Proposal for an ISSI Team Project

Dispersive cascade and dissipation in collisionless space plasma turbulence – observations and simulations

Team leader: Emiliya Yordanova

Abstract

We propose a team to study the cascade and dissipation at small scale turbulence in different (astrophysical, interplanetary and near Earth's) plasmas. The work will be based on the application of the recent knowledge on this topic and the synergy between novel data analysis of *in-situ* multipoint observations (Cluster, Themis) and advanced numerical simulations (AstroGK and Landau fluid codes).

Magnetized plasmas in the Universe are turbulent and characterized by multiple spatial and temporal scales. If the large MHD scale turbulence is relatively well-documented, the physics lying behind scales smaller than the ion gyroscale , where the energy is dissipated and the ideal description of turbulence fails (dissipation range), and where a second cascade may take place, in the so called dispersive range, remains an open question. Investigating plasma turbulence at these scales is important not only from a basic plasma physics point of view, but the expected results have crucial implications on various processes occurring in laboratory and astrophysical plasmas (e.g., transport and particle acceleration, plasma heating and magnetic reconnection) as well as on designing and operating future space missions (e.g., MMS, Cross-Scale, Solar Orbiter).

The goals of the team activity are:

- Identification of the nature of the dispersive and dissipation ranges of plasma turbulence:
  - What turbulence (whistler, kinetic Alfvén (KAW), magnetoacustic waves) is present in this dispersive range?
  - What are the processes (ion cyclotron, electron Landau) that govern the waves damping and at which scale the energy is dissipated?
  - What appropriate theoretical approximations apply to the small-scale cascade and dissipation (Hall MHD, electron MHD (EMHD) or Gyrokinetics (GK))?
- In addition, the answers to the questions above will elucidate the role of turbulence dissipation in the processes such as plasma heating and acceleration, and small-scale magnetic reconnection.

The team activity will initiate with reviewing and summarizing the current state-of-the-art of the topic. In the following further study, we will endeavour to extensively probe the observational data to narrow down current theories. We will analyze the pertinent dissipation/dispersive range quantities of different kind of plasmas (e.g. magnetosheath, slow and fast solar wind) and test the different theoretical approaches, particularly with the help of numerical simulations. The achieved results will be presented at international conferences and published in peer-reviewed journals of space and plasma physics.

Scientific rationale

State-of-the-art and motivation

Space is in many aspects the best laboratory where plasma turbulence can be studied *in-situ* in great details. Up to date, a vast amount of studies of the solar wind turbulence confirmed the Kolmogorov-like scaling $k^{-5/3}$ of the magnetic spectrum, predicted in the classical picture of energy cascade from large scales, where the energy is injected to small (kinetic) scales at which it is dissipated into plasma heat. Yet the dissipation is one of the key aspects of the physics of turbulence in magnetized plasmas that is still poorly understood. As the time resolution of the most recent spacecraft measurements (Cluster, Themis) is increased and the current level of numerical codes is so developed, even smaller length scales of the turbulence can be probed. In the last years, key results were achieved thanks to the *multipoint* Cluster mission measurements in the solar wind and the magnetosheath (Bale et al., 2005, Retino et al., 2007; Sundkvist et al. 2007; Alexandrova et al., 2008; Yordanova et al., 2008), confirmed by numerical simulations (Howes et al., 2008; Galtier, 2008; Serdivio et al., 2009). We have now reached a new frontier in the study of turbulence as we are able to focus on the dynamics of the plasma turbulence at kinetic scales (ion gyroradius ρ_i and inertial length d_i). *The main question as to whether the turbulence dissipates at these scales, or undergoes a second dispersive cascade to the smaller scales, or both processes take place, remains to be elucidated and this is the task that the proposed team will challenge.*

Observations of plasma turbulence dissipation and dispersive cascade

Observations give indeed evidences of both scenarios - strong steepenings of the spectra to f^{-4} below ρ_i (Goldstein et al., 1994; Leamon et al., 1998) which has been interpreted as a dissipation range of the turbulence, and moderate steepenings to ~$f^{-2.5}$ interpreted as due to dispersive and/or compressible effects (Bale et al., 2005, Alexandrova et al., 2008; Sahraoui et al., 2009, Yordanova et al., 2008).

The first measurements (Cluster) of the solar wind electric field fluctuation spectrum over the inertial and dissipative wave number ranges in $\beta \geq 1$ plasma were presented in (Bale et al., 2005). Fig. 1 (Annex 1) shows perfect agreement of the observed inertial range from the magnetic fluctuation spectrum with the Kolmogorov -5/3 scaling, with a wave phase speed in this regime consistent with the Alfvén speed. At the smaller wavelengths $k\rho_i \geq 1$ the electric spectrum is enhanced and is consistent with the expected dispersion relation of short wavelength kinetic Alfvén waves. It was suggested that these waves in turn damp on the solar wind ions and electrons and may act to isotropize them which may explain the more fluid like nature of the solar wind.

In the study of small-scale turbulent fluctuations in the solar wind (Alexandrova et al. 2008) was shown that the small-scale cascade is much more compressible than the lower frequency Alfvénic cascade, caused by a partial dissipation of magnetic fluctuations at the spectral break: the left hand Alfvénic fluctuations with $k_{par} >> k_{perp}$ are damped by the ion cyclotron damping. Above the break, a new "magnetosonic cascade" takes place up to the electron characteristic scales. This energy cascade was suggested to be dominated by fluctuations with $k_{perp} >> k_{par}$ (Sahraoui et al. 2006, Mangeney et al., 2006).

Besides the wave-like dissipation mechanisms evoked above (Landau and cyclotron dampings), the first *in-situ* evidenced small-scale reconnection, occurring in abundant thin current sheets in turbulent magnetosheath plasma, was suggested to act as a dissipation

mechanism, with observed dissipation rates comparable to or even dominating over collisionless damping rates of waves at ion inertial length scales (Retino et al. 2007, Sundkvist, 2007).

More recently Sahraoui et al. (2009) by using high resolution Cluster wave data (up to 100 Hz) have shown for the first time that magnetic energy cascades about 2 decades of scales below ρ_i and is dissipated at the electron gyroscale ρ_e by electron Landau damping. Using the Vlasov theory they have shown that the observations are consistent with the kinetic Alfvén wave (KAW) turbulence, as predicted also by the GK (Howes et al., 2008).

Theoretical predictions and numerical confirmations of the dissipation/dispersive range

Biskamp et al. (1999) have predicted a $k^{-7/3}$ magnetic spectrum below the ion scale (d_i or ρ_i), consistent with a local spectral energy transfer independent of the linear wave properties. Recently (Galtier, 2008) has derived the $k^{-7/3}$ scaling as exact solution of the Yaglom's equations for the Hall-MHD turbulence. In another recent study (Shaikh and Shukla, 2009), fully 3D simulations of a compressible Hall-MHD in the scale range smaller than the ion gyroradius exhibited turbulent spectral cascades in the presence of a mean magnetic field following an omnidirectional anisotropic inertial-range spectrum close to $k^{-7/3}$. The spectral index was associated with the Hall current arising from non-equal electron and ion fluid velocities in the model. Weak turbulence theory of anisotropic incompressible Hall-MHD predicts a $k_\perp^{-5/2}$ scaling for either the whistler or the Alfvén branches (Galtier, 2008, Sahraoui et al., 2007).

Fully electromagnetic, kinetic simulations of magnetized turbulence in a homogeneous, weakly collisional plasma under the assumptions of strong anisotropy $k_{perp} >> k_{par}$ and when $\omega << \omega_{ci}$, were proposed by (Howes et al., 2008). This model, known as Gyrokinetic (GK) theory, follows the nonlinear cascade of energy from the driving scale in the MHD regime, through the transition at the ion gyroradius into the kinetic Alfvén wave regime, in which the turbulence is dissipated by kinetic processes (Fig. 2, Annex 1). The comparison of Fig. 2 (simulations) and Fig. 1 (observations) in Annex 1 show a striking similarity between the simulated spectra and the observed magnetic- and electric energy spectra in the solar wind (Bale et al., 2005; Sahraoui et al., 2009) – both approaches confirm that the breaks in the spectra are caused by a transition to a KAW cascade, not by the onset of ion cyclotron damping. GK theory predicts a $k_\perp^{-7/3}$ magnetic spectrum and a $k_\perp^{-1/3}$ eletric field spectrum (Scheckochihin et al., 2007, Howes et al., 2008). A numerical analysis of kinetic effects along the turbulent energy cascade in the solar wind plasma (Valentini et al., 2008) shows that, simultaneously with an increase in the ion perpendicular temperature, strong bursts of electrostatic activity in the form of ion-acoustic turbulence are produced together with accelerated beams in the ion distribution function.

Main research questions and related topics (reconnection, plasma acceleration and heating)

The main problem of dissipation/dispersive range is to recognize what physical processes are responsible for the spectrum formation bellow the ion cyclotron scale. In details:

- what is the scaling of the dispersive cascade;
- into which plasma wave mode turbulence is cascading (whistler, KAW, magnetoacustic);
- which is the appropriate theoretical approach (Hall-, E- MHD or GK) to the problem;
- what roles play the anisotropy and compressibility in the dispersive cascade;
- if there is a dispersive range, then at which scales the energy is dissipated and what dissipation mechanism acts.

One more aspect to be investigated, from a theoretical as well as experimental point of view, is the nature and the role that inherent small scale stochasticity of the medium might play in the dissipation, in the topology of small scale turbulent magnetic and plasma structures, and in initiating fast topological transitions responsible for plasma acceleration (Materassi and Consolini, 2007, 2008). Scaling over the dissipation scale should be investigated near the possible reconnection sites in the solar wind (Gosling, 2007), where Hall signatures might be present; far from any reconnection, where Hall signatures might not be present; and/or near slow reconnection associated with magnetic holes in the solar wind (Zhang et al., 2008).

