

European Research Training Network
Turbulent Boundary Layers in Geospace Plasmas
[Uppsala, Bochum, Oxfordshire, Warsaw, Orléans, Rome](#)
Sponsored by the European Commission (HPRN-CT-2001-00314)
<http://cluster.irfu.se/rtn/>

The Periodic Progress Report 2 **1 April 2003 – 31 March 2004**

For RTN:
Turbulent Boundary Layers in Geospace Plasmas

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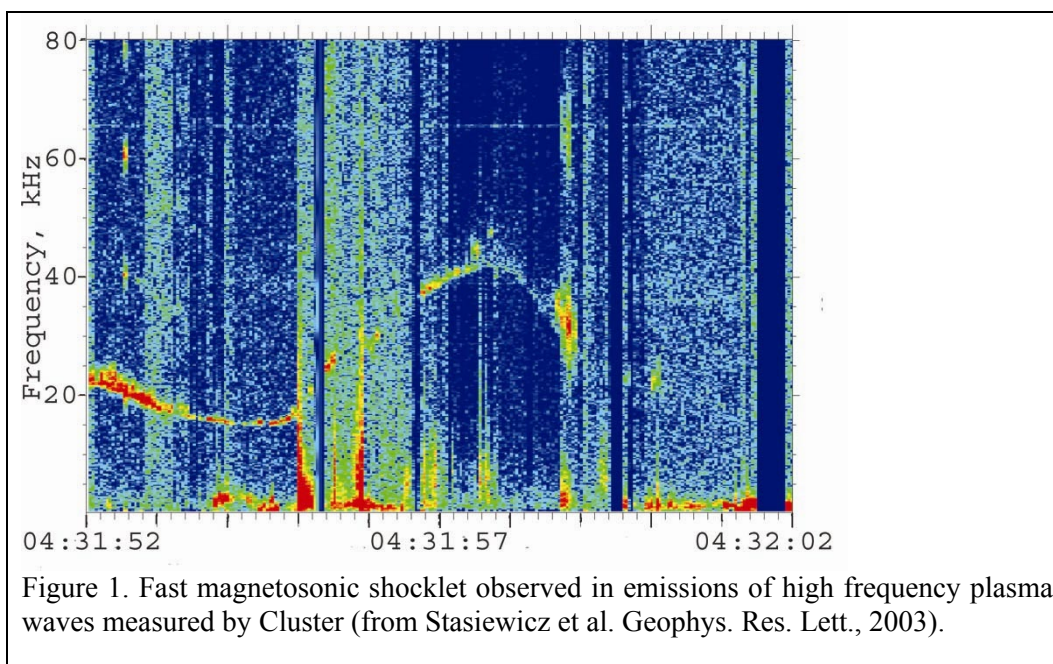
Part A – Research Results

During the period ending 31 March, 2004, we have achieved the following results:

- ✓ Over 45 articles published in refereed journals or submitted for publication (**7 articles in Physical Review Letters**).
- ✓ Experimental discovery of magnetosonic solitons in space.
- ✓ 26 presentations involving young researchers at international conferences.
- ✓ 8 network meetings and related conferences/schools.
- ✓ Research training provided to 18 young researchers from 10 countries.

A.1 Scientific Highlights (only during 2nd year)

Magnetosonic Shocklets at the Bow Shock



In a paper published in GRL we presented detailed properties of fast magnetosonic shocklets (1000 km in size and amplitude of 10 times the background B-field and density values) observed in natural unbounded collisionless plasma by a fleet of four Cluster spacecraft at the quasi-parallel bow shock. We provide for the first time details of the internal structure of shocklets which have magnetic pulses shifted in time from the plasma density pulses, have localized regions with ion acoustic turbulence, and are shown to slow down and thermalize the solar wind ions. The shocklets emit weak electron plasma waves which are used to verify the plasma density profiles within the structure and are for the first time reported in this paper. We provide an explanation for the observed relationship between the magnetic field and plasma density profiles within the structure. The results have been published in Geophysical Research Letters, 30(24), 2241, 2003. The physics behind the fast magnetosonic shock is not well understood and it will be the subject of further investigations within the network.

Computer simulations of nonlinear interactions in plasmas

The Bochum group collaborated with the groups at RAL, IRFU Uppsala, and U. Orleans in the areas of wave turbulence and coherent nonlinear structures. We developed Vlasov, hybrid, and particle in cell (PIC) codes to investigate the generation of waves, their saturation via particle trapping and the formation of phase space ion and electron holes, which have been

observed at the turbulent boundary layers of the Earth's magnetosphere. Fully nonlinear theories for trapping of Langmuir waves in density holes have been presented. A statistical theory for drift wave turbulence in a nonuniform magnetoplasma has been developed, and is being applied to understand the origin of incoherent fluctuations in space plasmas. We also reviewed the status of electron acceleration by intense electrostatic fields in plasmas, and published a topical review article in Plasma Physics and Controlled Fusion. Prof. Shukla and Prof. Bingham organized the International Topical Conference on Plasma Physics in Santorini which took place from 8.9.03-12.9.03, and the Conference Proceedings will be published as one of the Topical Issues of Physica Scripta. The Santorini Conference provided young researchers with the opportunity to display their results in the form of poster and oral presentations. Dr. Mark Dieckmann of Sweden was hired on the project for two months (Sept.-October '03) and carried out PIC simulations of ion beam driven turbulence in space plasmas. Specifically, he collaborated with Dr. B. Eliasson and Prof. P. K. Shukla and wrote several papers dealing with shock waves and particle acceleration. Drs. Mark Dieckmann and Mattias Marklund (both Swedish nationals) have joined the Bochum group starting January 1, 2004.

