Final report of INTAS99-0335 project:
The ionospheric Alfvén resonator, ULF waves (0.1-10Hz), and particle phenomena in the near-Earth environment

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accumulating report: progress during 3rd year with greyish/coloured background

SUMMARY OF RESULTS AND KEY REFERENCES

1. RESEARCH

1.1. Overview of Research Activities / Conformance with the Work Programme

T1.1. Fully implied and accomplished as outlined in the co-operation agreement (P1, P2, P5, P6, P7, also P4 joined the topic). Diurnal, seasonal, and long-term behaviour of parameters characterising SRS at high and low-latitude were investigated. Two related publications in 2002/2003 [4, 7]. Study of non-linear dependence of IAR reflection on the precipitated energetic proton flux using full-wave modelling (P4). A new type of experiment on large scale spatial distribution of ULF fields from a controlled source at Kola Peninsula was carried out in September – October 2001 (P6). First differential ULF field measurements with a base line distance of only 50 km (P4). First report on joint high, mid and low latitude simultaneous triple point SRS measurements in preparation (P1, P2, P7, [15]).

T1.2. Collecting low latitude quasi-periodic, long period modulation in magnetic background noise intensity presumably caused by travelling gravity waves (P6, P1). Paper dealing with a terminator effect at sunrise and sunset on polarization properties of magnetic background noise in press (P1, P7; [30]).

T2.1. Comparison of properties of transmitted and reflected waves using analytical and numerical modelling (P4; [1]). Development of a theory for ULF electromagnetic wave propagation in the Earth-ionosphere cavity for arbitrary types of sources, for a realistic model of the ionosphere with an arbitrary inclination of the Earth magnetic field (P6; [39, 40]). Study of the coupling between the ionospheric and magnetospheric resonators at low latitudes to explain specific features of low-latitude SRS (P1, P4).

T2.2. Comparison of an existing model for SRS formation with experimental results from low-latitude SRS (P4, P1, also P5 joined the topic). Comparison of statistical properties of SRS at L=5.2 with IAR theory based on combination of the ionosphere model (IRI) and ionosonde observations (P5, P2; [7]). Data processing and interpretation of first experiments on generation and receiving of artificial (0.3-12) Hz emissions at distances 800 and 1500 km using a 108-km power line on Kola Peninsula, Russia was completed (P6; [32]). A collection of data based on simultaneous measurements of magnetic background noise and electron density profile at receiving site " New Life " was carried out. Formulation of the inverse problem was performed based on a height profile of collision frequency between molecules and ions in the ionosphere above the reception point (P6).

T3.1. Satellite data survey for IAR effects (P1). Analysis of vertical profiles of Alfvén waves in the ionosphere in relation to existing satellite data (DE 2) to reveal the role of reflection in the origin of Pc 1 emission (P4, P1;[1]). Collecting information for the possibility of defining a small scale satellite mission entirely devoted to the E- and B-field measurements in the ionosphere resonator region in cooperation with UCLA/Berkeley (P1, P4, V. Angelopolous).

T3.2. Study of reflection of Alfvén waves from the ionosphere: comparison of analytical and numerical results (P4). Extended case study of simultaneous satellite-ground Pc1 observations providing unique observations of critical timing parameters and Poyting-flux measurements (P1, [22]). Modeling of latitudinal and longitudinal dependences of total amplification of magnetospheric Pc1 waves with accounting of ionospheric reflection. (P3, P4, P1; [37]).

T3.3. Numerical modelling of Pc 1 pearls (P4, P6, [28]). Ionosphere modification due to precipitation of energetic protons related to Pc1 and, as consequence, modification of the ionosphere reflection coefficient was estimated (P4, P6). Numerical modelling of Pc 1 pearls using results of full-wave calculation of IAR reflection coefficient in a self-consistent model of Pc 1 pearls; studying effects of external modulation by Pc3-4 waves with symmetric and asymmetric structure relative to the geomagnetic equator on Pc 1generation (P4, [33]). Studying joint effects of external modulation by Pc3-4 waves, magnetosphere/ionosphere interaction, and diurnal variation on Pc 1 generation (P4, [34, 35]); analyzing spatial structure of Pc1 wave packets in the magnetosphere (P4, [36]) and their spectrum detected on the ground (P6, P2, [35]) to interpret satellite observations of pearl repetition periods and the relation between downgoing and upgoing waves.

T4.1. The relationship between geomagnetic pulsations in the Pc1 frequency range and specific proton precipitation at sub-auroral latitudes (P5; [2]). New type of proton precipitation closely related to Pc1 pulsation discovered and investigated (P5, P4, P2, [2, 6]). A specific type of energetic proton precipitation closely related to Pc1 pulsations was identified, a distinction between Pc1 and IPDP related precipitation could be established, and magnetospheric conditions for generation of these precipitations were determined [11]. Long-term behaviour of the Pc 1 frequency and the proton precipitation latitude was studied, and correlation between these parameters was established; experimental evidence for multi-band Pc1 generation by multiple sources was found (P5, P4, P2, P1, [14]).

T4.2. Modelling and inter-comparison of IPDP observations implying full-wave analysis and ionospheric parameters detected by EISCAT (P1, P7). The IAR was numerically simulated during periods when the ionosphere and the magnetosphere were non-stationary. It coincided with the appearance of IPDP type of magnetic pulsations [3, 5].

T5.1. Analytical and numerical modelling of the IAR and the IAR feedback instability with different values of the ionospheric conductivity to determine the role of IAR in forming small-scale Alfvénic structures in the auroral iono- and magnetospheres (P7, P3). Using a simplified model of the topside ionosphere the physical properties of the IAR interaction with magnetospheric convective flow were analyzed (P7; [16]). It was shown that at mid-latitudes an additional mechanism of IAR excitation could operate (P7; paper in preparation). It was also shown that Alfvén waves in the ionosphere might also arise in course of the conversion of drift mirror mode into Alfvén mode [17, 18, 19, 24].

T5.2. A study finalized of the weakly turbulent Kolmogorov type spectra and their locality for the ion-drift and drift-Alfvén waves in presence of dust grains (P7, P3, [20, 21, 23, 26]).

- Has the research been in accordance with the Work Programme?
  Yes.