Solar wind plasma is known to cool down more slowly away from the Sun than expected from an adiabatic spherical expansion. The recently evidenced MHD cascade in the solar wind (Sorriso-Valvo et al., 2007) provides for the first time a direct estimation of the turbulent energy transfer rate, which can contribute to the *in-situ* heating of the plasma. Marino et al. (2008), have compared the energy transfer rate with the heating rate necessary to reproduce the temperature radial decrease in the solar wind. They have estimated that the energy transfer rate is an important fraction (from 5% to 100%) of the total heating, and is strongly correlated with the wind temperature. However, this result does not give any information about the dissipation mechanism which is still an open issue.

In addition to the heating of the plasma by the dissipation of turbulence, temperature anisotropy instabilities can act on the collisionless solar wind plasma to redistribute particle energy (Hellinger et al., 2006 and the references therein). A preliminary study by Howes et al. (in preparation), reveals a clear evidence of the action of electron temperature anisotropy instabilities in the near-Earth' solar wind, as shown in Fig. 3 (Annex 1).

Tools and resources for the study

Apart from the standard spectral and analytical approaches, the investigation of the turbulent features of magnetic field and plasma parameters will benefit of the use of approaches based on discrete and continuous wavelets (Soucek et al., 2004), information theory (Materassi and Consolini, 2008; Materassi et al. 2007), statistical analyses (Chapman et al., 2002) and robust error quantification (Kiyani et al., 2009).

The simultaneous *multipoint high-resolution* measurements of fields and particles from Cluster and Themis (at the Dayside Scientific Phase) in the solar wind and the magnetosheath, complemented by data from the observer WIND are essential for observing the dissipation/dispersive range.

The numerical codes will be run to compare results with selected satellite events. In addition they will be used for cases in which spacecraft measurements cannot resolve the scales smaller than the ion gyroradius. The team will employ AstroGK, a new gyrokinetic simulation code for astrophysical plasmas, developed from scientists from USA and UK (http://www.physics.uiowa.edu/~ghowes/astrogk/); also Landau fluid model, incorporating the linear kinetic physics in the gyrokinetic limit (Passot and Sulem, 2007); and it will compare the relevance of the different approaches. Independently, the numerical simulations will be run to investigate the problem of dissipation of astrophysical plasma turbulence.

Expected output

The main output of the proposed team activity will be a review paper on the synergy of the two approaches (observations and simulations) submitted for publication to reputable journal in space or plasma physics (candidate journals include Planetary and Space Science, Plasma Physics, Journal of Applied Physics and Space Science Reviews) – and presentations at scientific meetings of AGU, EGU, and EPS. Deadline for submission is shortly after the team approval during the 2nd meeting. In addition we expect at least one detailed study of the topic incorporating both observations and simulations, to be submitted close to the end of the official team activity.

Timeliness

Measuring in the dissipation range of turbulence is quite difficult because of space and time resolution limits. Only recently the inertial energy cascade, which is the most characteristic signature of MHD turbulence, was observed in the solar wind using a variant of the Kolmogorov -4/5 law for MHD turbulence (Sorriso-Valvo, 2007). Last years' Cluster breakthroughs were achieved thanks to the unique *multipoint high-resolution* measurements in the turbulent solar wind and magnetosheath. This opens new ways to determine the energy transfer and thus dissipation range. It is now *possible* and very important to obtain measurements at the dissipative scales at various plasma conditions (e.g. fast and slow wind) to check whether the dissipation and the heating rates match and, if not, what could be an alternative way for the energy transfer to even smaller scales.

The numerical simulations are of an exceptional for this study value due to their important very recent results in the dissipation/dispersive range. Now it has became possible to make a detail comparison of these results with the multipoint high resolution observations of Cluster and Themis. Additionally, the tuned runs of the numerical simulations on various plasma conditions and combinations of plasma parameters, which in the real world measurements is often difficult to meet, allows to eliminate different scenarios and confirm the most probable mechanisms acting in dissipation/dispersive range.

The timeliness of the team proposal should be also viewed in the context of basics understanding of plasma turbulence underlying in the design and operation of experiments in upcoming (MMS, Solar Orbiter, Solar Probe, Sentinels, SDO) and future (Cross-scale) missions, and in the spirit of the future cosmic vision of close international cooperation of ESA, NASA, JAXA, and national space agencies and organizations.

ISSI implementation

Even though, we are living in a world where technology is so advanced that provides all sorts of means for communication, nothing can replace the live human contact and brainstorming when scientists from different countries are brought together at one place. ISSI with its interdisciplinary orientation and broad international representation provides excellent environment for a creative and productive scientific work.

The team leader is familiar with the institute's organization and arrangements. The team members represent the best research groups working on turbulence in different plasma environments (astrophysical, interplanetary and near Earths'). The team is also well balanced with respect to the expertise in this field, covering the range of theoretical, numerical and experimental methods and techniques. The average age of the team members is young, but their scientific achievements and experience speak for themselves. All of the above premises for the expected output of a significant scientific importance.

Project schedule

We anticipate three week-long working meetings at ISSI. In the periods between the meetings the team members are expected to work at their home institutions on the project assignments and to exchange data and scientific information with their team fellows.

- ***1st meeting (autumn 2009)*** - introductory presentations, brainstorming and assignments, outline of a review paper on the state-of-the-art of the research topic.
- ***2nd meeting (spring 2010)*** - finalization of the review paper, identification of detailed studies, new assignments.
- ***3rd meeting (spring 2011)*** - finalization of the detailed studies, brainstorming on future common studies and development of the field.

List of participants of the proposed team

Name	Institution	Country	Expertise
1. Roberto Bruno	**INAF-IFSI, Rome**	**Italy**	Theory and solar wind turbulence, instrumentation
2. Vincenzo Carbone	**DP-CNISM, Rende**	**Italy**	Theory, laboratory and solar wind turbulence
3. Sandra Chapman	**CFSA, Warwick**	**UK**	Theory, fusion and space plasma turbulence
4. Giuseppe Consolini	**INAF-IFSI, Rome**	**Italy**	Theory, complexity, space plasma turbulence
5. Gregory G. Howes	**University of Iowa, Iowa City**	**USA**	Astrophysical turbulence and simulations
6. Khurom Kiyani	**CFSA, Warwick**	**UK**	Laboratory and space plasma turbulence, modeling
7. Massimo Materassi	**ISC, CNR, Florence**	**Italy**	Theory, complexity, magnetospheric turbulence
8. Alain Noullez	**CNRS, Nice**	**France**	Space and atmospheric turbulence, simulations
9. Thierry Passot	**CNRS, Nice**	**France**	Theory and numerical simulations
10. Silvia Perri (*young scientist*)	**ISSI, Bern**	**Switzerland**	Solar wind and magnetospheric turbulence
11. Fouad Sahraoui	**NASA, Maryland LPP, Vélizy**	**USA France**	theory, space and laboratory plasma turbulence
12. Luca Sorriso-Valvo	**LICRYL-UNFM, Rende**	**Italy**	theory, solar wind and laboratory turbulence
13. Zoltan Vörös	**IAPP, Innsbruck**	**Austria**	solar wind and planetary turbulence
14. Emiliya Yordanova	**IRF, Uppsala**	**Sweden**	Solar wind and magnetospheric turbulence

Facilities and financial requirements

No special facilities are necessary. A meeting room with a projector and an internet connection are sufficient for the needs of the team. Accommodation expenses and per diem are required for the team members while attending the three (week-long) meetings in Bern. The travel costs are to be arranged by the team members themselves.

References

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Annex 1 – Figures

Fig. 1 (Bale, PRL, 2005)

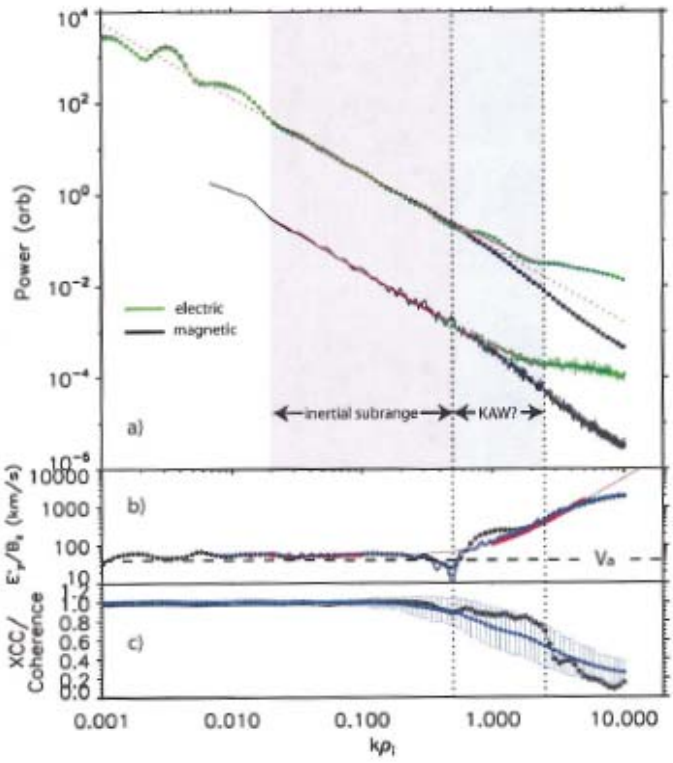


Fig. 2 (Howes, PRL, 2008)