[A new simulation Model for SW – Planetary Magnetosphere Interactions under development at RAL.](#)

This work is complimentary to research that we are undertaking with the Cluster spacecraft measurements of the bow shock and magnetopause. The second part of our research project involves the development and implementation of a three-dimensional particle in cell code which can model fully the interaction of the solar wind with planetary magnetospheres. Our young doctoral student, Luis Gargate, is developing this code as part of his doctoral research. He successfully posted an existing code developed for the analysis of the Ampte active space experiments. The code was previously running on a mainframe as a serial code and is now in the process of being parallelized to run on the multi-mode cluster. Preliminary results of the code simulating the solar wind interacting with non-magnetized neutral plasmasphere demonstrate the full versatility of this code. The main success of this work is that within a few months we have a state of the art fully dimensional particle ion fluid electron simulation code that is much superior to the usual magnetohydrodynamic codes used at present to simulate these types of problems. The main results of the initial analysis are being written up in a paper which will be submitted in the near future. In fact, the code will provide an ideal source of turbulent wave structures which will be compared with Cluster spacecraft and Mars express spacecraft measurements.

[Microstructure of the reconnection layer.](#)

Popielawska et al. (2003) have studied electric, magnetic field and plasma signatures at the reconnection region near the cusp. They found whistler type electromagnetic wave packets and electron holes at the wall of the magnetic cavity near the reconnection region. The magnetic separatrix region was associated with a sharp minimum of the local plasma density, as predicted by simulations with electron PIC codes. This study involves data from Polar and the results were presented at the EGS meeting in Nice, 2003.

[Interpretation of Downshifted Electron Plasma Oscillations observed by Cluster.](#)

WHISPER measurements made aboard four Cluster satellites during the Earth's bow shock crossing on 24 January 2001 have shown the presence of two types of high-frequency electrostatic waves in the electron foreshock region: Langmuir and downshifted waves with frequencies between electron and ion plasma frequencies. The downshifted waves are observed upstream of the shock front and they grow just in the vicinity of the forward edge of the whistler precursor wave train. The variations of the central frequency of the downshifted oscillations are non-monotonic and coordinated with the evolution of the electron distributions across the foreshock. These variations can result from non-stationarity of the shock front, i.e. from the variations of the suprathermal electron fluxes reflected from the shock front. Due to a plasma-beam instability, the varying electron fluxes generate

downshifted electrostatic waves with varying central frequency and bandwidth. Stability analysis with the use of typical parameters of the suprathermal electrons shows that the downshifted waves can be generated in a plasma, where the relative velocity of the bulk and reflected components is comparable with the thermal velocity.

[Statistical properties of magnetic field and plasma parameter fluctuations in turbulent regions.](#)

In this second year, Consolini et al. (2003) studied the existence of nonlinear turbulent coherent structures in the magnetospheric transition layers by analysing CLUSTER satellite data using the wavelet Local Intermittency Measure (LIM) technique and the wavelet spectral bicoherence, which allows the detection of short-lived events and pulses in the phase coupling. In detail, the existence of coherent time-frequency structures has been found in coincidence with short-lived phase coupling, suggesting that the origin of the observed turbulence is the results of localized interacting magnetic structures. The results were presented at the ITCPP on *Complex Plasmas in the New Millennium*, held in Santorini, and are the subject of a paper in preparation.

Furthermore, the IFSI group in cooperation with other groups (IRFU, LPCE and SRC) started to investigate the scaling properties of the Probability Distribution Functions (PDFs) of the magnetic field and plasma parameters fluctuations as observed in different turbulent regions (the magnetosheath, the central plasma sheet, etc.) using data from different satellites (AMPTE/CCE, INTERBALL Tail, CLUSTER, etc.). The investigation of the scaling properties is relevant for the study of the transport features in turbulent regions. In this framework, it has been shown that the PDFs exhibit different scaling in the kinetic and MHD domains suggesting the occurrence of a continuous symmetry breaking, and that the PDFs in the kinetic domain differ from the usual Gaussian distribution. A new approach to non-Gaussian distributions of turbulent fluctuations has been proposed in the Framework of the Nonextensive Statistical Mechanics introduced by Tsallis (1988), suggesting that the fluctuations at the smallest scales do not obey the standard Boltzmann-Gibbs Statistical Mechanics. This new approach has been presented at the Workshop on *Nonlinear approaches to turbulent geoplasmas*, held at IFSI in Rome (November, 2003), and at the *Conference on Sun-Earth Connections: Multiscale coupling of Sun-Earth Processes*, held in Kona, USA (February, 2004). A paper on this topic is in preparation.

A.2 Joint Publications

Note: Alphabetical order, **young researchers** are marked with bold font.