1.2. Scientific Results (max. 3 pages, + list of references)

For the first time properties of SRS observed at a low latitude station (Crete) were studied and new topics on the basis of this data were taken up [4]. A new effect was found dealing with long period, quasi-periodic modulation of Magnetic Background Noise (MBN not SRS) intensity initiated at sunset. For the first time the statistical characteristics of the SRS were investigated in the auroral zone (L=5.2). They include diurnal, seasonal and long-term variations of the occurrence rate and frequency interval. It was found that there is a trend of a general decrease in probability observing SRS from minimum to maximum solar activity. Both, occurrence as well spectral intervals are higher in winter than in summer, and higher during night- than daytime. A 5-year's variation of the frequency interval was calculated on the basis of the IAR theory using ionosonde observations and an ionosphere model (IRI-95). The results show good agreement with observed values [7, 10].

A specific type of energetic proton precipitation was identified from data of low-altitude satellites TIROS/NOAA. This type is characterised by isolated precipitating particle bursts (latitudinal width is about 1 degree) within anisotropic fluxes at sub-auroral latitudes. A close connection of precipitation with geomagnetic pulsation Pc1 (EMIC waves) could be demonstrated. The particle/wave correlation was suggested for a long time, but was never clearly demonstrated [2, 6, 11].

A distinction between Pc1 and IPDP related precipitation could be made. The main difference is in the width of the particle energy spectra: Pc1 is related to "monochromatic" (E=30-80 keV) protons while IPDP related precipitation includes particles with E<20 keV and E > 80 keV. Each occurs in different MLTs, under different geomagnetic activity, and with different cold plasma densities detected at the outer plasma sphere [6].

The concept of a wave-particle interaction developing in the region of contacts between cold plasma tubes and drifting energetic particles was confirmed in a case study of multi-satellite observations: The ion-cyclotron waves were detected in a localised region of cold plasma enhancement as well as energetic proton scattering into the loss cone and proton precipitation. These observations directly confirm the relationship between the subauroral localised proton precipitation and EMIC waves. [6,12].

The long-term (half of the solar cycle) of the Pc1 frequency behaviour at the auroral zone station were investigated. For the first time the seasonal variations of the Pc1 frequency were found. On the basis of comparison with the proton precipitation the conclusion was made that the frequency variations were due to long-term changes of the EMIC wave source location in the magnetosphere [14].

Multi-band Pc1 events were considered. It was concluded that more likely this kind of the Pc1 is due to the existence of multiple sources. Some experimental evidences were obtained against the frequency filtration due to the resonant nature of the ionosphere reflection [14].

Generation of Pc1 pulsations was modelled taking into account the cyclotron amplification of the bouncing wave packet in the magnetosphere and reflection of the packet from conjugated ionospheres. Using the modern knowledge on the cold plasma distribution in the plasmaspheric trough, a good agreement between observed and calculated Pc1 features was obtained [12]).

Vertical profiles of Pc 1 wave fields produced in the ionosphere by Alfvén waves of magnetospheric origin were analysed. We show that the ratio of the electric and magnetic fields varies strongly with frequency due to the influence of the ionospheric Alfvén resonator. Low-orbiting satellites detecting Pc 1 emissions in the ionosphere (at the same field line as their magnetospheric source) can thus provide valuable information regarding the question whether these waves are generated at conditions of maximum or minimum ionospheric reflection. Comparison of our theoretical result with recent statistical analysis of Pc 1 pearls recorded onboard DE 2 suggests that these waves correspond to the maximum reflection [1].

Numerical code for a self-consistent model for generation of Pc 1 pearl emissions, known as Alfvén sweep maser (ASM) model [Polyakov et al., 1983, Belyaev et al., 1984] and taking into account both the non-linear feedback and group-velocity dispersion of Alfvén waves, has been developed and various simulations were carried out. Diurnal variation of magnetically conjugate ionospheric regions reflecting the waves, realistic calculation of the ionospheric reflection using the IRI model, and modulation of the wave amplification with the period comparable to that of pearl sequence were taken into account. The simulation output was compared with both recent and previous satellite and ground-based observations of Pc 1 emissions. We showed that the pearl-like regime of wave generation is possible in a wide range of parameters. In particular, it was shown that a single bouncing-wave packet can be formed in the system even if properties of the conjugate ionospheres are strongly different and vary in time [28,33]. This allows one to explain satellite observations in which the upward flux of Alfvén waves was found to be 5-10 times smaller than the downward flux. Moreover, it was shown that the arguments against the Alfvén maser scenario of Pc1 pearls, based on satellite measurements of the Pc1 Pointing flux and pearl repetition periods, should be carefully revised taking into account mixing of down-going and reflected wave packets of finite length. It was demonstrated using the modelling results that the reflected waves can be totally faded by down-going waves everywhere except rather narrow near-equatorial region. If this effect is taken into account, then the repetition periods onboard a satellite and on the ground are equal, and Pointing flux is directed downwards, consistently with observations [36]. The possibility of explaining pearls excited in several bands could be demonstrated (*Demekhov et al.*, 2001). The influence of the external modulation (e.g., by large-period hydromagnetic oscillations having both antisymmetric and symmetric Pc3/4 structure with respect to geomagnetic equator) was studied separately and jointly with the magnetosphere-ionosphere feedback. This influence was shown to be very sensitive to the mismatch between the modulation period and the intrinsic period of the system, related to the propagation of wave packet between the reflection points (P4;[34, 35]). These studies have led to the conclusion that the modulation of the cyclotron amplification by Pc3/4 waves is unlikely to be itself the dominant mechanism for formation of Pc1 pearls but still it can influence this process and either speed it up or slow it down, depending on the match between the structures of the Pc3/4 pulsation and the Pc1 wave packet.

Analytical formulas and numerical results for Alfvén wave reflection coefficient from the ionosphere were compared. In particular, the influence of Alfvén-wave transformation into the compressional mode on the reflection coefficient was investigated. It was shown that existing analytical formulas provide a reasonable agreement with numerical results for high and middle latitudes but the discrepancy increases significantly at low latitudes. This is explained by an increased transformation between the Alfvén and compressional modes for large inclination of the geomagnetic field. These results are now useful for the interpretation of ground-based and satellite data on Pc 1 emissions and background noise in this frequency range (Demekhov and Ostapenko, 2001).

The IAR has been numerically simulated during non-stationary ionosphere and magnetosphere conditions during an IPDP event on December 4, 1986. A full wave method is applied using ionospheric plasma parameters obtained from the EISCAT radar [3, 5].