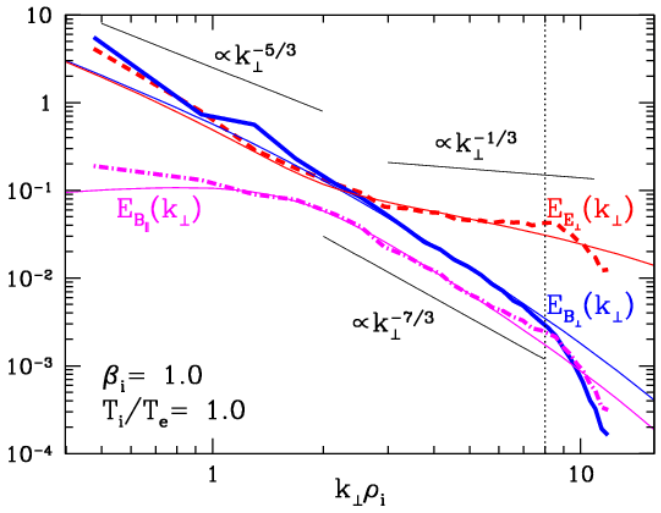
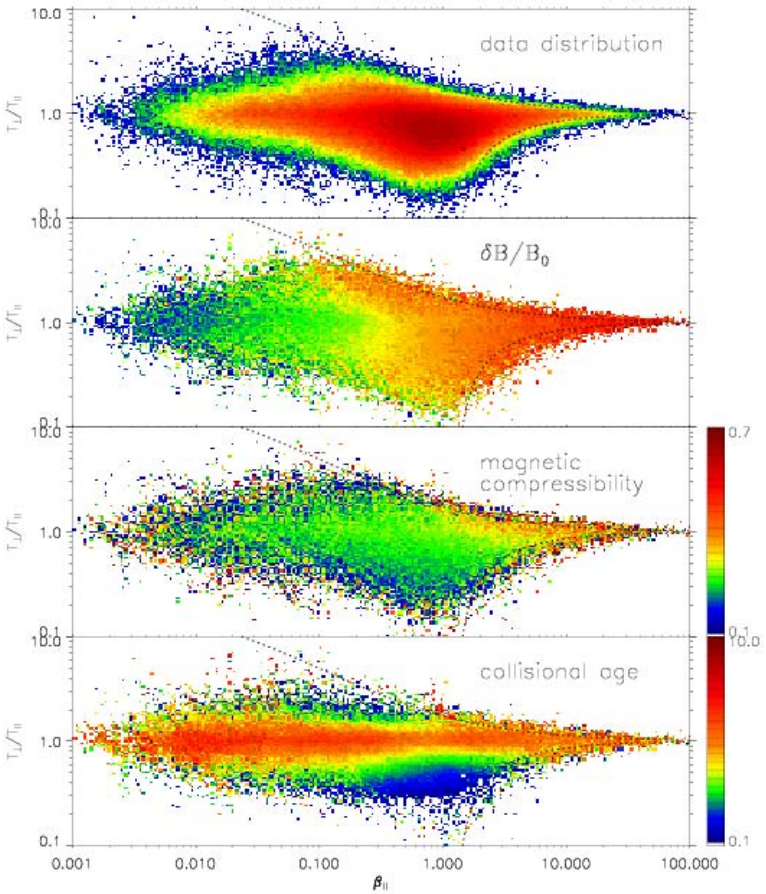


Fig.3 (Howes et al., 2008, preliminary)



Annex 2 - Team member contacts

Roberto Bruno
Istituto di fisica dello Spazio Interplanetario, Instituto Nazionale di Astrofisica
Via Fosso del Cavaliere 100, 00133 Rome, Italy
Tel: +39 06 49934389
Email: roberto.bruno@ifsi-roma.inaf.it

Vincenzo Carbone
Dipartimento di Fisica, Universita della Calabria
Ponte P. Bucci, Cubo 31C, 87036 Rende (CS), Italy
Tel: +39 0984 496131
Email: carbone@fis.unical.it

Sandra Chapman
Centre for Fusion, Space and Astrophysics, Physics Department, University of Warwick
Coventry CV4 7AL, U.K.
Tel: +44 (0)2476 523390
Email: S.C.Chapman@warwick.ac.uk

Giuseppe Consilini
Istituto di fisica dello Spazio Interplanetario, Instituto Nazionale di Astrofisica
Via Fosso del Cavaliere 100, 00133 Rome, Italy
Tel: +39 06 49934564
Email: Giuseppe.Consolini@ifsi-roma.inaf.it

Gregory G. Howes
Department of Physics and Astronomy, University of Iowa
505 Van Allen Hall, Iowa City, IA 52242
Tel: +1 319 335-1221
Email: gregory-howes@uiowa.edu

Khurom Kiyani
Centre for Fusion, Space and Astrophysics, Physics Department, University of Warwick
Coventry CV4 7AL, U.K.
Tel: +44 2476 528 407
Email: k.kiyani@warwick.ac.uk

Massimo Materassi
Instituto dei Sistemi Complessi, Consiglio Nazionale delle Ricerche
via Madonna del Piano, 10 - 50019 - Sesto Fiorentino, Italy
Tel: +39-055-5226627
E-mail: massimo.materassi@isc.cnr.it

Alain Noillez
Observatoire de la Côte d'Azur
B.P. 4229, 06304 Nice Cedex 4, France
Tel: +33 492 00 30 74
Email: anz@obs-nice.fr

Thierry Passot
Observatoire de la Côte d'Azur
B.P. 4229, 06304 Nice Cedex 4, France
Phone: +33 4 92 00 30 21
E-mail: passot@oca.eu

Silvia Perri
International Space Science Institute
Hallerstrasse 6, 3012 Bern, Switzerland
Tel: +41-316314896
E-mail: silvia.perri@issibern.ch

Fouad Sahraoui
NASA, Goddard Space Flight Center
20771, Greenbelt, Maryland, USA
Tel: +1 301-286-1047
Email: fouad.sahraoui@nasa.gov

Luca Sorriso-Valvo
Liquid Crystal Laboratory, INFM/CNR
Ponte P. Bucci, cubo 31C, I-87036 Rende, Italy
Tel: +39 0984 496128
Email: sorriso@fis.unical.it

Zoltan Vörös
Institute of Astro- and Particle Physics
Technikerstraße 25/8, A-6020 Innsbruck, Austria
Tel: +43 512 507 60 41
Email: zoltan.voeroes@uibk.ac.at

Emiliya Yordanova
Swedish Institute of Space Physics
Box 537, SE-751 21 Uppsala, Sweden
Tel: +46 18 471 5926
Email: eya@irfu.se

Annex 3 - team members CVs

Name: ROBERTO BRUNO
Date and place of birth: 29-11-1954 Pescara, Italy
Nationality: Italian
Office address: INAF-IFSI, Via Fosso del Cavaliere 100, 00133 Rome, Italy
Tel/Fax: +39-06-49934389, +39-06-49934242
Email: roberto.bruno@ifsi-roma.inaf.it
Education: Laurea in Fisica (L'Aquila, Italy, 1978)
Employment: Senior Researcher at INAF-IFSI
Research: 1) Turbulence in the solar wind, 2) laboratory activity to develop new electrostatic analysers for space plasmas
Scientific work:
over 100 refereed papers, over 25 invited talks, member of AGU, IAU, associate editor of JGR (2004-2005) LOC and SOC member of Solar Wind 10 (Pisa, It, 2002) and Editor of Solar Wind 10 Proceedings, Convener of Session II "Composition and Internal State of the Solar Wind" in Solar Wind VIII, 1995, Discussion Leader at Gordon Research Conference "Modeling in Solar Terrestrial Physics", 1989, Convener of Session III "Waves, Turbulence and Kinetic Physiscs in Solar Wind X, 2002; Organizer and Director of the Advanced School on Space Environment (ASSE 2006), World Institute for Space Environment Research – WISER, L'Aquila, Italy, 2006; Organizer and Director of the International School "Turbulence and waves in space plasmas", L'Aquila, Italy, 2007; SOC member of NLW6 meeting held in Japan, October 2006; SOC member of Solar Orbiter Workshop II held in Greece in Ottobre 2006; Convener of the session "The solar wind as a turbulence laboratory" during the Fall-AGU in S.Francisco, 2006; Convener of the session "Heliosphere" at the "International Heliophysical Year, II Meeting", held in Turin, Italy, 2007; Referee for: JGR, GRL, Phys. Plasmas, Ann. Geophys., Planet. Space Sci. , J. Advances in Space Res. , NPG, Space Sci. Rev., Phys. of Plasmas; Referee of proposals submitted to the National Science Foundation (NSF), 2003, 2005, 2006, 2008; Co-I of Mars 94 Ion Spectrometry experiment: HISEMA; Co-I of Composition and Ion Spectrometry Experiment onboard ESA-Cluster; Co-I Composition and Ion Spectrometry Experiment onboard DoubleStar; Co-I electron analyser onboard MMO (Bepi Colombo); Co-I Energetic Neutral Atoms analyser onboard MPO (Bepi Colombo); Co-I of RPW, NSWD and METIS instruments for ESA-Solar Orbiter; Lead Co-I of SWA(Solar Wind Analyzer) for ESA-Solar Orbiter; Member of the "Theory Team" of the plasma consortium for NASA-SOLAR PROBE +; Member of the plasma consortium study team for Cross Scale (Cosmic Vision 2015-2025) and coordinator of the "Study for Common Payload Processor (CPP) for Particle Experiment on Cross-Scale"
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Name: VINCENZO CARBONE
Date and place of birth: Cosenza (Italy) 29 - 10 - 1957
Nationality: Italy
Office address: Dipartimento di Fisica, UniversitÃ della Calabria,
Ponte P. Bucci, Cubo 31C, 87036 Rende (CS), Italy
Tel: +39 0984 496131
Fax: +39 0984 494401
Email: carbone@fis.unical.it
Education: Degree in Physics at the University of Calabria (Italy), PhD in Physics at University of Messina (Italy)
Employment: Full Professor of "Applied Physics" at the University of Calabria
Main Research Interests:
Turbulence in plasmas and other complex fluids; Solar Physics; Nonlinear dynamics and complex systems; Nonlinear optics; Mathematical biosciences; Environmental science
Scientific activity:
Approximate number of publications: 140 papers published on scientific reviews with international referee; 10 chapters of books; 30 papers published on Conference Proceedings; 10 papers on popular national reviews; Hirsh factor H = 22; Total number of citations 1590; *Reviewer in 14 international journals*; *Teaching activity:* course - General Physics; Turbulence and Chaos; Solar Physics; Magnetohydrodynamics; Numerical analysis; *Supervisor* of 40 degree thesis in Physics and 8 PhD Thesis; *Scientific coordinator* of research projects funded by INFM, MURST, ASI, INAF; *Membership* of committees for evaluating positions at University of Calabria, University of Marseille, Institute of Interplanetary Space (Rome); *NASA panelist* for evaluating research projects at "Heliophysics Guest Investigators" (HGIP 2007); *Membership* of AGU, EGS