This list includes publications from the start of the network.

R. Bingham, P. K. Shukla and D. S. Spicer

Solar Coronal heating by dissipating current sheets, *Physica Scripta* T107, 247 (2004).

Networking: RAL, RUB, Work Package WP3.1

R. Bingham, J. T. Mendonca and P. K. Shukla

Plasma based charged particle accelerators, *Plasma Phys. Contr. Fusion* 46, R1-R23, 2004.

Networking: RAL, RUB.

J. Blecki, S. Savin, H. Rothkaehl, R. Wronowski, K. Stasiewicz, Z. Nemecek, J. Safrankova and K. Kudela

The role of the wave particle interactions in the dynamics of the plasma in the polar cusp, *Cosmic Research*, vol 41, no 4, 332-339, 2003. Networking: SRC, IRFU, WP1.1

J. Błęcki, R. Wronowski, S. Savin, N. Cornilleau-Wehrin, M. Parrot, J. Safrankova, Z. Nemecek, O. Santolik and J-A. Sauvaud

Filamentation of the space plasmas, "Proceedings of WDS Conference, pp 371- 380, Prague 2003. Networking: SRC, LPCE.

J. Błęcki, S. Savin, N.Cornilleau-Wehrin, K. Kossacki, M. Parrot, H. Rothkaehl, K. Stasiewicz, R. Wronowski, O. Santolik and J-A. Sauvaud

Fine structure of the polar cusp as deduced from the plasma wave and plasma measurements, *Adv Space Res.*, vol 32, No 3, pp315-321, 2003. Work packages: WP1.1. Network: SRC, IRF

M. E. Dieckmann, B. Eliasson, A. Ynnerman and A. Stathopoulos

Connecting shock velocities to electron injection mechanisms. *Phys. Rev. Lett.*92, 65006 (2003).

M. E. Dieckmann, B. Eliasson, A. Stathopoulos and A. Ynnerman

Kinetic simulation of electron injection by electrostatic waves,
Baltic Astronomy, Proceedings of JENAM conference in Budapest, in press, 2004.

M. E. Dieckmann, B. Eliasson, and P. K. Shukla

Streaming instabilities driven by mildly relativistic proton beams in plasmas. *Phys. Plasmas* 11, 1394 (2004).

M. E. Dieckmann, B. Eliasson and P. K. Shukla,

Relativistic Ion Beam Instability as a source for Gamma-Ray Bursts,
Phys. Rev. Lett., submitted 2004.

B. Eliasson

Numerical Modelling of the Fourier Transformed Two-Dimensional Vlasov-Maxwell System,
Journal of Computational Physics, 190, pp. 501-522, (2003).

B. Eliasson and P. K. Shukla

Trapping of Langmuir Waves in Ion Holes, *Physica Scripta T107*, 192, 2004.

B. Eliasson and P. K. Shukla

Production of Non-Isothermal Electrons and Langmuir Waves Due to Colliding Ion Holes and Trapping of Plasmons in an Ion Hole. *Physical Review Letters* 92, 095006, 2004.

B. Eliasson and P. K. Shukla

Simulation Study of Radiation Generation by Upper-Hybrid Waves in Space Plasmas, *Phys. Rev. Lett. A* 312, p. 91-96, 2003. Work packages: WP3.1, WP3.2

B. Eliasson and P. K. Shukla

Analytical and Simulation Studies of Nonlinear Effects Caused by Upper-Hybrid Waves in Plasmas. *Phys. Plasmas*, 10, p3539, 2003. Work packages: WP3.2

B. Eliasson, Domain decomposition of the Pade scheme and pseudospectral method applied to Vlasov simulations. Submitted to *SIAM Journal on Scientific Computing*, 2003.

L. Gargate, R. Bingham and L. O. Silva

Three-dimensional Hybrid simulations of mass loading in space plasmas. To be submitted to *J. Comp. Phys.* (2004). Work package WP3.1

Y. Khotyaintsev, S. Buchert, K. Stasiewicz, A. Vaivads, S. Savin, V. O. Papitashvili, C. J. Farrugia and B. Popielawska

Transient reconnection in the cusp during strongly negative IMF B_y , Accepted for publication in *J. Geophys. Res.*, 2003. Networking: IRF-Uppsala, SRC-Warsaw. Work packages: WP1.1, WP1.2

Y. Khotyaintsev, A. Vaivads, Y. Ogawa, B. Popielawska, M. Andre, S. Buchert, P. Decreau, B. Lavraud and H. Reme

Magnetic reconnection in high-beta plasma: Cluster observations in cusp. Submitted to *Ann. Geophys.*, 2003. Work packages: WP1.2, Networking: IRFU, SRC, LPCE

V. Krasnoselskikh, V. Lobzin, S. Schwartz, P. Décreau, B. Lefebvre, J.-L. Pinçon, M. Dunlop, J.-M. Bosqued, S. Bale, A. Balogh, N. Cornilleau-Wehrin, A. Fazakerley and G. Gustafsson

Interpretation of Downshifted Electron Plasma Oscillations observed by Cluster. Submitted to *J. Geophys. Res.*, 2003. Networking: LPCE, IRFU.