The problem of ULF electromagnetic wave propagation in the earth-ionosphere cavity was solved for arbitrary types of sources, and for a realistic ionospheric model with an arbitrary inclination of the earth's magnetic field. An impedance boundary condition at the ionosphere and a one-dimensional model for the medium are used. An analytical solution in the earth-ionosphere cavity is obtained, using the method of incomplete cylindrical functions. This solution generalizes the previous finding for the case of a vertical earth's magnetic field (azimuthal symmetry). The results obtained will be used for the interpretation of ULF electromagnetic noise spectra in different geographical latitudes and longitudes [39, 40].

A new investigations of large-scale spatial distribution of ULF fields from a controllable ULF-transmitter at Kola Peninsula was carried out in September–October 2001(Tereshenko et al., 2002; Polyakov and Shlugaev et al., 2002). The R-polarization for the ULF signal at the nighttime was found to be predominant at all receiving sites. Peculiarities in amplitude-frequency dependence of the artificial signal were compared with polarization properties of magnetic background noise during the time of observation. It allowed us to conclude that the properties of the artificial signal are related to the influence of the ionosphere overhead of the receiving site for distances form the transmitter larger than some 400 km.

Theoretical estimations of the efficiency of ULF radio waves transmission to the magnetosphere from a ground-based source were performed. Energy loss to the Earth-ionosphere and into the ionospheric magnetosonic wave-guide in addition to diffractive diffusion of the electromagnetic beam are accounted for. The estimation is of relevance for future combined ground-satellite experiments.

In 2002 a gradient measurement of magnetic background noise in the ULF frequency range was developed and tested. The measurement implies two stations separated by only 20 km. The differential reception allows to lower significantly the level of large-scale noise from distant thunderstorms and thereby to increase the sensitivity of the equipment for small scale horizontal ULF fields (Polyakov et al., 2003).

A theory of ionospheric Alfvén resonator and IAR feedback instability was developed. It was found that in absence of convection the IAR eigen modes exhibit a strong damping due to leakage of the wave energy through the resonator upper wall and Joule dissipation in the conductive ionosphere. It was further found that maximal dissipation appears when the ionospheric conductivity approaches the Alfvén parallel conductance. However, the presence of Hall dispersion, associated with coupling of Alfvén wave modes with compressional modes reduces the infinite damping of the IAR eigen modes in this region and makes it dependent on wavelength. An increase of the convection electric field leads to a substantial modification of the IAR eigen mode frequencies and a reduction of the eigen mode damping. The cornerstone of this analysis is a refined type of IAR feedback instability with the lowest threshold value of the convection velocity ever found [16].

It was discovered that at mid-latitudes an additional mechanism of the IAR excitation can also operate. Strong convective flows do not exist or have very low values. The most probable mechanism of the IAR excitation in such conditions refers to the IAR excitation by fluctuating (turbulent) winds. The spectrum of the turbulent winds at high altitudes ranges from several tens of mHz to several Hz, which falls in the frequency range of the IAR. For the dayside ionosphere the first resonant frequencies of the IAR lie in the same frequency range that makes it possible to excite the IAR in the auto-vibrator regime. For the nighttime conditions both modes, the compressional and shear Alfvén, can occur in the IAR cavity. Based on our calculations we arrive to the conclusion that the peaks in the power spectrum observed during the night time conditions can be explained by excitation of the IAR compressional mode rather than Alfvén one.

A comprehensive linear theory of drift mirror instability was developed accounting for the nonzero electron temperature effects. Generalizing previous analyses of this instability by accounting for a non-vanishing parallel electric field an expression for the mode frequency and instability growth rate was derived. It is shown that in a plasma with nonzero electron temperature the drift mirror mode is accompanied by field-aligned currents, which vary in phase with the compressional changes in the magnetic field. The transition to the cold-electron temperature limit is discussed [17, 18, 19, 22, 24]. Recently a theory of non-linear interaction of the shear Alfvén waves with convective motions was developed which can be the base of the "predator-prey" model for the ionospheric Alfvén resonator. The growth rate of the modulated instability was calculated which leads to the “inverse cascade”, i.e. to shearing of the slow convective flows. There latter process results in a complex dynamics of the coupled system – IAR eigenmodes-convective flows. The shearing of the convective flow will diminish the turbulent level of the shear Alfvén waves in the IAR region [29].

The locality of weakly turbulent Kolmogorov spectra of ion-drift and flute waves for plasmas with dust grains was analysed. Using a standard kinetic approach for the description of the wave turbulence it is shown that the wave spectrum associated with the wave enstrophy flux is nonlocal, whereas that related to the wave energy flux is local. The nonlocality of the wave enstrophy spectrum is associated with the long wavelength portion of the turbulence. It is found that the wave energy flux is directed towards smaller spatial scales. [19, 23, 26]

- Up to now, which scientific papers, presentations & patents have resulted **directly** from this project?

  - Joint Publications of INTAS and NIS project teams

    - **International journals.**

2000

1. **Demekhov, A. G., V. Yu. Trakhtengerts, and T. Bösinger**, Pc 1 waves and ionospheric Alfvén resonator: Generation or filtration?, Geophys. Res.Lett., 27, No.23, 3805-3808, 2000.
2. **Yahnina T.A., A.G. Yahnin, J. Kangas, J. Manninen**, Proton precipitation related to Pc1 pulsations, Geophys. Res. Lett.,V.27, 2000.

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3. **Prikner K., K. Mursula, J. Kangas, and F. Z. Feygin,** The Ionospheric Alfvén resonator control over the frequency variable Pc1 event in Finland on May 14, 1997, Studia Geophys. Et Geod., 45, 363-381, 2001.

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4. **Bösinger T.,** C. Haldoupis, **P.P. Belyaev, M.N. Yakunin, N.V. Semenova, A.G. Demekhov,** V. Angelopoulos, Spectral properties of the ionospheric Alfvén resonator as observed at a low latitude station (L = 1.3). *J. Geophys. Res.*, **107**, No.A10, 1281, doi:10.1029/2001JA005076, 2002.
5. Prikner K., **K. Mursula, J. Kangas, F. Z. Feygin, and R. Kerttula,** Numerical simulation of the high-latitude non-stationary Alfvén resonator during an IPDP event, Studia Geoph. et Geodet., 46(3), 507-526, 2002.