Recent papers relevant to the project:

- S. Perri, E. Yordanova, V.Carbone, P. Veltri, L. Sorriso-Valvo, R. Bruno, M. Andre': ``Magnetic turbulence in space plasmas: scale dependent effects of anisotropy", JGR (2009)
- S. Servidio, W.H. Matthaeus, V. Carbone: ``Ergodicity of ideal Galerkin three-dimensional magnetohydrodynamics and Hall magnetohydrodynamics models", PR E, 78, 046302 (2008)
- Vecchio, V. Carbone, F. Lepreti, L. Primavera, L. Sorriso-Valvo, T. Straus, P. Veltri: "Spatio-Temporal Analysis of Photospheric Turbulent Velocity Fields Using the Proper Orthogonal Decomposition", Solar Physics 251, 163 (2008)
- K.P. Reardon, F. Lepreti, V. Carbone, A. Vecchio: "Turbulent velocity fluctuations in the solar chromosphere", Astrophysical Journal Letters 683, L207 (2008)
- S. Servidio, W.H. Matthaeus, V. Carbone: "Statistical properties of ideal three-dimensional Hall Magnetohydrodynamics: The spectral structure of the equilibrium ensemble", Physics of Plasmas 15, 0423141 (2008)
- R. Marino, L. Sorriso-Valvo, V. Carbone, A. Noullez, R. Bruno, B. Bavassano: "Heating the solar wind by a magnetohydrodynamic turbulent energy cascade, Astrophys. J. Let. 677, L71 (2008)
- O. Alexandrova, V. Carbone, P. Veltri, L. Sorriso-Valvo: "Small scale energy cascade of the solar wind turbulence", Astroph. J. 674, 1153 (2008)
- S. Servidio, V. Carbone, L. Primavera, P. Veltri, K. Stasiewicz: "Compressible turbulence in Hall Magnetohydrodynamics", Planetary and Space Science 55, 2239 (2007)
- L. Sorriso-Valvo, R. Marino, V. Carbone, A. Noullez, F. Lepreti, P. Veltri, R. Bruno, B. Bavassano, E. Pietropaolo: "Observation of inertial energy cascade in interplanetary space plasma", PRL 99, 115001 (2007)

DR. GIUSEPPE CONSOLINI

ADDRESS: Istituto Nazionale di Astrofisica - Istituto di Fisica dello Spazio Interplanetario,
Via del Fosso del Cavaliere 100 Roma, Italy

PHONE: 39 06 49934564 · FAX 39 06 49934383 · E-MAIL: GIUSEPPE.CONSOLINI@IFSI-ROMA.INAF.IT

DATE AND PLACE OF BIRTH: Roma(Italy) -16 August 1963

EDUCATION: 1991 - Laurea in Physics, Università degli Studi di Roma "La Sapienza"

ACADEMIC HONORS: Award of *Fondazione "Dr. Giuseppe Borgia"* assigned by the *Accademia Nazionale dei Lincei* on year 2000 for his contribution to the magnetospheric physics studies

PROFESSIONAL POSITION: Permanent Research Scientist at Ist. Fisica Spazio Interplanetario, INAF (Roma, Italy) since 2001

RESEARCH FIELDS: Complexity and criticality in space plasma physics, Observations and study of auroral phenomena and magnetospheric dynamics, Solar convection and energy transport in the outer layers of the solar atmosphere, Study of the long-term evolution of the geomagnetic field , Study of the properties of water confined on the surface of enzymes.

A SELECTED LIST OF JCR (ISI)- PUBLICATIONS (OUT OF 69):

1. M. Materassi and **G. Consolini**, "Turning the resistive MHD into a stocastic field theory", *Nonlin. Proc. Geophys.*, **15**, 701 (2008)
2. **G. Consolini**, P. De Michelis and R. Tozzi, "On the Earth's magnetospheric dynamics: Nonequilibrium evolution and the fluctuation theorem", *J. Geophys. Res.*, **113**, A08222 doi: 10.1029/2008JA013074 (2008)
3. M. Materassi and **G. Consolini**, "Magnetic reconnection rate in space plasmas: a fractal approach", *Phys. Rev. Lett.*, **99**, 175002 (2007)
4. **G. Consolini**, et al., "On the magnetic field fluctuations during magnetospheric tail current disruption: A statistical approach", *J. Geophys. Res.*, **110**, A07202, doi: 10.1029/2004JA010947 (2005)
5. **G. Consolini**, & T. Chang, "Magnetic Field Topology and Criticality in the Magnetotail Dynamics: Relevance to Substorm Dynamics", *Space Sci. Rev.*, **95**, 309 (2001)
6. **G. Consolini** & A.T.Y. Lui "Sign-Singularity Analysis of a Current Disruption Event." *Geophys. Res. Lett.*, **26**,1673 (1999)
7. **G. Consolini**, M.F. Marcucci and M. Candidi "Multifractal structure of Auroral Electrojet Index Data" *Phys. Rev. Lett.* **76** (21), 4082 (1996)

Summary CV: Sandra C. Chapman

Sandra Catherine Chapman
Date of birth: 11/05/61, **Nationality**: British, **Sex**: Female

Qualifications: Ph.D D.I.C.(Physics) 1985, BSc(Hons) A.R.C.S.(Physics) 1982, CPhys FInstP, FRAS

Contact Address: Centre for Fusion, Space and Astrophysics, Physics Department, University of Warwick, Coventry CV4 7AL, U.K.
Tel. Office: 44 (0)2476 523390 direct dial, **mobile** 07900 495342, **Physics Dept. Fax**: 44 (0)2476 692016
email: S.C.Chapman@warwick.ac.uk

Current position: Professor of Physics and Director of the Centre for Fusion, Space and Astrophysics (CFSA) at the University of Warwick. Co -Director of Warwick's Doctoral Training Centre for Complexity.

Research leadership: The CFSA was created in 2006 with a recent EPSRC initiative in plasma physics. This builds on the Space and Astrophysics Group at Warwick formed on my appointment in 1995. I am responsible for the overall management and funding strategy of the Centre's current 8 faculty and 31 research fellows, students and support staff. I am currently Principal Investigator of the Centre's STFC Rolling Grant for Space and Astrophysics, and EPSRC Science and Innovation award for Fusion Plasma Physics, a programme in excess of £6M running to 2012. I am also a Co- Director on Warwick's Complexity DTC and a founding member of Warwick's Complexity Complex- an interdisciplinary centre to facilitate research and graduate training in complex systems. I have a track record of continuous research funding since 1988, and a leadership role at Head of Group level since 1992.

Research interests: Nonlinear processes in solar system, astrophysical and laboratory plasmas. My interests include chaotic dynamics in waves and current sheets, high performance computing applied to wave- particle interactions and plasma acceleration for example at astrophysical shocks, cometary dynamics, complex systems approaches to solar system and laboratory plasmas, turbulence, and nonlinear time series analysis techniques.

Publications: Over 100 in the refereed literature. Undergraduate textbook: Core Electrodynamics.

PhD students (*completed*): A. Richardson, P. E. Devine, C. G. Mouikis, W. Brown, S. K. Matsoukis, M. E. Dieckmann, W. J. Wykes, M. Hopcroft, P. Birch, M. Tsalas, J. Greenhough, B. Hnat, R. E. Lee, T. K. March, J. A. Merrifield, R. Wicks, **(*current*)**: , R. Nicol, R. Cook, E. Zaloumis. **MSc students (*completed*)**: R. Henwood

Service to the Scientific Community:

International Evaluation Committee- Review of Basic Physics Research, reporting the Research Council of Norway, 2009

Appointed (by the Minister for Science) to Assessment Panel 2 (Physics, Chemistry, Earth Sciences) for the Research Quality Framework, DEST Australia, 2008

Vice President, Royal Astronomical Society 2001-2003

Member: Commission for Astrophysics, International Union of Pure and Applied Physics, and representative to SCOSTEP, 2002-; International Advisory Committee (IAC) of the International Congress on Plasma Physics (ICPP) 2006-

Panel member/reviewer for PPARC, EPSRC, NASA, NSF and the Research Councils of Sweden and Norway and Royal Society Dorothy Hodgkin Fellowships, 2005-2006

Co- Investigator on ESA CLUSTER-II DWP and WHISPER instruments, on LOIS- LOFAR deep space radar.

American Geophysical Union, Nonlinear Section Executive Committee 2004-

Awards and Honours:

Personal research fellowships from the Particle Physics and Astronomy Research Council, the Royal Society and Japan Society for the Promotion of Science, the Nuffield Foundation, NESTA, The Radcliffe Foundation (Harvard), visiting Professor at the University of Kyoto, Japan and at the University of Uppsala, Sweden.

COSPAR/Russian Academy of Sciences Zeldovich Medal, Commission D, 1994. Citation: 'For outstanding contributions to theoretical studies of plasma dynamics in the Earth magnetotail'.

European Geophysical Society 1993 Young Scientists' Publication Award. Title: 'Chaotic single particle dynamics in a multi-timescale parameterizable field reversal'.