W. Macek, R. Bruno and G. Consolini

Testing for multifractality in slow solar wind

Physical Review E, submitted 2004-04-02

Networking: IFSI-Rome, SRC-Warsaw

Work Packages: WP2.2

J. Mendonca, R. Bingham and P. Shukla

Resonant quasi-particles in plasma turbulence, *Phys. Rev. E* 68, 016406, 2003. Networking RUB, RAL, Work packages WP3.2

B. Popielawska and G. Gustafsson

The distant cusp and the surrounding magnetopause: A view in snapshots from POLAR, *Adv. Space Research*, Vol 31, No.5, pp 1353-1362, 2003. Networking: SRC-Warsaw, IRF-Uppsala, Work packages: WP1.2, WP1.3

S. Savin, L. Zelenyi, S. Romanov, I. Sandahl, J. Pickett, E. Amata, L. Avano, J. Blecki, E. Budnik, J. Buechner, C. Cattell, G. Consolini, J. Fedder, S. Fuselier, H. Kawano, S. Klimov, V. Korepanov, D. Lagoutte, F. Marcucci, M. Mogilevsky, Z. Nemecek, B. Nikutowski, M. Nozdrachev, M. Parrot, J. L. Rauch, V. Romanov, T. Romantsova, C. T. Russell, J. Safrankova, J. A. Sauvaud, A. Skalsky, V. Smirnov, K. Stasiewicz, J. G. Trotignon and Y. Yermolaev

Magnetosheath - Cusp Interface, *Ann. Geophys.*, in press, 2003. Networking: IFSI-Rome, SRC-Warsaw, LPCE-Orleans. Work packages: WP1.1, WP2.2, WP2.1

S. Savin, A. Skalsky, L. Zelenyi, P. Song, T.A. Fritz, E. Amata, J. Buechner, J. Blecki, L. Avano, N. Borodkova, G. Consolini, C. Farrugia, S. Klimov, **Y. Khotyaintsev**, V. Lutsenko, N. Maynard, B. Nikutowski, E. Panov, J. Pickett, J.L. Rauch, S. Romanov, J.A. Sauvaud, V. Smirnov, K. Stasiewicz, J. G. Trotignon and Y. Yermolaev

Magnetosheath interaction with high-latitude magnetopause, *Surveys in Geophys.*, 2003. Networking: SRC-Warsaw, IRF-Uppsala, IFCI-Rome, LPCE-Orleans. Work packages: WP1.1, WP2.2, WP2.1

S. Savin, J. Buchner, G. Consolini, B. Nikutowski, L. Zelenyi, E. Amata, H. U. Auster, J. Błęcki, E. Dubinin, K. H. Fornacon, H. Kawano, S. Klimow, F. Marcucci, Z. Nemecek, A. Pederson

On the properties of turbulent boundary layer over polar cusps, *Nonlinear Processes in Geophysics*, **9**, 443-451, 2002. Networking: IFSI-Rome, SRC-Warsaw, LPCE-Orleans. Work packages: WP1.1, WP2.2, WP2.1

P. K. Shukla, **M. Marklund**, D. D. Tskhakaya, B. Eliasson, Nonlinear effects associated with interactions of intense photons with a photon gas, *Physics of Plasmas*, (in press, 2004)