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6. **Yahnina T.A., A. G. Yahnin, J. Kangas, J. Manninen,** D.S. Evans, A.G. **Demekhov, V.Yu. Trakhtengerts,** M.F. Thomsen, and G.D. Reeves, Energetic particle counterparts for geomagnetic pulsations of Pc1 and IPDP types, Ann. Geophys., accepted, 2003.
7. **Yahnin A.G., N.V. Semenova, A.A. Ostapenko, J. Kangas, J. Manninen, T. Turunen**, Comprehensive Morphology of the Spectral Resonance Structure of the Electromagnetic Background Noise in the Range of 0.1-4 Hz at L=5.2, *Ann. Geophys*., **21**, 779–786, 2003.
8. Prikner K**., K. Mursula, J. Kangas, R. Kerttula,** and **F. Z. Feygin**, An effect of the ionospheric Alfvén resonator on multiband Pc1 pulsations, Ann. Geophys., in press, 2003.

Some 5 to 8 papers in preparation (cf. http://spaceweb/projects/INTAS_99-0335/**).**

- **National journals**

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9. **Yahnina T.A., A.G. Yahnin, N.V. Koropalova, J. Kangas, J. Manninen**, Comparison of characteristics of the localised proton precipitation and Pc1 pulsations. In: *"Physics of auroral phenomena",* Proceedings of XXIII Apatity seminar "Physics of auroral phenomena", Apatity, 28-31, 2001.
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11. **Yahnin, A.G., T.A. Yahnina,** N.Y. Ganushkina, V. Angelopoulos, F.S. Mozer, **J. Kangas, J. Manninen,** T.A. Fritz, C.T. Russell, and M.F. Thomsen, Multi-satellite study of phenomena in the evening magnetosphere during the Pc1-2 event, In: *"Physics of auroral phenomena",* Proc. XXV Annual Seminar, Apatity, pp. 85–88, 2002.
12. **Yahnina, T.A., A.G. Yahnin, J. Kangas, and J. Manninen,** Localized enhancement of the energetic proton fluxes at low altitude in sub-auroral zone and their relation to Pc1 pulsations, *Cosmic Research*, #3, 2002.
13. **Semenova, N.V., A.G. Yahnin,** A.A. Ostapenko, **J. Kangas, and J. Manninen,** Comparison of observed parameters of the spectral resonance structure with predictions of the ionospheric Alfven resonator theory, In: *"Physics of auroral phenomena",* Proc. XXV Annual Seminar, Apatity, pp. 77–80, 2002.

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14. **Yahnin A. G., T. A. Yahnina, A. G. Demekhov, J. Manninen,** J, Kultima, and **J. Kangas,** Interpretation of some features of Pc1 geomagnetic pulsations as deduced from comparison with data on energetic proton precipitation, Geomagn. Aeron., 2003, submitted.
15. **Khabazin, V Pokhotelov O. A., F. Z. Feygin, Yu. G.. V. Khrushchev, T. Bösinger, J. Kangas,** and K. Prikner, Observations of IAR spectral resonance structures at a large triangle of geophysical observatories, Proc. XXVI Annual Seminar "Physics of the Auroral Phenomena", Apatity, 2003 (in press).

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Problem of Geocosmos. Book of abstracts, St.Petersburg, Russia, 22-26 May, 2000, p.59.

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♦ Publications **without** INTAS-NIS co-authorship of the project teams

▪ **International journals**

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25. Safargaleev V., **J. Kangas,** A. Kozlovsky, A. Vasilyev, Bursts of ULF noise excited by sudden changes of solar wind dynamic pressure, Ann. Geophys., 20, 1751-1761, 2002.

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space plasmas: Hydrodynamic and kinetic instabilities, J. Geophys. Res., v. 108, No A3, 1098, doi:10.1029/2002JA009651, 2003.

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Tereshenko E.D., **S.V. Polyakov**, L.A. Sobchakov, B.Z. Khudokon, A.V. Vasil'ev, Frequence dependency of polarization of artificial electromagnetic radiation at frequency range (0.6-10Hz), Abstracts of VIII Region Conference of radio wave propagation, p.12-13, St.-Peterburg, 29-30 Oktober, 2002.

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Niskala K., and **K. Mursula,** EMIC waves with dispersion and large frequency range: POLAR and CLUSTER-II observations, Joint EGS-AGU-EUG Assembly, Nice/France, Geophysical Research Abstracts, Vol. 5, 10544, 2003.

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Stasiewicz K., P. K. Shukla, G. Gustafsson, S. Buchert, B. Lavraud, B. Thidé, and Z. Klos, Magnetosonic solitons detected by the CLUSTER spacecraft, Joint EGS-AGU-EUG Assembly, Nice/France, Geophysical Research Abstracts, Vol. 5, 08778, 2003.

- Books, monographs, internal reports, thesis, patents

T.A. Yahnina: Experimental study of consequences of the interaction between the low-frequency waves and near-Earth plasma, PhD thesis, University of St-Petersburg, 2001.
R. Kerttula: Ground-based studies of Pc1 pulsations, PhD thesis, University of Oulu, 2001.
Y. Khotyaintsev: Alfvén waves and energy transformation in space plasma, University of Uppsala, 2002.

- Summarise the scientific output (number of papers, etc.) in the table below:

	ALL PUBLICATIONS			ONLY: Jointly by INTAS and NIS Project teams
Scientific Output	**published**	**in press/accepted**	**submitted**	
Paper in an International Journal	18	3	1	8
Paper in a National Journal *)	10	7	2	7
Abstract in proceedings (conferences, workshops)	35			12
Book, Monograph *)				
Internal Report **)				
Thesis (MSc, PhD, etc.) *)			3	
Patent				

1.3. Impact and Applications (if appropriate)

- Describe the impact of the results achieved to date.

- Detailed statistical studies of SRS at high and low latitudes and their comparison with the theory confirmed existence of universal features in the IAR influence on the ULF atmospheric background noise (ABN). On the other hand, significant new features have been discovered in the ABN behavior at low latitudes, such as stronger variability and finer spectral structures. These studies showed high potential of using ABN to diagnose the ionosphere parameters and wavelike disturbances.
- The significance of reflection of Alfvén waves from the ionosphere for their generation in the magnetosphere was shown and new experiments for the verification of this relation were proposed.