Gregory G. Howes

Department of Physics and Astronomy
505 Van Allen Hall
University of Iowa
Iowa City, IA 52242
gregory-howes@uiowa.edu

Birthdate: 18 October 1971
Birthplace: Oakland, CA, USA
Nationality: USA
Office: (319) 335-1221
Fax: (319) 335-1753

Education

B.A. in 3/2 Physics and Liberal Arts, Occidental College (6/94).
B.S. in Applied Physics, Calfornia Institute of Technology (6/94).
Dip.App.Sci. in Geophysics, Victoria University of Wellington, New Zealand (11/95).
M.S. in Physics, University of California, Los Angeles (12/98).
Ph.D. in Physics, University of California, Los Angeles (10/04).

Employment

University of Iowa, (6/08–present). Assistant Professor, Department of Physics and Astronomy. Teaching graduate plasma physics and research on theoretical and numerical studies of astrophysical turbulence in kinetic plasmas employing multi-scale algorithms for efficient simulation on high-performance computing resources.

University of California, Berkeley, (8/04–8/08). Assistant Professional Research Astronomer, Department of Astronomy. Research on theoretical and numerical studies of magnetized turbulence in astrophysical environments.

Scientific Work

Number of Publications: 11
Number of Invited Talks: 14
Number of Reviewed Publications: 11
Membership of Unions: American Physical Society (1998–present)
American Astronomical Society (1998–present)
Committees: Review Panel member: NASA Solar and Heliophysics , 2008.
Session Organizer: Space Physics, Internationl Conference on Plasma Science, 2009.

Relevant Publications

Schekochihin, A. A., Cowley, S. C., Dorland, W., Hammett, G. W., Howes, G. G., Quataert, E., and Tatsuno, T., *Kinetic and Fluid Turbulent Cascades in Magnetized Weakly Collisional Astrophysical Plasmas*, Astrophys. J. Supp, in press 2009.

Howes, G. G. *Limitations of Hall MHD as a model for turbulence in weakly collisional plasmas*, Nonlin. Proc. Geophys. **16**, 219-232 (2009).

Schekochihin, A. A., Cowley, S. C., Dorland, W., Hammett, G. W., Howes, G. G., Plunk, G. G., Quataert, E., and Tatsuno, T. , *Gyrokinetic turbulence: a nonlinear route to dissipation through phase space*, Plasma Phys. Control. Fusion, **50**, 124024 (2008).

Howes, G. G., Cowley, S. C., Dorland, W., Hammett, G. W., Quataert, E., Schekochihin, A. A., and Tatsuno, T., *Kinetic Simulations of Magnetized Turbulence in Astrophysical Plasmas*, Phys. Rev. Lett. **100**, 065004 (2008).

Howes, G. G., Cowley, S. C., Dorland, W., Hammett, G. W., Quataert, E., and Schekochihin, A. A., *A Model of Turbulence in Magnetized Plasmas: Implications for the Dissipation Range in the Solar Wind*, J. Geophys. Res. **113**, A05103 (2008).

Howes, G. G. *Inertial Range Turbulence in Kinetic Plasmas*, Phys. Plasmas **15**, 055904 (2008).

Howes, G. G., Cowley, S. C., Dorland, W., Hammett, G. W., Quataert, E., and Schekochihin, A. A., *Astrophysical Gyrokinetics: Basic Equations and Linear Theory*, Astrophys. J., **651**, 590 (2006).

CFSA, Dept. of Physics
University of Warwick
Coventry CV4 7AL
++44 2476 528 407
k.kiyani@warwick.ac.uk

Nationality: British
Date of Birth: 13/12/1978
Place of Birth: London, UK

Khurom Kiyani

Employment

University of Warwick - Centre for Fusion, Space & Astrophysics

Department of Physics, Coventry CV4 7AL, UK

2005 – Present **Postdoctoral Research Fellow in Solar System Plasma Turbulence**

- Studying the cross-over behaviour between different physics in plasma turbulence using very large high-frequency *in-situ* solar wind data sets from spacecraft in inter-planetary space plasmas.
- Investigating and correcting for the role of extreme events and finite-size effects on the scaling behaviour of self-similar (fractal and multifractal) stochastic processes – especially on the role of intermittency and anomalous scaling in space plasma turbulence; with a focus on non-Gaussian and non-stationary heavy-tailed statistics; and a view to understand and model the processes underlying the phenomena with reduced (stochastic) models. The work is primarily analytic and data analysis based with some larger computation; and involves a high degree of group interaction as well as collaborations with data teams.

Education

University of Edinburgh, School of Physics

Kings Buildings, Edinburgh EH9 3JZ, UK

2001 – 2004 **PhD** Thesis title: `*An Assessment of Renormalization Methods in the Statistical Theory of Isotropic Turbulence*'

Imperial College of Science, Technology and Medicine, University of London

South Kensington, London SW7 1NA, UK

1997 – 2001 **MSci Physics** 2:1 – Upper Second Class Honours

Research and Scientific Work Summary

- 8 papers in peer-reviewed journals; 3 invited talks; regular referee of Phys. Rev. Lett.; membership of the Institute of Physics, the American Geophysics Union and the Royal Astronomical Society; member of ISSI team 132.

Recent Refereed Publications

- K. Kiyani, S. C. Chapman, B. Hnat and R. M. Nicol, *Self-Similar Signature of the Active Solar Corona within the Inertial Range of Solar-Wind Turbulence*, Phys. Rev. Lett. **98**, 211101 (2007)
- B. Hnat, S. C. Chapman, K. Kiyani, G. Rowlands and N. W. Watkins, *On the fractal nature of the magnetic field energy density in the solar wind*, Geophys. Res. Lett. **34**, L15108 (2007)
- S. C. Chapman, B. Hnat and K. Kiyani, *Solar cycle dependence of scaling in solar wind fluctuations*, Nonlin. Processes Geophys., **15**, 445–455 (2008)
- K. H. Kiyani, S. C. Chapman and N. W. Watkins, *Pseudononstationarity in the scaling exponents of finite-interval time series*, Phys. Rev. E **79**, 036109 (2009)
- S. C. Chapman, R. M. Nicol, E. Leonardis, K. Kiyani and V. Carbone, *Universality in the Generalized Similarity of Evolving Solar Wind Turbulence as seen by ULYSSES*, accepted in Ap. J. Lett. (2009)

MATERASSI Massimo

Work: Instituto dei Sistemi Complessi, Consiglio Nazionale delle Ricerche
Address: via Madonna del Piano 10 - 50019 - Sesto Fiorentino (FI)
Telephone: +39-055-5226627
E-mail: massimo.materassi@isc.cnr.it

Citizenship: ITALIAN

Birth date: April 27, 1970

Qualification: PhD

Employment: Permanent position as a researcher at the Institute for Complex systems, National Research Council, December 28, 2001 - today
Post-doc fellowship at the Space Research Centre, Warsaw (Poland), June 15, 2004 – December 15, 2004

Recent/Relevant Publications:

MATERASSI M., CONSOLINI G (2008). Turning the resistive MHD into a stochastic field theory, *NPG*, vol. 15; p. 1-10, ISSN: 1023-5809

MATERASSI M., A. W. WERNIK, E. YORDANOVA (2007), Determining the verse of magnetic turbulent cascades in the Earth's magnetospheric cusp via transfer entropy analysis: preliminary results, *NPG*, vol. 14; p. 153-161, ISSN: 1023-5809

MATERASSI M., G. CONSOLINI (2007). On the magnetic reconnection rate in space plasmas: a fractal approach, *PRL*, ISSN: 0031-9007

MATERASSI M., A. W. WERNIK, E. YORDANOVA (2006), Statistics in the p-model. CHAOS, *Solitons And Fractals*, vol. 30; p. 642-655, ISSN: 0960-0779

Name: Alain NOULLEZ
Date and place of birth: Nov. 13th 1962, Renaix (Belgium)
Nationality: Belgian

Office address: Observatoire de la Côte d'Azur
B.P. 4229
06304 Nice Cedex 4
FRANCE
Tel/Fax: +33 492 00 30 74 / +33 492 00 30 58
Email: anz@obs-nice.fr

Education:
Research Director Habilitation (Université de Nice,2002)
Ph.D. in Physical Sciences (Université de Bruxelles, 1990)
M.D. in Physical Sciences (Université de Bruxelles, 1990)

Employment:
CNRS CR1 Researcher, UMR 6202 Cassiopée, 1994--
EEC ``Marie Curie" HCM Postdoctorate fellow, Nice Observatory, 1992—1994.
CNRS Associate Researcher, Nice Observatory, 1991—1992.

Research:
Fluid and MHD Turbulence in Fluids and Interplanetary Plasmas
Statistical Physics
Statistics and Signal Processing, Algorithms, Numerical Analysis

Scientific work:
43 publications (41 scientific, 2 popular)
24 papers in reviewed journals, 2 invited talks at international conferences
Member of AGU, Nice Observatory administration council

Recent (and/or relevant) papers:
R. Marino, L. Sorriso-Valvo, V. Carbone, A. Noullez, R. Bruno & B. Bavassano,
Heating the solar wind by a magnetohydrodynamic turbulent energy cascade,
Astrophys. J. Lett. 677, p. L71 (2008).

L. Sorriso-Valvo, R. Marino, V. Carbone, A. Noullez, F. Lepreti, P. Veltri, R. Bruno, B. Bavassano & E. Pietropaolo,
Observation of inertial energy cascade in interplanetary space plasma,
Phys. Rev. Lett. 99, p. 115001 (2007).

R. Bruno, V. Carbone, S. Chapman, B. Hnat, A. Noullez & L. Sorriso-Valvo,
Intermittent character of interplanetary magnetic field fluctuations,
Phys. Plasmas 14, p. 032901 (2007).