B. Eliasson and P. K. Shukla, Dust Acoustic Shock Waves, *Phys. Rev. E* 69, (in press, 2004)

- P. K. Shukla, **M. Marklund** and **B. Eliasson**, Intensification of light in an electron-positron plasma *Phys. Lett. A* 324, 193 (2004);
- P. K. Shukla, **M. Marklund** and **B. Eliasson**, Vacuum compression of trapped electromagnetic waves. *Optics Communication* 235/4-6, pp. 373-376 (2004);
- P. K. Shukla, **B. Eliasson**, **M. Marklund** and R. Bingham, Nonlinear model for magnetosonic shocklets in plasmas. *Physics of Plasmas* 11, 2311 (2004);
- P. K. Shukla, A A Mamun and **B. Eliasson**, 3D electron-acoustic solitary waves introduced by phase space electron vortices in magnetized space plasmas. *Geophysical Research Letters* **31**, (in press, 2004);
- D. Tshkhakaya, **B. Eliasson** and P. K. Shukla, On the theory of plasma-wall transition layers. *Physics of Plasmas* **11**, (in press, 2004);
- M. Marklund**, **B. Eliasson** and P. K. Shukla, Self-Compression and Catastrophic Collapse of Photon Bullets in Vacuum. *JETP Letters* 79, No 5, pp. 208-212 (2004) [Pis'ma v Zhurnal Éksperimental'noi i Teoreticheskoi Fiziki, Vol. 79, No. 5, 262-266 (2004)];
- P. K. Shukla and **B. Eliasson**, Modulational and Filamentational Instabilities of Intense Photon Pulses and Their Dynamics in a Photon Gas, *Physical Review Letters*, 92, 73601/1-4 (2004)
- P. K. Shukla and **B. Eliasson**, Complete theory for Langmuir envelope solitons in dusty plasmas *Physics of Plasmas* **11**, 584 (2004);
- P. K. Shukla, **B. Eliasson** and L. Stenflo, Stimulated scattering of intense radio waves in partially ionized space dusty plasmas. *Journal of Geophysical Research* 109, A03301 (2004)
- P. K. Shukla, **B. Eliasson** and L. Stenflo, Nonlinearly coupled upper-hybrid and magnetosonic waves in collisional magnetoplasmas *Phys. Rev. E* 68, p. 067401 (2003)
- P. K. Shukla and **B. Eliasson**, Trapping of Plasmons in Ion Holes *JETP Lett.* , 77, 778 (2003).
- P. K. Shukla, **B. Eliasson** and **I. Sandberg**, Theory of Cavitons in Complex Plasmas. *Physical Review Letters*, 91, 75005 (2003);
- P. K. Shukla, A. A. Mamun and R. Bingham
Comment on Mach cones and magnetic forces in Saturn's rings, *JETP Lett.*, 78, 110-111, 2003. Networking: RUB, RAL
- P. K. Shukla and R. Bingham
Generation of density enhancement by magnetohydrodynamics waves, *Physica Scripta T107*, 2004. Networking: RUB, RAL.
- K. Stasiewicz, P. Shukla, G. Gustafsson, S. Buchert, **B. Lavraud**, B. Thidé and Z. Klos
Magnetosonic Solitons Detected by the Cluster Spacecraft, *Phys. Rev. Lett.*, 90(8), 085002, doi:10.1103/PhysRevLett.90.08502, 2003. Networking: IRF-Uppsala, RUB-Bochum, SRC-Warsaw. Work packages: WP3.2
- K. Stasiewicz, **Y. Khotyaintsev** and **M. Grzesiak**,
Dispersive Alfvén Waves Observed by Cluster at the Magnetopause, *Physica Scripta*, T105, in press, 2004,. Networking: IRFU, SRC.

K. Stasiewicz, **M. Longmore**, S. Buchert, P. Shukla, B. Lavraud, J. Pickett
Properties of Fast Magnetosonic Shocklets at the Bow Shock, *Geophys. Res. Lett.*, 30(24),
2241, doi:10.1029/2003GL017971, 2003. Networking: IRFU, RUB, Work packages: WP3.2

R. Trines, R. Bingham, L. O. Silva, P. K. Shukla et al.
Wave Kinetic Code for turbulent wavepackets. To be submitted to *J Comp, Phys.*, 2003.
Networking RAL, RUB, Work packages: WP3.3

R. Wronowski, J. Błęcki, N. Cornilleau-Wehrin, M. Parrot, O. Santolik and S. Savin
Applications of wavelet and bispectral analysis for studies of wave processes in the polar
cusp., *Proceedings of WDS Conference*, pp381-385, Prague 2003. Networking: SRC, LPCE.
Work packages: WP3.2

E. Yordanova, **M. Grzesiak**, A. W. Wernik, B. Popielawska and K. Stasiewicz
Multifractal structure of turbulence in the magnetospheric cusp, submitted to *Ann.
Geophysicae*, 2003. Networking: SRC, IRFU, Work packages

Presentations on International Conferences involving young researchers, summer schools.

D. Clack

Current density structure of shocklets/SLAMS, *Workshop on Nonlinear approaches to
Turbulent Geoplasma, 27-28 November 2003, Rome.*

D. Clack

Summer school, *Basic Processes of Turbulent Plasmas, 23-28 September 2003 in Chalkidiki,
Greece.*

G. Consolini, **M. Kretzschmar**, E. Amata and S. Savin, *Scaling features of Magnetic field
fluctuations in the geotail neutral sheet, Conference on Sun-Earth Connections: Multiscale
coupling of Sun-Earth Processes, 9-13 February 2004, Kona, (USA)*

B. Eliasson and P. K. Shukla, Excitation and trapping of electrostatic waves by ion and
electron phase space holes, *EGU - 1st General Assembly, 25--30 April, 2004, [EGU04-A-01422](#)*, invited talk.

B. Eliasson and P. K. Shukla

Analytical and Simulation Studies of Nonlinear Effects Caused by Upper-Hybrid Waves in
Plasmas, *STAMMS meeting, Orleans, France, May 12-16, 2003.*

B. Eliasson

Interactions between ion holes and the generation of Langmuir waves in space plasmas,
ITCPP, 8-12 September, 2003, Santorini, Greece. Invited.

B. Eliasson and P. K. Shukla, Simulation Study of Nonlinear Effects at the Upper-Hybrid
Layer in Plasmas, *ITCPP conference in Santorini*, Poster presentation, 2003

B. Eliasson

Excitation and trapping of nonisothermal electrons and Langmuir waves by colliding ion
holes, *Workshop on Nonlinear approaches to Turbulent Geoplasma, 27-28 November 2003,
Rome.*

B. Eliasson, Vlasov-Maxwell computer simulations of plasma turbulent processes in geospace to be studied with LOIS. *4th LOIS Workshop*, Uppsala, Sweden, 23-25 June, 2003.

M. Grzesiak

Lifted wavelets in application to turbulence, *Workshop on Nonlinear approaches to Turbulent Geoplasma*, 27-28 November 2003, Rome.