- First results of numerical self-consistent model for Pc 1 pearls were obtained and the important role of the magnetosphere-ionosphere feedback in pearl formation was confirmed. It showed that this feedback could operate in a wide range of ionospheric parameters.
- A significant step forward in the comparison of different mechanisms of Pc 1 pearl formation was made by including the external modulation by Pc3/4 waves into the self-consistent model mentioned above.
- The comparison of analytical and numerical results for the Alfvén-wave reflection proved to be useful for constructing advanced models of ULF-wave interaction with the ionosphere.
- The long lasting, high-resolution measurements from a low latitude station in Crete, at L = 1.4, fill the latitudinal gap in basic knowledge of SRS.
- The proton precipitation, "missing link" of EMIC wave generation, was finally found, and distinct morphological properties of particle precipitation associated with either Pc1 pearl or IPDP pulsation could be separated.
- Additional theoretical ground was found for the interpretation of existing satellite observations of particle precipitation and electromagnetic waves above the auroral region.
- Comparison of analytical and numerical results for the wave-wave reflection is a useful tool for constructing advanced models of ULF-wave interaction with the ionosphere.
- A new experiment on investigations of large-scale spatial distribution of ULF fields from controlled source at Kola Peninsula was carried out in September/October 2001. The peculiarities in amplitude-frequency dependencies of the signal at different receiving stations connected with the influence of the near-ground wave-guides and ionosphere resonance structures were investigated.
- Software for numerical calculations of the spectrum and polarization of ULF fields in the impedance approximation has been developed.
- Theoretical estimations of the efficiency of the ULF radio waves transmission to the magnetosphere from a ground-based source have been performed. The estimations of ULF fields from a ground-base source for experiments using satellites are performed.
- A new type of the IAR feedback instability with the up-to-date lowest threshold value for the convection velocity was found. This low value of a marginal electric field capable to trigger the feedback instability turns out to be only half the predicted one in previous analyses.
- The IAR was numerically simulated during periods when the ionosphere and the magnetosphere are non-stationary.
- An additional mechanism of IAR excitation was considered for mid-latitudes.
- A comprehensive linear theory of drift mirror instability was developed accounting for nonzero electron temperature effects.
- Based on our studies of the ion-drift modes a non-linear theory of shear Alfvén waves in the presence of dust grains was developed.

- Are you seeking patents or other protection of intellectual property?
  No.

2. MANAGEMENT

2.1. Meetings and visits

- What co-ordination meetings, exchange visits of scientists, or major field trips took place up to now?

Working group (co-ordination) meetings:

Oulu, October 2000, O. Pokhotelov, F. Feiguine, A. Khrouchtchev, X. Khabazin, OU team (update, co-ordination).
Sodankylä, December 2000, A. G. Yahnin, T. A. Yahnina, T. Bösinger, SGO team (joint paper work and data collection).
Nizhny Novgorod, January 2001: T. Bösinger, NIRFI and IAP teams (joint paper work and scientific testament from P. Belyaev).
Apatity, September 2001, joint INTAS-0335 and INTAS-0503 working-group meeting, M. Rycroft, D. Nun, V. Trakhtengerts, A. Demekhov, S. Isaev, E. Titova, B. Kozelov, Kornilov, Pasmanik, Lubich, A. Yahnin, T. Yahnina, J. Manninen, T. Bösinger (bringing electron and ion cyclotron wave instabilities under a common frame of ongoing investigations and perspectives).
Moscow, December 2001, 1st working-group meeting at IPE-team, F. Feiguine (host), Michael Gokhberg, vice president of the Institute, Sergei Shalimov, A. Guglielmi, Popov, Senchenkov, Khabazine, Khrouchtchev, V. Trakhtengerts , A. Demekhov, S. Isaev, S. Polyakov, L. Ermakova, B. Reznikov, Yura Shlugaev, A. Yahnin, J. Kangas, R. Kertulla, T. Bösinger (central update within the 3 year's project time).
Sodankylä, June 2002, 'Mini-Workshop', A. Demekhov, S. Isaev, A. Yahnin. T. Yahnina, N. Semenova, J. Kangas, J. Manninen, R. Kerttula, T. Bösinger, (data analysis and paper writing workshop).
Sodankylä, March 2003, 'Mini-Workshop', T. Bösinger, V. Trakhtengerts, A. Demekhov, D. Pasmanik, A. Yahnin. T. Yahnina, J. Manninen, (data analysis, discussion and paper writing workshop).

Joint meetings in association with conferences:

Annual PGI Seminar, February 2001, V. Yu. Trakhtengerts, S. V. Isaev, J. Kangas, R. Kerttula, T. Bösinger.

EGS conference in Nice/France, March 2001, V. Trakhtengerts and D. Pasmanik, T. Yahnina and A. G. Yahnin.

Annual Optical Conference in Oulu/Finland, July 2001, A. Yahnin, N. Semenova, T. Bösinger.

Annual PGI Seminar in Apatity/Russia, March 2002, V. Trakhtengerts, S. Isaev, T. Yahnina, A. G. Yahnin, N. Semenova.

EGS conference in Nice/France, April 2002, V. Trakhtengerts, A. Demekhov, A. Yahnin, T. Yahnina, N. Semenova, K. Mursula.

Problems of Geocosmos, St-Petersburg, June 2002, A. Demekhov, A. Yahnin, T. Yahnina, N. Semenova, T. Bösinger.

COSPAR meeting in Houston/USA, October 2002, A. Demekhov, R. Kerttula.

International Symposium in Memory of Prof. Yu. I. Galperin, Moscow/Russia, February 2003, V. Trakhtengerts, A. Demekhov, T. Yahnina, A. G. Yahnin.

Annual PGI Seminar in Apatity/Russia, February-March 2003, T. Bösinger, V. Trakhtengerts, A. Demekhov, S. Isaev, T. Yahnina, A. G. Yahnin, N. Semenova.

EGS conference in Nice/France, April 2003, V. Trakhtengerts, A. Demekhov, K. Mursula, R. Kerttula.

Mutual exchange of team members:

Young INTAS scientist invitation to OU and SGO:
N. Semenova from PGI (SRS analysis from Crete, data collection).

Network expert visit to OU:
B. B. Gvozdevsky from PGI.

- Summarise the meetings and visits in the table below:

Visits	**Number of scientists**	**Number of person days**
West ==> East	3 + 3	22 +36
East ==> West	13 + 4	91 +170
West ==> West	1 + 2	4 +10
East ==> East	1+ 3	6 + 50

2.2. Collaboration

- In your opinion, how intense was the collaboration among the different Contractors up to now?

Intensity of Collaboration	**high**	**rather high**	**rather low**	**low**
West <=> East	**X**			
West <=> West		**X**		
East <=> East	**X**			

- In this project, do you co-operate to a major extent with additional (inter)national organisations and institutions not mentioned in the Co-operation Agreement?

No, not to a major extent, besides IPE with a substantial co-operation with the Swedish Institute of Space Physics and Sheffield University.

2.3. Time Schedule

- Has the time planning been in accordance with the Work Programme?
  Yes.
- Do you foresee any deviations from the Work Programme for the future?
  No.