Thierry Passot

Personal information

Born:	September 11, 1960
in:	Nice, France
Nationality: :	French
Family status:	married, 1 child

Affiliation

CNRS, Laboratoire "Cassiopée", U.M.R. 6202,
University of Nice Sophia Antipolis
Observatoire de la Côte d'Azur, BP 4229, 06304 Nice Cédex 4, France
Phone: +33 4 92 00 30 21 ; Fax: +33 4 92 00 31 21
E-mail: passot@oca.eu

Education

1991	Habilitation à diriger des recherches en Sciences
1987	Ph.D. in Physics, University of Paris VII under the supervision of A. Pouquet.
1984	DEA "Astrophysique et Techniques Spatiales", Meudon, research training under the supervision of J. Léorat.
1983	Engineer from Ecole Polytechnique.

Current Situation

Directeur de Recherche 2eme classe at CNRS, since October 1999.
Head of Laboratory Cassiopée since January 2008.

Previous employments

1997, 1999 & 2000 :	Visiting Associate Professor
(January to June)	Department of Mathematics, University of Arizona
1992-1999 :	Chargé de Recherche 1^{ere} classe, CNRS
1990-1992 :	Maître de Conférence in Mechanics at Ecole Polytechnique
1988-1992 :	Chargé de Recherche 2eme classe, CNRS
1987-1989 :	Postdoctoral Research Associate Department of Mathematics, University of Arizona

Fields of research

Plasma physics, nonlinear waves, astro and geophysical turbulence, patterns

Activities

Articles in refereed journals: 84
Proceedings articles : 39
Invited talks: 30
International conferences organized: 5
PhD students supervised: 5
Other research advising: 9

Selected publications

- T. Passot, & P.L. Sulem
Collisionless magnetohydrodynamics with gyrokinetic effects; *Phys. Plasmas*, **14**, 082502-(1-14), (2007) (see also AIP Conference Proceedings,**1061**, 227-236 (2008)).

Name: SILVIA PERRI;
Place and date of birth: Cosenza, 02/01/1982;
Nationality: Italian;
Office address: International Space Science Institute, Hallerstrasse 6, CH-3012, Bern, Switzerland;
Tel/Fax: +41-316314896/+41316314897;
E-mail: silvia.perri@issibern.ch

Education: Degree in Physics (five years of course of study) with the best marks obtained at Università della Calabria on July 2005 discussing a thesis about test particles diffusion in stochastic electromagnetic fields. Ph.D. in Physics obtained at Università della Calabria on December 2008.

*Employment:*Two years Postdoc position at the International Space Science Institute.

Grants, Projects and Awards: Research Project "MHD Turbulence in active regions of solar corona and in the Earth's Magnetopause" financed by Progetto di Ricerca per giovani ricercatori, Università della Calabria, February 2006;
Itoh Project Prize 2008, European Physical Society (EPS) Conference on Plasma Physics, Silvia Perri "Superdiffusive transport of energetic particles through the heliosphere" received "high commendations from the judges";
ESA student sponsorship to attend the COSPAR Conference in Montreal (13-20 July 2008).

Contributions to international Conferences: 6 oral presentations and 5 poster presentations.

Publications: 9 reviewed papers on international journals, 5 papers submitted to international journals, 4 proceedings of international conferences.

Memberships of working groups and teams: Team of Prof. M. Gedalin, Relativistic reconnection and collisionless shocks, ISSI, 25-31 January, 2009.

Relevant papers: S. Perri, E. Yordanova, V. Carbone, P. Veltri, L. Sorriso-Valvo, R. Bruno and M. Andrè, "Magnetic turbulence in space plasmas: cross-scale effects of anisotropy", J. Geophys. Res., **114**, doi:10.1029/2008JA013491 (2009);
S. Perri, E. Yordanova, V. Carbone, L. Sorriso-Valvo, Y. Khotyaintsev, R. Bruno and M. Andrè, "Analysis of small-scale anisotropy with the high resolution Cluster data", Adv. Sp. Res., *submitted.*

Name: FOUAD SAHRAOUI

Date and place of birth: 06-02-1975
Nationality: Algerian
Office address: 1) NASA Goddard Space Flight Center, 20771, Greenbelt, Maryland USA
2) Laboratoire de Physique des Plasmas, CNRS-Ecole Polytechique, Vélizy France
Tel: +1 301-286-1047
Email: fouad.sahraoui@nasa.gov

Education:

- 1998: Master 1 Nuclear Physics, University of Algiers, Algeria.
- 1999: Master 2 Gaz and Plasmas Physics, University Paris VI
- 2003: PhD, University of Versailles, France (Weak turbulence theory in space plasmas)

Employment:

- 2003-2005: Post-doctoral position, French Space Agency (CNES)
- Since 2005: ‘‘Chargé de Recherches’’ (Academic position), CNRS, France
- Since 2007: Visiting scientist at NASA/GSFC, Greenbelt, Maryland, USA

Research:

- Theory and observations of nonlinear processes in space and laboratory plasmas (turbulence, coherent structures and intermittency, wave particle interactions, magnetic reconnection, …)
- Fluid and kinetic description of space and laboratory plasmas.
- Classical mechanics and Hamiltonian field theory in plasmas
- Developing data processing techniques for space turbulence (e.g., multi-spacecraft measurement techniques)

Scientific work:

- About twenty publications in different peep reviewed journals (PR, PRE, JGR, Phys. Plasmas, …)
- About fifteen invited talks
- Reviewer for JGR, Phys. Plasmas, Ann. Geophys.
- Member of a former ISSI group ‘‘Reconnection and Turbulence’’ (2006-2007)

Recent (and/or relevant) papers:

- **F. Sahraoui** et al., Evidence of cascade and dissipation in solar wind turbulence at electron scales, PRL (submitted).
- **F. Sahraoui,** Diagnosis of magnetic structures and intermittency in space-plasma turbulence using the technique of Surrogate data, Phys. Rev. E **78,** 026402, 2008
- **F. Sahraoui** et al., Anisotropic Turbulent Spectra in the Magnetosheath as Seen by the Cluster Spacecraft, PRL 96, 075002, 2006.

Name: LUCA SORRISO-VALVO
Date and place of birth: 9/10/1973, Cosenza (Italy), **Nationality:** Italian, **Office address:** Liquid Crystal Laboratory, INFM/CNR, c/o Dipartimento di Fisica, Università della Calabria, Ponte P. Bucci, cubo 31C, I-87036 Rende (CS), Italy, **Tel/Fax:** +39.0984.496128 / +39.0984.494401, **Email:** sorriso@fis.unical.it

Education: *PhD in Physics*, Università degli Studi della Calabria, Cosenza, Italy (November 1998 – January 2000), and Observatoire de la Cote d'Azur, Nice, France (February 2000 – October 2001). Title of the PhD thesis: "Intermittency in plasma turbulence". Directors: Vincenzo Carbone (Italy), Annick Pouquet (France), Hélène Politano (France). Date of release: 31/01/2002.
Laurea in Fisica (Degree), Università degli Studi della Calabria, Cosenza, Italy, with marks *110/110 cum laude*. Title of the thesis: "Analisi delle funzioni di distribuzione delle fluttuazioni di velocità e campo magnetico nel Vento Solare: un metodo per caratterizzare l'intermittenza" (in italian). Director: Vincenzo Carbone. Date of release: 28/02/1998.

Employment: Researcher at Laboratorio Regionale LICRYL – INFM/CNR

Research: Theoretical and experimental study of nonlinear dynamical systems and complex systems. Among others: Turbulence in plasmas in astrophysical, laboratory and numerical systems (solar wind, intermittency, anisotropy, scaling laws). Solar physics, including the dynamical properties of photosperic motions, active regions, solar activity.

Scientific work: 42 publications on reviewed papers (ISI), 17 proceedings, 2 book chapters; 7 invited talks; memberships of AGU; memberships of ESA "Cross-Scale" Science Study Team.

Recent (and/or relevant) papers:

Sorriso-Valvo L., Carbone V., Veltri P., Consolini G., Bruno R., *Intermittency in the solar wind turbulence through probability distribution functions of fluctuations,* Geophys. Res. Lett. **26**, 1801-1804 (1999)

Sorriso-Valvo L., Marino R., Carbone V., Noullez A., Lepreti F., Veltri P., Bruno R., Bavassano B., Pietropaolo E., *Observation of Inertial Energy Cascade in Interplanetary Space Plasma,* Physical Review Letters **99**, 115001-1-115001-4 (2007)

Alexandrova O., Carbone V., Veltri P., Sorriso-Valvo L., *Small-scale energy cascade of the solar wind turbulence,* The Astrophysical Journal **674**, 1153-1157 (2008)

Marino R., Sorriso-Valvo L., Carbone V., Noullez A., Bruno R. and Bavassano B., *Heating the solar wind by a magnetohydrodynamic turbulent cascade,* The Astrophysical Journal Letters **677**, L71-L74 (2008)

Sorriso-Valvo L., Carbone V., Bruno R. and Veltri P., *Persistence of small-scale anisotropy of magnetic turbulence as observed in the solar wind,* Europhysics Letters **75**, 832-838 (2006)
Sorriso-Valvo L., Carbone V. and Bruno R., *On the Origin of the Strong Intermittent Nature of interplanetary Magnetic Field,* Space Science Reviews **121**, 49-53 (2005)

Sorriso-Valvo L., Giuliani P., Carbone V., Veltri P., Bruno R., Antoni V., Martines E., *Intermittency in plasmas,* Planetary Space Sciences **49**, 1193-1200 (2001)

Name: ZOLTÁN VÖRÖS

Date and place of birth: 25. 12. 1959, Komarno, Slovak Republic
Nationality: Slovak

Office address: Institute of Astro- and Particle Physics, Technikerstraße 25/8, A-6020 Innsbruck
Tel/Fax: +43 512 507 60 41/+43 512 507 2923
Email: zoltan.voeroes@uibk.ac.at