Y. Khotyaintsev, A. Vaivads, Y. Ogawa, B. Popielawska, M. Andre, S. Buchert, P. Decreau, B. Lavraud and H. Reme
Reconnection in high-beta plasma: Cluster observations in the exterior cusp, *Sixth Cluster Workshop, ESTEC, Nordwijk, October 2003*.

M. Kretschmar

Multifractality and non-Gaussian statistics in a magnetospheric turbulent region: an example. *Workshop on Nonlinear approaches to Turbulent Geoplasma*, 27-28 November 2003, Rome.

M. Longmore, D. Clack, K. Stasiewicz, E. Amata and S. Buchert

The turbulent nature of the quasi-parallel shock: Observations from Cluster, Poster, *ITCPP conference on Plasma Physics, September, 2003, Greece*.

M. Longmore, K. Stasiewicz, **B. Lavraud**, S. Schwartz and S. Buchert

Particle Thermalisation by Fast Magnetosonic Structures at the Bow Shock, *ITCPP conference on Plasma Physics, September, 2003, Greece*.

M. Longmore

Observations properties of large amplitude compressive structure at the quasi-parallel bow shock, *Workshop on Nonlinear approaches to Turbulent Geoplasma*, 27-28 November 2003, Rome.

M. Longmore

Summer school, *Basic Processes of Turbulent Plasmas*, 23-28 September 2003 in Chalkidiki, Greece.

B. Popielawska, G. Gustafsson, **Y. Khotyaintsev**, I. Sandahl and V. A. Styazhkin
High-Latitude magnetopause under northward IMF: Signatures of Magnetic Merging, *International Symposium in Memory of Professor Yuri Galperin, Feb. 4-7, 2003, Space Research Institute of R.A.S., Moscow*.

B. Popielawska, **Y. Khotyaintsev**, G. Gustafsson, B. Kellett, C. Farrugia, J. Pickett and K. Stasiewicz
Structure of high-latitude magnetopause near the merging site, *EGS/AGU Meeting in Nice, France, 7-12 April, 2003*.

B. Popielawska, **Y. Khotyaintsev**, G. Gustafsson, B. Kellett, C. Farrugia, J. Pickett, and K. Stasiewicz
Structure of high-latitude magnetopause near the merging site, *STAMMS: Orleans, France, 12-16 May 2003*.

B. Popielawska, **Y. Khotyaintsev**, J. Pickett, C. Farrugia, B. Kellett, G. Gustafsson and K. Stasiewicz
Langmuir and Electron Solitary Waves at High-latitude Magnetopause Near the Merging Site, *Prague Conference, Magnetospheric Response to Solar Activity, solicited talk, Prague, 2003*.

P. K. Shukla, **B. Eliasson** and **I. Sandberg**

Density holes created by modulated Langmuir waves in complex plasmas, *Tenth Workshop on the Physics of Complex Plasmas, St. Thomas, United States Virgin Island, June 18-21, 2003.*

K. Stasiewicz, P. Shukla, G. Gustafsson, S. Buchert, **B. Lavraud**, B. Thidé and Z. Klos
Slow magnetosonic solitons detected by Cluster, *EGS/AGU Meeting in Nice, France, 7-12 April, 2003. Invited.*

K. Stasiewicz, **M. Longmore**, S. Buchert and P. Shukla
Properties of magnetosonic solitons and shocklets at the bow shock, *ITCPP, 8-12 September, 2003, Santorini, Greece. Invited.*

R. Trines

Photon Kinetic Description of 1-D Relativistic EM Pulse Solitons, *Workshop on Nonlinear approaches to Turbulent Geoplasma, 27-28 November 2003, Rome.*

E. Yordanova, M. Grzesiak, A. W. Wernik, B. Popielawska and K. Stasiewicz
Multifractal structure of turbulence in magnetospheric cusp, *STAMMS, Orleans, France, 12-16 May 2003.*

E. Yordanova

Multifractal analysis of turbulent magnetic field in the high-altitude polar cusp, *Summer school Basic Processes of Turbulent Plasmas, 23-28 September 2003 in Chalkidiki, Greece.*

Part B – Comparison with the Joint Programme of Work

B.1 Research Objectives

Research objectives, as set down in Annex I of the contract are fully relevant and achievable.

B.2 Research Methods

The research method for our network as described in Annex I of the contract remains unchanged. We note that the RUB-Bochum group provides a larger contribution to the simulation efforts than anticipated in the original proposal.

B.3 Work Plan

The work plan and breakdown of tasks is essentially unchanged. There may be some variation in the time sequence of work packages and milestones. Some changes in the work plan will be implied by the discovery of slow and fast magnetosonic solitons and identification of fast magnetosonic shock waves as described in section A. In order to take advantage of our leading position in this “hot” research direction we shall temporarily concentrate our effort around the studies of the emergence and properties of strongly nonlinear plasma structures, shock waves, and solitons. However, this topic was already in our research plan, hence it represents a change of emphasis rather than a change of the work plan.