2.4. Problems encountered

- Up to now, did you encounter any major problems?

  We do not see significant problems worth mentioning.

2.5. Actions required

- At present, do you have or do you foresee any problem, which needs action from INTAS? E.g. is there any need to prolong the duration of the project or to amend other aspects of the co-operation agreement?

No.

3. FINANCES (in EURO[1])

- How did you spend the money that has been available from this grant up to now? Please use the table below to give for each contractor a breakdown in EURO[1] of the expenditures **actually** incurred under the different cost categories.

# *)	Name of Contractor *)	Individ. Grants Labour Costs	Overheads	Travel and Subsistence	Equipment **)	Consumables	Other Costs	**(Euro)**
1	Bosinger	0	500	4 860			450	5 810
2	Manninen	0	500	1 940			0	2 440
3	Stasiewicz	0	500	1 800			0	2 300
4	Trakhtengerts	12 200	1 800	7 500	3 840	660	0	26 000
5	Yahnin	16 700	2 000	4 500	2 020	780	0	26 000
6	Polyakov	23 160	500	1 400	1 240	100	0	26 400
7	Pokhotelov	21 000	485	6 000			0	27 485
TOTAL (Euro)		73 060	6 285	28 000	7 100	1 540	450	**116 435**

- Up to now, has the spending been in accordance with the one foreseen in the Work Programme?

Yes

For more details see previous annual reports. Last year's details are given in the Annexes as "Some financial details of the project's 3rd (last) year".

4. ROLE AND IMPACT OF INTAS

In your mind (i.e. the Co-ordinator's) how important was this grant for starting and carrying out the project? Please tick the adequate boxes in the table below.

Role of INTAS	**Definitely yes**	**rather yes**	**rather not**	**definitely not**
Would the project have been started without funding by INTAS?		X		
Would the project have been carried out without funding from INTAS?				X

From your point of view, what were the most important achievements of the project? Please tick the adequate boxes in the table below.

Main achievement of the project	**very important**	**quite important**	**less important**	**not important**
exciting science	X			
new international contacts			X	
additional prestige for my lab		X		
additional funds for my lab		X		
helping scientists in NIS	X			
other (specify)**: to guarantee continuation and to increase productivity in an ongoing co-operation lasting already**				

for more than one decade

Will the project continue? yes
Will the co-operation among the project Contractors continue in the future? yes

5. RECOMMENDATIONS TO INTAS

What was particularly good and should not be changed? Clear financial overviews, contact with scientific officer.
What was particularly bad and should be changed? Please specify and explain how it could be improved? Redistribution of travel funds within INTAS MEMBER TEAMS should be more flexible and not require an amendment to the cooperation agreement.

Oulu, 8. 9. 2003

Tilmann Bösinger
(co-ordinator)

ANNEXES

- Attach a **summary report** of each team describing its work undertaken in relation to the work programme and results achieved (approx. 1 page per team). It should also include a list of the team members and a brief description of their contribution to the project.
- Some more **financial details** of the project's 3rd (last) year
- Some **reprints** with acknowledgement of INTAS

Summary report

University of Oulu, Department of Physical Sciences (OU, P1):

Prof. K. Mursula: Correlation studies of simultaneously observed Pc1, IPDP and IAR observations in space and on the ground. Long-term analyses of SRS properties at high and mid latitude, several papers and abstracts related to this project (cf. reference list; T1.1, T3.1, T3.2).

Dr. T. Bösinger: Co-ordination of the project, creation and updating of a project related Web page (http://agnes.oulu.fi/projects/INTAS_99-0335/), maintenance of a pulsation magnetometer in Crete, upgrading of Finnish chain of pulsation magnetometers in cooperation with SGO, Web based quick look data service, exploration of SRS and related phenomena at a low latitude (Crete), supervision of a young (INTAS) scientist, joint paper work with IAP, NIRFI, and PGI, one (own) paper and several papers and abstracts related to this project (cf. reference list; T1.1, T1.2, T3.1, T3.2).

Dr. R. Kerttula: defended his PhD thesis with good success in April 2001 on Pc1 observations in relation to magnetospheric storms (supervisor K. Mursula). Comparison between IAR theory and IPDP observation implying full wave analysis and usage of ionospheric parameters detected by the EISCAT-radar. First assessment of a non-stationary ionospheric Alfvén resonator in theory and praxis, participation in several papers and abstracts related to this project (cf. reference list; T4.2).

University of Oulu, Sodankylä Geophysical Observatory (SGO, P2):

Prof. J. Kangas: As head of the observatory - as far as time allows - paper work with the PGI team, frequent participation in working group meetings, tough discusser, splendid writer, gifted organizer (organized the 1st Workshop entirely devoted to the IAR subject, and organized two "Mini-Workshop" related to this project), and good father for all scientists with complains, moreover other and co-author of several papers related to this project (cf. reference list; T1.1, T4.1).
Ph.L. J. Manninen: Web based quick look data service, data delivery to PGI and IAP, paper work with the PGI and IAP teams, incorporates in his science the VHF (whistlers) as well UHF (Pc1, IPDP, IAR/SRS) aspects. Participation in several papers and abstracts related to this project (cf. reference list; T1.1, T4.1).

MS J. Kultima: Statistics of Pc1 occurrence and properties with a new offer of quick look service, fieldwork, calibration and data service.

Swedish Institute of Space Physics (IRFU, P3):

Dr. K. Stasiewicz: he cooperates with IPE, expert in the field of kinetic Alfvén waves and small-scale Alfvénic structures (that is why he was asked to join the project), studies on the origin of those structures and their relation to auroral arcs, the altitude distribution of non-linear Alfvén waves and current structures, and the electron acceleration by inertial Alfvén waves (T5.1). His contribution is focusing ongoing satellite project (POLAR, CLUSTER) with emphasis on kinetic Alfvén wave phenomena: he presented with collaborators data collected from the Polar satellite in the high-latitude magnetopause boundary. Their analysis shows close association of kinetic Alfvén waves and magnetic field depressions. Probably the drift mirror mode, which has been amplified in the region with substantial pressure anisotropy, is then transferred to the region where it is converted to the kinetic Alfvén wave due to mode coupling (not connected to the IAR scenario). Supervisor of one PhD thesis with relevance to this project (Yuri Khotyaintsev, Uppsala 2002).

Institute of Applied Physics (IAP, P4):

Prof. V. Yu. Trakhtengerts (team leader): Planning of work and coordination with other teams, analytical study of ULF wave interaction with the ionospheric and magnetospheric plasma, preparation of paper.

