National Research Council Senior Fellow, NASA/MSFC.
January 1991-September 1999: Research Physicist, Computational Physics Inc., Fairfax, VA. Contracted out to the Naval Research Laboratory (NRL), Washington, DC., to work with the Yohkoh solar satellite. Posted in Japan for most of the period.
January 1989 - January 1991: Japan Society for the Promotion of Science Postdoctoral Research Fellow, Kyoto University, Kyoto, Japan.
January 1988 - January 1989: National Research Council Postdoctoral Fellow, Naval Research Laboratory, Washington, DC.

Professional Affiliations

July 2003-June 2008: Honorary Professor, Univ. College London, Department of Space and Climate Physics.
Ongoing: Member, American Astronomical Society

Selected Publications

- Pasachoff, J. M., Tingle, E. D., Dammasch, I. E., & Sterling, A. C., "*Simultaneous Observations of the Chromosphere with TRACE and SUMER*," Sol. Phys., 268, 151, 2011
- Sterling, A. C., Harra, L. K., & Moore, R. L., "*Fibrillar Chromospheric Spicule-like Counterparts to an Extreme-ultraviolet and Soft X-ray Blowout Coronal Jet*," ApJ, 722, 1644, 2010
- Moore, R. L., Cirtain, J. W., Sterling, A. C., & Falconer, D. A., "*Dichotomy of Solar Coronal Jets: Standard Jets and Blowout Jets*," ApJ, 720, 757, 2010
- Sterling, A. C., Moore, R. L., & DeForest, C. E., "*Hinode Solar Optical Telescope Observations of the Source Regions and Evolution of "Type II" Spicules at the Solar Polar Limb*," ApJ, 714, 1, 2010
- Pasachoff, J. M., Jacobson, W. A., & Sterling, A. C., "*Limb Spicules from the Ground and from Space*," Sol. Phys., 260, 59, 2009
- Sterling, A. C., "*Solar Spicules: A Review of Recent Models and Targets for Future Observations*," Sol. Phys., 196, 79, 2000 - (Invited Review)
- Sterling, A. C., "*Alfvenic Resonances on Ultraviolet Spicules*," ApJ, 508, 916, 1998
- Sterling, A. C., Shibata, K., & Mariska, J. T., "*Solar Chromospheric and Transition Region Response to Energy Deposition in the Middle and Upper Chromosphere*," ApJ, 407, 778, 1993
- Sterling, A. C., & Mariska, J. T., "*Numerical Simulations of the Rebound Shock Model for Solar Spicules*," ApJ, 349, 647, 1990
- Sterling, A. C., & Hollweg, J. V., "*A Rebound Shock Mechanism for Solar Fibrils*," ApJ, 343, 985, 1989

Dr. Tibor TÖRÖK

Research Scientist
Predictive Science, Inc.
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San Diego, CA 92121, USA
Tel: +1- 858-450-9504
E-mail: tibor@predsci.com

Education

University of Potsdam, Germany: Ph.D. (magna cum laude), 2004, Astrophysics.
Humboldt University Berlin, Germany: Diploma, 1999, Physics.

Experience and Appointments

Dr. Tibor Török is a research scientist at Predictive Science Incorporated (PSI), an employee-owned science and technology company. He has more than ten years of experience in the development and application of magnetohydrodynamic (MHD) simulations to problems in solar and plasma physics. Dr. Török started his Ph.D. thesis in 2000, working on MHD simulations of flux rope instabilities in solar eruptions. After receiving his Ph.D. degree, he joined the Mullard Space Science Laboratory (University College London, United Kingdom), where he spent three years as a postdoctoral researcher, funded by PPARC. In 2007, Dr. Török joined the Paris Observatory, France, where he worked until 2010, funded by the European research networks SOLAIRE and SOTERIA. During these two employments, he continued working on flux rope instabilities and the modeling of solar eruptions, and he extended his research to other dynamic solar phenomena, as for example magnetic flux emergence and coronal jets. In 2010, Dr. Török joined PSI, where he now mostly works on the numerical modeling of solar coronal mass ejections and their propagation through interplanetary space.

Selected Publications

- Török, T., R. Chandra, E. Pariat, P. Démoulin, B. Schmieder, G. Aulanier, M. G. Linton, & C. H. Mandrini, "*Filament interaction modeled by flux rope reconnection*," ApJ, 728, 65, 2011
- Török, T., Berger, M. A., & Kliem, B., "The writhe of helical structures in the solar corona," A&A, 516, A49, 2010
- Aulanier, G., T. Török, P. Démoulin, & E. E. DeLuca, "*Formation of torus-unstable flux ropes and electric currents in erupting sigmoids*," ApJ, 708, 314, 2010
- Török, T., G. Aulanier, B. Schmieder, K. K. Reeves, & L. Golub, "*Fan-spine topology formation through two-step reconnection driven by twisted flux emergence*," ApJ, 704, 485, 2009
- Török, T. & Kliem, B., "*Numerical simulations of fast and slow coronal mass ejections*," AN, 328, 743, 2007
- Kliem, B. & T. Török, "*Torus Instability*," PRL, 96, 255002, 2006
- Török, T. & Kliem, B., "*Confined and ejective eruptions of kink-unstable flux ropes*," ApJ, 630, L97, 2005
- Williams, D. R., T. Török, P. Démoulin, L. van Driel-Gesztelyi, & Kliem, B., "*Eruption of a kink-unstable filament in NOAA active region 10696*," ApJ, 628, L163, 2005
- Török, T., Kliem, B., & V. S. Titov, "*Ideal kink instability of a magnetic loop equilibrium*," A&A, 413, L27, 2004
- Kliem, B., V. S. Titov, & T. Török, "*Formation of current sheets and sigmoidal structure by the kink instability of a magnetic loop*," A&A, 413, L23, 2004
- Török, T. & Kliem, B., "*The evolution of twisting coronal magnetic flux tubes*," A&A, 406, 1043, 2003