Project Milestones (Table 2 from the contract)

Year	<u>WP1. Properties of Turbulence</u>
1	M1.1. Provide full picture of spectral characteristics of the observed turbulence in the frequency and k-domains.
2	M1.2. Classification of nonlinear structures together with determination of their physical properties.
3	M1.3. Provide details of energised particles and their relation to turbulent fields.
<u>WP2. Statistical Characteristics of Turbulence</u>	
1	M2.1. Determination of nonlinear wave-wave interactions by using modern spectral methods.
2	M2.2. Demonstration of intermittency and anomalous scaling laws for nonlinear dynamical scenarios.
3	M2.3. Determination of anomalous diffusion coefficient and anomalous resistivity related to turbulence.
<u>WP3. Theory and Computer Simulation</u>	
1	M3.1. Development of kinetic theory in the presence of various energy sources.
2	M3.2. Microscopic theories for nonlinear structures and development of 3D.
3	M3.3. Development of quasi-linear and renormalised turbulence theories and their application to transport processes.

B.4 Organisation and management

As can be seen in section A.2 all groups have contributed to joint publications, although with variable extent.

The research staffs at the professor or senior scientist level, responsible for training of young researchers in member groups are listed below:

IRF-Uppsala

Kristof Stasiewicz, Georg Gustafsson, Bo Thidé.

RAL-CCLRC

Robert Bingham, Barry Kellet, Chris Perry.

RUB-Bochum

Padma K. Shukla, Bengt Eliasson.

SRC-Warsaw

Zbigniew Klos, Barbara Popielawska, Andrzej Wernik, Wieslaw Macek, Jan Blecki.

LPCE-Orleans

Vladimir Krasnoselskikh, Pierrette Décreau, Thierry Dudok de Wit, Jean-Louis Pinçon.

IFSI-Rome

Giuseppe Consolini, Ermanno Amata.

B4.2 network meetings and related conferences

All network activities and events have been announced through e-mail to all network participants and posted also on the network WWW website <http://cluster.irfu.se/rtn/>. We have

avoided purely administrative meetings, and most network meetings were scheduled in association to larger international meetings that would have been attended by several network members anyway.

After 1 April 2002, the official start of the network, we had the following network meetings and network related conferences:

29-30 April 2002: Meeting of group leaders, IFSI, Rome.

Topics discussed: Organization of the network, requirements imposed by RDG EC, relation to the Cluster project, recruitment of young researchers.

17-19 September, 2002: 2nd RTN Meeting and Cluster workshop, RAL, Oxfordshire, UK.

The network meeting was organised in connection to the Cluster workshop at RAL, UK, which was attended by over hundred participants. The network was represented by 12 members.

7-11 April, 2003. Combined EGS-AGU meeting in Nice.

The total number of participants was over five thousand. About 10 network members attended this meeting and had either invited, oral or poster presentations during the congress.

12 May 2003, 3rd Network Meeting, Orleans, France.

This meeting was scheduled together with an international conference STAMMS (Spatio-Temporal Analysis of Multipoint Measurements in Space), Orleans, France, 12-16 May. The conference was organised by our network members at LPCE-Orleans, V. Krasnoselskikh, T. Dudok de Wit and P. Decreau. It was an opportunity for young researchers to present initial results of their work.

7 September 2003: 4th Network Meeting, Fira, Greece.

This meeting was organised in association with the International Topical Conference on Plasma Physics, 8-12 September, Santorini. The conference gathered over 120 participants and was organised by two members of our network, P.K. Shukla and R. Bingham. Young researchers had opportunities to present their work and to listen to tutorial presentations from experts in various fields of plasma physics. Through this conference we trained a large number of network pre- and postdoctoral researchers as well as many young European researchers from other networks in the interdisciplinary areas of space and astrophysics.

23-28 September 2003: Summer school in Chalkidiki, Greece.

The summer school "Basic Processes of Turbulent Plasmas" was attended by several young researchers from our network.

27-28 November, 2003: Workshop on nonlinear approaches to turbulent geoplasmas, Rome, Italy.

This workshop was organised by our group at IFSI-Rome (G. Consolini and E. Amata). Fourteen members from our network attended this workshop. It provided relaxed atmosphere and plenty of time to discuss topics of complexity in space plasmas, fractals, chaos, and other advanced concepts of nonlinear dynamical systems.

13 December 2003: Nobel lectures, Uppsala, Sweden.

Young researchers and network members from our group in Uppsala attended lectures of Nobel laureates in physics at Uppsala University. It was interesting to note that Vitaly Ginzburg mentioned "*nonlinear physics, turbulence, solitons, chaos, strange attractors*" as interesting topics to be investigated by the younger generation of physicists. Incidentally, these are also main topics of our network.

21-25 January 2004: Industrial training in Kiruna.

Young researchers visited ESRANGE a satellite and rocket range station run by the Swedish Space Corporation in northern Scandinavia. Young researchers learned about space technology, rocket launchers, balloon launching, satellite telemetry stations, remote sensing, operations of a LIDAR station, etc. Valuable was also visit to fully automated iron ore mine in Kiruna.