Education: Faculty of Nuclear Physics, Comenius University, Bratislava
PhD: Solar-Terrestrial Physics
Employment: Institute of Astro- and Particle Physics, University of Innsbruck

Research: Application of mathematical methods to turbulent fluctuations in the solar wind and in the planetary magnetospheres; **Number of refereed publications**: 60
Number of invited talks: 17; **Memberships**: AGU, EGU, IAU; **Memberships of review:** NASA Geospace program panelist;
Organization committees:
- Local organizer of the IXth IAGA Workshop on Geomagnetic observatories, 2000;
- Member of LOC and International Advisory Committee of the World Space Environment Forum, Austria, 2005;
- Member of Program Committee of the 6th International Workshop on Nonlinear Waves an Turbulence in Space Plasmas, Kyushu University, Japan, 2006;
- Member of LOC of the IAGA 11th Scientific Assembly, Sopron, Hungary, 2009;

Membership of working groups and teams: Cluster - Graz, Venus Express – Graz, Themis – Innsbruck/Los Angeles

Recent (and/or relevant) papers:

Vörös, Z., T.L. Zhang, M.P. Leubner, M. Volwerk, M. Delva and W. Baumjohann, Intermittent turbulence, noisy fluctuations and wavy structures in the Venusian magnetosheath and wake, J.Geophys.Res.(Planets), 113, E00B21, doi:10.1029/2008JE003159, 2008;

Vörös, Z., T.L. Zhang, M.P. Leubner, M. Volwerk, M. Delva, W. Baumjohann, and K. Kudela, Magnetic fluctuations and turbulence in the Venus magnetosheath and wake, Geophys.Res.Lett. (AGU Journal Highlight), 35, L11102, doi:10.1029/2008GL033879, 2008;

Vörös, Z., R. Nakamura, V. Sergeev, W. Baumjohann, A.V. Runov, T.L. Zhang, M. Volwerk, T. Takada, D. Jankovičová, E.A. Lucek, and H. Rème, Study of reconnection-associated multi-scale fluctuations with Cluster and Double Star, J.Geophys.Res., 113, A07S29, doi:10.1029/2007JA012688, 2008;

Vörös, Z., W. Baumjohann, R. Nakamura, A. Runov, M. Volwerk, T. Takada, E.A. Lucek, H. Reme, Spatial structure of plasma flow associated turbulence in the Earth's plasma sheet , Ann. Geophys.25, 13-17, 2007;

Vörös, Z., W. Baumjohann, R. Nakamura, A.V. Runov, M. Volwerk, Y. Asano, D. Jankovičová, E.A. Lucek, H. Reme, Spectral scaling in the turbulent Earth's plasma sheet revisited, Nonlin. Proc. Geophys.14, 535-541, 2007

EMILIYA YORDANOVA
Swedish Institute of Space Physics
Box 537, SE-751 21 Uppsala, Sweden
Tel: +46 18 471 5926
Email: eya@irfu.se

DATE AND PLACE OF BIRTH
7 November 1972, Pernik, Bulgaria

EDUCATION
PhD in Geophysics, Space Research Center, Polish Academy of Science, May, 2005
Master degree of Physics, Faculty of Physics, Sofia University "St. Kliment Ohridsky", 1996

ACADEMIC POSITIONS
Research assistant at the Swedish Institute of Space Physics, Uppsala, Sweden, January 2009-present
Postdoctoral position at the International Space Science Institute, Bern, Switzerland, January 2008 – December 2008
Senior scientist at the Space Research Institute, Bulgarian Academy of Science, Sofia, Bulgaria, June 2007 – present
Postdoctoral position at the Swedish Institute of Space Physics, Uppsala, Sweden, September 2005 – May 2007
Visiting researcher in the frame of RTN, "Turbulent Boundary Layers in Geospace Plasmas" EC contract HPRN-CT-2001-00314 at the Space Research Center, Polish Academy of Sciences, February 2003 - March 2005
Senior scientist, Space Research Institute, Bulgarian Academy of Science, March 2002 – August 2005
Ph.D. student, Space Research Institute, BAS, January 1999 - December 2001

RESEARCH WORK
Publications – 15, invited talks - 3
Member of AGU, since 2007; Member of the EGU, since 2006; Member of Union of the Physicists in Bulgaria, since 1999
Member of ISSI Team *"Comparative study of turbulence and anomalous transport in space and fusion plasmas"*, start of the project – January 2008

AWARDS
'Acad. Kiril Serafimov' for young scientist of 2002, Space Research Institute, Bulgarian Academy of Science

AREAS OF INTEREST AND PROJECTS
Solar wind and magnetospheric turbulence, plasma transport across magnetospheric boundary layers; Solar wind - magnetosphere - ionosphere coupling, Space weather

RECENT PUBLICATIONS

- Yordanova E., Balogh A., Noullez A., and R. von Steiger, Turbulence and intermittency in the heliospheric magnetic field in fast and slow solar wind, JGR, 2009JA014067, submitted, 2009
- Yordanova, E., Vaivads A., M. André, S. C. Buchert, and Z. Vörös, Magnetosheath plasma turbulence and its spatiotemporal evolution as observed by the Cluster spacecraft, Phys. Rev. Lett., 100, 205003, 10.1103/PhysRevLett.100.205003, 2008.

Curriculum Vitae

Dr. Peter Hunana
Observatoire de la Côte d'Azur,
Nice, 06304, France
cell phone: (+33) 6-48-62-48-26
email: hunana@oca.eu

Education:
- University of California, Riverside, PhD in Physics, 2008
- University of California, Riverside, Master of Science (MS) in Physics, 2005
- Comenius University in Bratislava, Slovakia, Faculty of Mathematics Physics and Informatics, Master Degree (Mgr.) in Theoretical and Mathematical Physics, 2003

Awards:
- Poincaré Postdoctoral Fellowship, Observatoire de la Côte d'Azur, Nice, France, 2009-2011
- Dean's Fellowship, University of California, Riverside, USA, 2003-2008
- Poe Memorial Scholarship for outstanding PhD graduate, Department of Physics, University of California, Riverside, USA, 2008
- Outstanding Student Paper Award, Space Physics and Aeronomy Section, AGU Fall Meeting, San Francisco, USA, 2007

Appointments:
- Poincaré Postdoctoral Fellow, Observatoire de la Côte d'Azur, Nice, France, 2009-
- Research Associate, Center for Space Plasma and Aeronomic Research, University of Alabama, Huntsville, USA, 2008 – 2009
- Graduate Student Researcher, Institute of Geophysics and Planetary Physics, University of California, Riverside, USA, 2005-2008
- Teaching Assistant, Department of Physics, University of California, Riverside, USA, 2003-2005

Refereed publications:
1. Hunana P., Zank G. P., "Inhomogeneous nearly incompressible description of magnetohydrodynamic turbulence", Astrophys. J., submitted (2009)
2. Hunana P., Zank G. P., Heerikhuisen J., and Shaikh D., "Nearly incompressible fluids: decay of solar wind density fluctuations", J. Geophys. Res. 113, A11105 (2008)
3. Hunana P. and Zank G. P., "Passive scalar spectrum in high-Schmidt-number stationary and nonstationary turbulence", Phys. Rev. E 77, 17301 (2008)
4. Hunana P., Zank G. P., Shaikh D., and Heerikhuisen J.," Nearly incompressible theory and large scale flows", AIP Conference proceedings 932, 45 (2007)
5. Hunana P., Zank G. P., and Shaikh D., "Nearly incompressible fluids: Hydrodynamics and large scale inhomogeneity", Phys. Rev. E 74, 026302 (2006)

Conferences:
- Invited talk at "Voyagers in the Heliosheath: Observations, models, and plasma physics", Kauai, Hawaii, January 2009
- Invited talk at 2008 Huntsville Workshop, "The Physical Processes for Energy and Plasma

Transport across Magnetic Boundaries", Huntsville, Alabama, October 2008
- Invited talk at 6th Annual International Astrophysics Conference, "Turbulence and nonlinear Processes in Astrophysical Plasmas", Honolulu, Oahu, Hawaii 2007
- Poster presentations at AGU (American Geophysical Union) Fall Meetings, San Francisco, 2004, 2005, 2006, 2007, 2008
- Participation at 4th & 5th Annual International Astrophysics Conference, Palm Springs 2005, Honolulu, Hawaii 2006

Service:
- I have reviewed a paper for Journal of Geophysical Research – Space Physics, and a paper for Annual International Astrophysics Conference Proceedings
- I have reviewed a proposal for National Fund for Scientific & Technological Development (FONDECYT), which is a Chilean government research funding agency

Advisors & Collaborators:
- Prof. Thierry Passot, director of the Laboratoire Cassiopée, Observatoire de la Côte d'Azur, Nice, France, my current postdoctoral advisor
- Prof. Gary Zank, director of the Center for Space Plasma and Aeronomic Research (CSPAR), Pei-Ling Chan Chair of Physics, University of Alabama, Huntsville, USA; PhD advisor at the University of California, Riverside, 2003-2008, also postdoctoral advisor at the University of Alabama, Huntsville
- Prof. Jacob Heerikhuisen, Assistant Professor, University of Alabama, Huntsville, USA
- Dr. Dimitri Laveder, Research Scientist, Observatoire de la Côte d'Azur, Nice, France
- Dr. Pierre-Louis Sulem, Research Scientist, Observatoire de la Côte d'Azur, Nice, France
- Prof. Dastgeer Shaikh, Assistant Professor, University of Alabama, Huntsville, USA
- Dr. Gary Webb, Research Scientist, University of Alabama, Huntsville, USA
- Dr. Lubomir Martinovic, Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovakia, Master degree advisor, 2000-2003

Research interests:
- direct numerical simulations of Landau fluids and turbulence in general
- solar wind turbulence, especially the decay of density fluctuations
- Nearly incompressible theory
- general turbulence theories for hydrodynamic and MHD flows
- turbulent passive scalar mixing
- fast-direct Poisson solvers

Kareem Osman

T: +1 302 419 5354; E: kto@udel.edu; A: 334 E. Main St., Apt. E1, Newark, DE 19711, USA; Nationality: British

EDUCATION

2004–2008 **Imperial College London (Space & Atmospheric Physics Group)**
Ph.D. Multi-Spacecraft Measurement of Turbulence in the Solar Wind

- Pioneered the implementation of a novel multi-spacecraft technique using the Cluster spacecraft.
- Demonstrated the anisotropy of solar wind turbulence using correlation functions.
- Implemented a 3D turbulent field model, allowing quantitative comparison with other studies.
- Measured power and scaling anisotropy using structure functions.
- Used data from ACE, Geotail, IMP8, and Wind satellites.
- Presented work within the research group, at national meetings, and an international conference.