Dr. A. G. Demekhov: analytical and numerical study of ULF wave interaction with the ionospheric and magnetospheric plasma, preparation of papers.

Mr. S. V. Isaev: development of numerical methods, numerical study of a self-consistent model for Pc 1 pearls, preparation of papers.

Mr. D. L. Pasmanik: development of self-consistent models of wave-particle interactions in the magnetosphere, analytical and numerical study of spatial structure of wave-induced precipitation of energetic particles, preparation of papers.

The team members were occupied mainly with tasks 2 and 3 of the project. One paper in collaboration with University of Oulu (UO) and two more papers are in preparation, one of them jointly with UO (T.3) and one with PGI (T.3). Four abstracts in the conference proceedings have been published.

Polar Geophysical Institute (PGI, P5):

Mr. B. Gvozdevsky has done a computer work related to visualisation and spectral analysis of data from search coil magnetometers in Lovozero and Barentsburg; he took part in the Pc1 data analysis and related precipitation.

Mr. A. Vasilyev was responsible for maintenance of the search coil magnetometer in Lovozero. Under his leadership similar magnetometer has been manufactured, and it is now operating in Barentsburg, Svalbard. Mr A.Vasilyev participated in the study of the Pc1 pulsations.

Ms N. Semenova made a computer program for spectral analysis and treatment of the geomagnetic pulsation data; she analysed observations of SRS and performed statistical study of the SRS observed in Sodankylä and Crete (one paper has been published, one paper is accepted, one paper is submitted).

Ms N. Koropalova participated in study of the relationship between Pc1 and energetic proton precipitation (published).

Mr A. Yahnin investigated peculiarities of the SRS and the Pc1/energetic proton relationship (three papers have been published, one paper is submitted, one paper is in preparation.

Ms T. Yahnina investigated relationship between energetic proton precipitation and Pc1 and IPDP pulsations (three papers have been published, one paper is in preparation).

The group worked mainly on Tasks 1.1., 2.2., 3.3, 4.1 (all according to the working programme).

Some 15 presentations (abstracts published) delivered at conferences.

Radiophysical Research Institute (NIRFI, P6):

Mr. B.Reznikov has done an important work related to the modernization of the equipment for registration of the VLF (0,1 – 10 Hz) electromagnetic background noise at the station "New Life". He is responsible for measurements using differential reception of magnetic noise and artificial signals (presentation at seminars, one paper in preparation).

Mr.E. Ovchinnikov is responsible for optimization of the search coil magnetometers at station "New Life" N. Novgorod, Russia. He participated on measurements of electromagnetic background noise.

Mr M. Yakunin made a computer program for spectral analysis of the SRS data obtained in Crete and performed statistical study of the SRS observed at station "New Life" and Crete (published).

Mr. A. Chukaev took part in the study of SRS data obtained at station "New Life"

Ms E. Ermakova participated in the study of polarization of magnetic background noise, in interpretation of SRS data obtained at station"New Life" (published) and in the data proccessing and interpreteation of experiments with Kola peninsula transmitter (presentations at seminars, one paper in preparation)

Mr S. Polyakov investigated peculiarities of the ULF electromagnetic field propagation in the near-earth space (two paper published, and one in press)

Mr. P. Belyaev performed the study of magnetic field data, obtained at the station "New Life"and Crete. (4 presentations at conferences).

Ms. N. Belova took part in development of software for data sampling with a 14-digit ADC, data processing software and software for time synchronization, based on JPS 1 second pulses.

The group has worked mainly on Tasks 1.1., 1.2, 2.1., 2.2 (all according to the workprogram).

- During 2001 the modernization of the equipment at the" station New Life" for the registration of ULF electromagnetic fields (0.1 - 10 Hz) was carried out.

- The theory of the formation of VLF electromagnetic field polarization in the frame of one-dimensional medium with the vertical magnetic field is developed. The theory correctly describes the mechanism of the polarization of the magnetic noise in the frequency range > 1 Hz. The theory explains predominance of the R circular polarization at frequency range (1-5)Hz and predominance of the L circular polarization at frequencies near and below 1 Hz, observed at magnetic field measurements near N. Novgorod, Russia.

- The study of propagation of VLF electromagnetic waves in the cavity Earth-ionosphere for orbitrary types of sources, for the realistic model of the ionosphere with an orbitrary inclination of the Earth magnetic field has been performed. The obtained results will be used for interpretation of VLF electro-magnetic noise spectra for diffirent geographical areas.

- The contribution of natural near-earth waveguides and resonance systems to the resulting electromagnertic field of different natural and artificial VLF sources was calculated. It is shown that for an ionospheric source the mentioned near-earth waveguides give comparable contributions to the resulting field.

- Software for numerical calculations of the spectrum and polarization of ULF fields in the impedance approximation has been developed based on theoretical analysis in the previous INTAS project stage. The software are planned to use for interpretation of experiments on the background noise investigations at Crete.

- Data processing and interpretation of first experiments on generation and receiving of artificial (0.3-12) Hz emissions at distances 800 and 1500 km using 108-km power line on Kola peninsula, Russia were completed. Amplitude-frequency dependences and polarization of artificial signal were found to be strongly different during daytime and nighttime. Similar behavior of magnetic noise spectrum from day to night was found.

- During 2002 the gradient method of receiving of background magnetic noise first in ULF frequency range was realized. The reception at spaced sites allowed us to lower approximately ten times a level of large-scale noise from distant thunderstorms. The experiment using the heating facility “SURA” for generation the artificial ULF signal was carried out, gradient method of reception of the signal has allowed to increase 2 times the ratio of signal to noise.

- A new experiment on investigations of large scale spatial distribution of ULF fields from a controlled source at the Kola peninsula was caried out in September – Oktober 2001. Data processing and interpretation of these experiments were completed. The registration of the signal at many receiving stations was distinctive peculiarity of this experiment. It was found, that amplitude-frequency dependence and polarization of the artificial ULF signal were influenced by ionospheric properties above reception points located at distance more than 400 km from Kola transmitter.

Institute of the Physics of the Earth (IPE, P7):

Prof. O. A. Pokhotelov: head of the IPE team, studied another way of destabilization shear Alfvén waves in the ionosphere in connection with the conversion of drift mirror mode into Alfvén mode, finally focused on the dynamics of dusty plasma, several abstracts and papers related to this project (cf. reference list; T5.2).