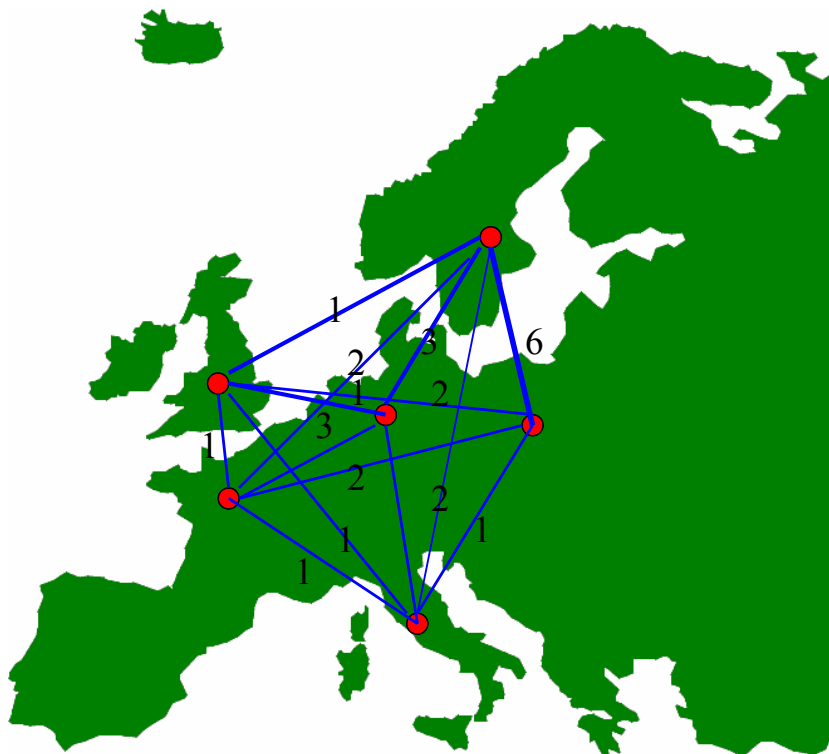
26-27 January 2004: Mid-term review in Uppsala, Sweden.

24 participants attended this meeting. Highlights from this meeting, as well as from the industrial training in Kiruna are posted on the web <http://cluster.irfu.se/rtn/>

8-13 February, Sun-Earth Connection Conference in Kona, USA

19-23 April, 2004: Alfvén workshop on Space Environment Turbulence, Beaulieu, France

24-28 April 2004: European Geophysical Union meeting in Nice, France.

B4.3 networking interactions

The map above shows the networking activity expressed in person-weeks of researchers from different nodes of our network.

B.5 Training

Employment of young researchers (status by 31 March 2004)

<i>Participant</i>	<i>Contract deliverable of Young Researchers to be financed by the contract (person-months)</i>			<i>Young Researchers financed by the contract so far (person-months)</i>		
	<i>Pre-doc (a)</i>	<i>Post-doc (b)</i>	<i>Total (a+b)</i>	<i>Pre-doc (c)</i>	<i>Post-doc (d)</i>	<i>Total (c+d)</i>
1. IRF	10	24	34	15	18	33
2. RAL	8	24	32	6	10	16
3. RUB	10	24	34		22	22
4. SRC	8	24	32	12	1	13
5. LPCE	8	24	32	1	4	5
6. IFSI	8	24	32		10	10
TOTAL	52	144	196	34	65	99

After initial delays in recruitment of young researchers in 2002, we have accelerated the pace of engagements of young researchers in the network's training programme. In 2004 we expect a peak activity in training and we should deliver the contracted person-months for young researchers at the end of the network in 2005. Certain groups have experienced some difficulties in recruitment.

Training Programme

The six groups have different approaches to conducting scientific research, which creates a multidisciplinary atmosphere within the network. IRF-Uppsala is the main provider of satellite measurements, which are analysed with non-linear statistical tools by groups in IFSI-Rome, SRC-Warsaw and LPCE-Orleans. The theory groups in RUB-Bochum and RAL-Didcot provide computer simulation tools that enable better understanding of the complexity of the observed phenomena in the turbulent boundary layers around the Earth.

Young researchers at RUB-Bochum played a significant part in the organization of a major conference (International Topical Conference on Plasma Physics, Greece, September, 2003), which was an opportunity for scientific training of young researchers, and where our network played a prominent role.

Several young researchers employed in the network participated in a conference on Spatio-Temporal Analysis of Multipoint Measurements in Space organized by LPCE-Orleans (May 2003). The conference provided a good opportunity to practice presentation skills and preparation of large scientific materials in the form of posters and Power Point presentations.

Young researchers in Uppsala are taking part in a wide offer of various courses at postgraduate levels offered by the local university. This includes courses in Swedish. In order to integrate international researchers with the rather large group of young researchers at IRF-

Uppsala we organised an integration camp on Åland islands. These activities are described on the network website.

Connection to industry

During January 21-25, 2004, we performed an industry related training of young researchers at ESRANGE in northern Scandinavia. ESRANGE is a satellite and rocket range station run by the Swedish Space Corporation. Young researchers have gained some experience related to space technology, rocket launchers, satellite telemetry stations, remote sensing, etc.

B.6 Difficulties

Some groups have difficulties with filling vacant positions for young researchers without full financial coverage in their accounts. This requirement is incompatible with the current procedure of transferring EU funds to participating institutes where funds may come at the end of the employment period. It would be beneficial to have a general regulation that would solve this problem.