2000–2004 **Imperial College London**
MSci (Hons) Physics (First Class)

1998–2000 **The Lampton School, London**
A Level: Mathematics (A), Physics (A), Chemistry (A).

WORK EXPERIENCE

2009–Present **Bartol Research Institute, University of Delaware, USA**
Research Assistant

- Lead data analyst with speciality in multi-spacecraft techniques.
- Involved in both national and international collaborations.
- Organise Plasma Group Seminars.

2008–2009 **Imperial College London (Space & Atmospheric Physics Group)**
Research Assistant

- Teaching assistant to second year undergraduate C++ course. Duties included continuous assessment of students, marking coursework, and conducting 30 minute oral examinations.
- Co-organised fortnightly seminars, giving Ph.D. students the opportunity to present research related topics to their peers in an informal environment.
- Refereed papers submitted to peer-reviewed journals.

2003 (Jul–Oct) **European Organisation for Nuclear Research (CERN), Geneva, Switzerland**

- Responsible for the quality control of lead tungstate crystals in the Compact Muon Solenoid (CMS) particle detector, which is part of the Large Hadron Collider (LHC).
- Managed and analysed large data sets, since the CMS contains nearly 80,000 crystals.
- Worked to strict deadlines, and regularly presented results to the project supervisor.
- Produced a report which was made available to the entire research group, and a poster which was presented to an audience of my peers.

2002 (Jul–Oct) **Molecular Cell Biology Group, Imperial College London**

- Designed and built apparatus to measure single cell adhesion for use as a general research tool, and specifically for research into possible cancer treatments.
- Became familiar with the subject area and learnt a variety of new techniques, including tissue culturing, all within a very short time frame.
- Demonstrated proof of concept, which later led to a journal publication.

1998–1999 **Mathematics Department, The Lampton School, London**

- Voluntary work as a teaching assistant to an under-achieving class of 13–14 year olds.
- Communicated concepts effectively and motivated the students to work harder.

SKILLS & ACHIEVEMENTS

IT Skills	Matlab, C++, LaTeX, MS Word, Excel, and PowerPoint.
Languages	Arabic (intermediate) and German (basic).
Interests	Reading fiction and non-fiction books, active member of the Critical Reading Group (CRG) philosophy discussion forum at King's College London, and micro-blogging via Twitter.
2005–2006	Member of Imperial College Union Council: proposed and argued for several motions, took leading roles in campaigns, and communicated effectively to a cross-section of students.
2002–2003	Awarded Imperial College Union Full Colours for special contribution as a campus society member.
2001–2004	Helped raise over $\pounds 40,000$ for charity.

PUBLICATIONS

K.T. Osman and T.S. Horbury, **Multi-spacecraft measurement of anisotropic power levels and scaling in solar wind turbulence**, Ann Geophys, Vol: 27, Pages: 3019–3025, 2009.

K.T. Osman and T.S. Horbury, **Quantitative estimates of the slab and 2D power in solar wind turbulence using multi-spacecraft data**, J Geophys Res, Vol: 114, CiteID: A06103, 2009.

T.S. Horbury and K.T. Osman, **Multi-Spacecraft Turbulence Analysis Methods**, In: G. Paschmann and P. W. Daly, editor, Multi-Spacecraft Analysis Methods Revisited, Noordwijk, ESA Communications, Pages: 55–64, 2008.

C.P. Palmer, M.E. Mycielska, H. Burcu, K. Osman, et al., **Single cell adhesion measuring apparatus (SCAMA): application to cancer cell lines of different metastatic potential and voltage-gated Na+ channel expression**, Eur Biophys J, Vol: 37, Pages: 359–368, 2008.

K.T. Osman and T.S. Horbury, **Multispacecraft measurement of anisotropic correlation functions in solar wind turbulence**, Astrophys J, Vol: 654, Pages: L103–L106, 2007.

K.T. Osman and T.S. Horbury, **Multispacecraft measurement of anisotropic correlation functions in solar wind turbulence**, 24th International Union of Geodesy and Geophysics (IUGG), Pages: 3672, 2007.

REFEREES

Prof. William Matthaeus
Bartol Research Institute
Sharp Laboratory
University of Delaware
Newark
Delaware 19711
United States of America
E: whm@udel.edu
T: +1 302 831 2780

Dr. Tim Horbury
Space & Atmospheric Physics Group
The Blackett Laboratory
Imperial College London
Prince Consort Road
London SW7 2AZ
United Kingdom
E: t.horbury@imperial.ac.uk
T: +44 (0)20 7594 7676

CURRICULUM VITAE

RAFFAELE MARINO

PERSONAL INFO

- NAME: Raffaele - SURNAME: Marino - GENDER: Male
- CITIZENSHIP: Italian - DATE OF BIRTH: 21 May 1981 - EMAIL: rmarino@fis.unical.it

EDUCATION

December 2009 : **Ph.D. in PHYSICS** *"in co-tutelle"* (shared: 18 +18 months) between the *University of Calabria* (Arcavacata di Rende – CS, Italy) and the *University of Nice Sophia Antipolis* (CNRS, Observatoire de la Côte d'Azur, Nice – France).

December 2006: *Laurea Specialistica in FISICA* (two year degree akin to ***M.Sc. in PHYSICS)*** obtained at the *University of Calabria* (Arcavacata di Rende – CS, Italy), grade: *110/110 cum laude - full marks.*

December 2004: *Laurea triennale in FISICA* (three year degree akin to ***B.sc. in PHYSICS***) obtained at the *University of Calabria* (Arcavacata di Rende – CS, Italy), grade: *110/110 cum laude - full marks.*

PUBLICATIONS

- *Referred articles on ISI journals :*

- L. Sorriso-Valvo, ***R. Marino***, V. Carbone, F. Lepreti, P. Veltri, A. Noullez, R. Bruno, B. Bavassano, E. Pietropaolo , "Observation of inertial energy cascade in interplanetary space plasma". *Physical Review Letters* , 2007 Vol. 99, pp. 115001-1 - 115001-4, *Editor Suggestion of the week* [20 citations].
- ***R. Marino***, L. Sorriso-Valvo, V. Carbone, A. Noullez, R. Bruno and B. Bavassano, "Heating the Solar Wind by a Magnetohydrodynamic Turbulent Energy Cascade". *Astrophysical Journal Letters*, 2008, 667, pp. L71-L74 [10 citations].
- ***R. Marino***, L. Sorriso-Valvo,V. Carbone, R. Bruno, B. Bavassano and A. Noullez, "The energy cascade in solar wind MHD turbulence". *Earth, Moon, and Planets* , 2009, Volume 104, pp. 115-119 .
- V. Carbone, ***R. Marino*** , L. Sorriso-Valvo , A. Noullez, R. Bruno, P. Veltri, "Scaling laws of turbulence and heating of fast solar wind: the role of density fluctuations". *Physical Review Letters* , 2009 Vol. 103, pp. 061102-1 - 061102-4 [3 citations].
- V. Carbone, L. Sorriso-Valvo and ***R. Marino***, "The turbulent energy cascade in anisotropic MHD turbulence", *Europhysics Letters*, 2009, Vol. 88, pp. 25001-5 .

- *Referred conference proceeding papers : 3*
- *Books: 1*

SCIENTIFIC FIELDS OF INTEREST

Theoretical and experimental study of turbulence in astrophysical plasmas:
- Characterization of solar wind turbulence in the MHD approximation
- Scaling laws and turbulent heating in the solar wind
- Role of density fluctuations in compressible plasma turbulence
- Effects of Alfenicity in the turbulent energy transfer in the solar wind
- Statistical data analysis of spacraft time series

Turbulence and non-linear phenomena in atmosphere and laboratory fluid flows

GRANTS AND AWARDS: 7

- June 2009: GRANT-Programma Alta Formazione e Ricerca (Regione Calabria) to attend the "Solar Wind 12 Conference" 21 – 26 June 2009, Saint-Malo (FRANCE).
- April 2009 : EGU-GRANT + GRANT-Programma Alta Formazione e Ricerca (Regione Calabria) to attend "European Geosciences Union General Assembly" 2009, 19 – 24 April 2009, Wien (AUSTRIA).
- December 2008 : AGU-GRANT to attend the "American Geophysical Union Fall meeting", 15 – 19 December 2008, San Francisco (California – USA).
- November 2008 : GRANT-Programma Alta Formazione e Ricerca (Regione Calabria) for a stage, 1 – 30 November 2008, at the department of applied physics of *Universitat Polytecnica de Catalunya*, Barcelona (SPAIN).March 2008 : *Università Italo-Francese Award* for the Ph.D. thesis project "in cotutela".
- July 2007 : IUGG-GRANT to attend the IUGG XXI General Assembly - "Earth: our changing planet", 2 – 13 July 2007, Perugia (ITALY) .
- September 2007: *University of Calabria "GRANT for young researcher"*.
- December 2006: *University of Calabria 3-years Ph.D. Fellowship.*

INTERNATIONAL CONFERENCE AND SCHOOLS: 12