Dr. F. Z. Feiguine: concentrated on experimental work on Pc 1 using ground and satellite data (T1.1).

Dr. V. V. Khrouchtchev: using a simplified model of the topside ionosphere he was engaged in reanalysing the physical properties of the IAR interaction with magnetospheric convective flow, participation to several abstracts and papers (cf. reference list, T4.1).

Dr. Yu. G. Khabazin: participated in developing a comprehensive linear theory of drift mirror instability accounting for the nonzero electron temperature effects, participation to several papers and abstracts (cf. reference list; T5.1).

MS K. V. Popov: involved in analyses of SRS properties as observed at the mid latitude stations Borok and Mondy (T1.1).

MS S. A. Senchenkov: involved in analyses of SRS properties as observed at the mid latitude stations Borok and Mondy (T1.1).

Using a simplified model of the topside ionosphere the physical properties of the IAR interaction with magnetospheric convective flow was reanalysed. IAR was numerically simulated during non-stationary ionosphere and magnetosphere conditions. Linear theory of the drift-mirror instability in high-beta-plasma was reconsidered for the cases of a one-and a two-component ion plasma. Nonzero electron temperature effects were taken into account. Besides the linear effects also non-linear aspects of the shear Alfvén wave theory were considered.

Some financial details of the project's 3rd (last) year

OU, P1 (for 3rd year):
The spending has been in accordance with the Work Programme.
Received for 3rd year:
- Other costs: 0 Euro
- travel: 500 Euro
- overheads: 0 Euro
actually spent (3rd year):
All travel money was spent for the working group meetings in Apatity (February 2003) and Sodankylä (April 2003).

SGO, P2 (for 3rd year):
The spending has been in accordance with the Work Programme.

Received for 3rd year:
- Other costs: 0 Euro
- travel: 1540 Euro
- overheads 0
actually spent (3rd year):
All travel money was spent for the working group meetings in Apatity (February 2003), Sodankylä (April 2003) and magnetometer service tour in Crete (May 2003).

IRFU, P3 (for 3rd year):
The spending has been in accordance with the Work Programme.
Received for 3rd year:
- other costs: 0 Euro
- travel: 900 Euro
- overheads: 500 Euro
actually spent (3rd year):

The travel money (900 Euro) was spent for participation in scientific conferences, Workshops (e.g. Joint EGS-AGU-EUG Assembly, Nice/France; April 2003).

IAP, P4 (for 3rd year):
The spending has mainly been in accordance with the Work Programme.
Received for 3rd year:
- Ind. Grants 1600 (VYT) + 400 (AD) + 600 (SI) = 2600
- Other costs: 0 Euro
- travel: 2000 Euro
- equipment: 0 Euro
- consumables: 300 Euro
- overheads 0

actually spent (3rd year):

- travel:	18 USD	AD foreign passport
	425 USD	COSPAR Assembly, Oct. 2002, part of AD perdiem + 1day hotel (LHR airport)[2]
	100 USD	S.Isaev travel to Apatity, Feb.2003
	1140 USD	SGO, March 2003 part of VYT+AD+PDL per diem[3]
	2769 USD	EGS-AGU-EUG Assembly, abstract submission, VYT&AD&SI registration, VYT&AD&PDL insurance, VYT&AD perdiem, AD visa & travel fare & hotel)[4]

- subtotal travel: 4452 USD approx 4754 Euro (coef. 0.936)

- equipment:	1700 USD - upgrade of 2 computers with monitors (Celeron to P–IV)
	215 USD - Scanner Epson Perfection 2400
	432 USD - 2 CD/DVD RW drives TEAC
	295 USD - Portable HDD SaroTech
- subtotal :	2642 USD[5] approx 2749 Euro

- consumables: 322 USD[6] approx 340 Euro

To be received after final report:
- ind. grants 400 (VYT) + 200 (AD) + 600 (SI) = 1200
- Other costs: 0 Euro
- travel: 0 Euro
- equipment: 0 Euro
- consumables: 300 Euro
- overheads 1800 Euro

Remark: 1840 Euro approx 1750 USD transferred from consumables for equipment
Some money have been transferred from the cost category 'consumables' to cost category 'equipment'. Larger travel expenses were expected for the last year of the project, but the the planned sum was sufficient to cover the realized travels (in particular, COSPAR Assembly in Houston and joint EGS-AGU conference in Nice)

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[2] was mentioned in the previous-year report as planned travel; partially covered from INTAS grant 99-0502 (finished in April 2003, report approved).
[3] Main costs for this trip were covered by the EU LapBIAT project.
[4] other costs covered from INTAS grant 99-0502.
[5] 1750 USD from consumables.
[6] including 103 USD for subscription to Annales Geophysicae and online access to JGR, GRL, & Radio Science

due to additional funding (e.g., registration fee for COSPAR has been covered by the OC) and not all travels realized.
Equipment money have been spent for upgrading computers and periphery.

PGI, P5 (for 3rd year):
Received for 3rd year:
- Ind. Grants 2500 (AGY) + 1500 (TAY) + 700 (NVS) = 37000 Euro

In 2003, subscription for Ann. Geophys online, JGR and GRL was paid from INTAS costs as well as some consumables.

To be received after final report:
- Other costs and travel and subsistance: 1500 Euro

NIRFI, P6 (for 3rd year):
The spending has been in accordance with the Work Programme.
Received for 3rd year:
- ind. grants 1560 (SP) + 1440 (LE) + 400 (Y) + 480 (Ch) + 500 (B) + 400 (O) + 900 (BR) = 5680 Euro
- Other costs: 0 Euro
- travel: 0 Euro
- equipment: 0 Euro
- consumables: 0 Euro
- overheads 0

Actually spent (3rd year): 5680 Euro

Money from "Consumables" was spent to purchase a laser printer because the old printer was not in operation, i.e. a PC (Pentium-II) and laser printer was bought.

To be received after final report:
- Ind. Grants, travel and subsistence, and overheads: 3600 Euro

IPE, P7 (for 1st year):
The spending has been in accordance with the Work Programme.

Received for 3rd year:
- Ind. Grants 975 (OP) + 975 (FF) + 195 (KP) + 780 (YK) + 195 (SS) + 780 (VK) = 3900 Euro
- Other costs: 0 Euro
- travel: 0 Euro
- equipment: 0 Euro
- consumables: 0 Euro
- overheads 0

Actually spent 3rd year: 3900 Euro

To be received after final report:
- Ind. Grants, travelling and subsistence, and overheads: 4585 Euro

Collection of some reprints (enclosed)