INTAS PROJECT 201–84

High Resolution Physics of the Solar Photosphere

FINAL REPORT

TECHNICAL INFORMATION

Call Specification:	INTAS Call 2000
Title:	"High Resolution Physics of the Solar Photosphere"
Reference number:	INTAS Project 201–84
Total Grant:	€54 800
Start Date:	July 1, 2001
Duration:	extended to 4.5 years in total

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First periodic report:	submitted July, 2002
Second periodic report:	submitted September, 2003
Final report due:	February, 2006
Submission date of this report:	March 9, 2007 (with sincere apology)

1 RESEARCH

1.1 Overview of the INTAS-funded research activities

The INTAS funding was used exclusively for eight East-to-West partner visits. These are specified as Visits A — H in Section 2.1 on page 9. They were very productive, particularly with respect to Tasks T2 and T4 in which Team CR3 collaborated with Teams CR1 and CO to generate most of the 39 publications in our list of grant-acknowledging papers on p. 5 ff. Highlights are detailed below with specific references to pertinent papers.

Task T1, however, implementing Irkutsk filter installation on the Dutch Open Telescope on La Palma (Teams CR2 and CO) met unforeseen organisational and technical difficulties causing long delays, including initial delay as well as considerable extension of the project – and also delay of this report. Unfortunately, this task remains effectively uncompleted even at the time of writing although much further effort has been spent and is being spent on it at present. This incompletion also affected Task T3, but only partially.

Overall, the project consortium regards its INTAS collaborations the past years as a very positive experience and a success in view of the excellent results from Tasks T2 and T4. The partners are very grateful for INTAS' support of their collaborations. They continue these on other funding.

1.1.1 Task T1: installation of the Irkutsk Ba II 4554 Å filter

Relevant papers: [22], [27]. This is the unsuccessful part of the project. The First Periodic Report already explained delays from securing funding for the Dutch Open Telescope (DOT) and an imposed priority order in other technical projects. When those came into full operation the intended project became the principal technology-development priority, but notwithstanding large effort in extended visits by the Irkutsk filter builders (Team CR2) to Utrecht (Visit G) and to La Palma (Visit H) we have not been able to fulfil Task T1 as yet. The Ba II 4554 Å filter was indeed refurbished (at Utrecht during Visit G) and installed on the telescope (La Palma, Visit H), but its photon throughput was found to be subnominal for reasons that are not yet understood. In an extensive campaign exploiting the optical benches at the adjacent Swedish 1-m Solar Telescope during last August the filter was tested there, but again without definite diagnosis of its aberrantly low transmission. It is presently again dismounted from the DOT for spectral passband measurement and optical re-tuning using a spectrometer that was built on-site specifically for this purpose by Team CR2 during their stay there. Our hope that we would arrive at a diagnosis and remedy sooner was the main motivation for delaying this report: we hoped to come up with good news in the end rather than this still inconclusive negative result – for which we apologise sincerely.

1.1.2 Task T2: calibration of diagnostics

Relevant papers: [11], [12], [30], [31], [33], [37], [38], [39]. This task was executed, with respect to INTAS funding, through second-year Visits A – C already reported in the Second Periodic Report. Since then, and up to the present, the intensive collaboration between teams CR3 and CR1 continues on other funding; in particular, CR3's Khomenko is now a long-term postdoc in the CR1 group at La Laguna while CR3's Shchukina remains a frequent visitor there. Visits F and H (of CR3's Sheminova to Utrecht = Team CO) addressed this task as well.

1.1.3 Task T3: data collection and reduction

Relevant papers: [1], [2]. This part of the project targeted usage of the Irkutsk Ba II 4554 Å filter on the DOT after completion of Task 1. Fortunately, the lack of success in the latter did not fully impede this part of the project (Andriyenko and Osipov) altogether since it was remedied through

Visit E of the team CR3 observers to utilise another solar telescope in the Canary Islands, the German Vacuum Solar Telescope on Tenerife, in Ba II 4554 Å spectrometry in collaboration with Khomenko, then postdoc at Laguna, in a CR1–CR3 collaborative project.

1.1.4 Task T4: analysis and interpretation

Relevant papers: all remaining ones in the list on p. 5 ff. This task became the most successful part of the project, in particular through the productive CR1–CR3 collaborations initiated in Visits A – C and continued since as noted above for Task 2. Most of the project publications stem from these intensive collaborations.

1.2 Scientific Results

Since we cannot treat all results exhaustively in 1–2 pages, we group them in presenting highlights. The numbered references refer to the complete publication list on p. 5 ff.

Quiet-Sun internetwork magnetism Papers [23], [29], [30]. [11], [10], [8], [9], [35]
The first three papers treat magnetic weak field determination using the Hanle effect through multilevel three-dimensional radiative transfer modelling of linear scattering polarisation in atomic and molecular lines. Combination with observational data indicates an ubiquitous, tangled magnetic field with average strength around 130 G, stronger in intergranular lanes than in granules. It suffices to balance radiative energy losses from the solar chromosphere. In the other papers, quiet-sun magnetism was studied from high-resolution infrared spectropolarimetric observations with the Tenerife Infrared Polarimeter (TIP) at the German VTT at the Observatorio del Teide. The measured Stokes V profiles were classified through single-value decomposition. The profiles exhibit different velocities, Zeeman splitting, and asymmetries, and are clustered in patches close to the angular resolution. Most field occurs within intergranular lanes.

Magneto-acoustic waves in sunspots Papers [7], [6]
The magnetic-field variations in sunspot umbrae comprise intrinsic oscillations contaminated by "false" oscillations from time-dependent opacity modulations. A successful method was developed to separate these components, based on analytical solution of the magnetohydrodynamical (MHD) equations including gravity, inclination of the magnetic field, and non-adiabaticity.

Excitation and propagation of waves in the photosphere Papers [21], [15], [12], [5], [25]
Fe I spectra from the German VTT were used to study five-minute oscillations within granules and intergranular lanes. Both the intensity and the velocity amplitudes are larger over intergranular lanes; the five-minute oscillation power is higher above faster convection in the low photosphere, suggesting that turbulent convection excites local oscillations. Simulations of the propagation of acoustic-gravity waves accounting for the convection pattern gave a satisfactory explanation of these observations.

Studies of solar granulation Papers [13], [20]
The granulation brightness and velocities were examined using Fe I-line spectra and compared to a multi-column model. Four types of motions were established. In the first two, only the sign of the relative contrast of the material changes but in the latter two, both contrast and the direction reverse. These results were compared with theoretical relations obtained from a three-dimensional hydrodynamical model which satisfactory reproduces all the basic features.

Bright features in the solar photosphere Papers [16], [14], [17], [39], [38]
In the first three papers spectra of quiet granulation revealed a stable bright structure of 3-4 arcsec size during the 2.5 hours of observation. It must have a non-convective origin. The observed decrease of oscillatory amplitude indicates the presence of magnetic field. In the latter two papers

high-resolution spectra from La Palma of such long-lived magnetic elements were used to establish that the temperature stratification within them is close to radiative equilibrium.

Applications to other stars Papers [31], [32], [34], [4], [3], [33], [24]
These studies concern the effect of non-LTE radiative transfer and convective inhomogeneities on the determination of elemental abundances in solar-like stars, taking solar expertise as guidance, addressing stellar iron, oxygen, magnesium and lithium abundances in particular. Major conclusions are that these abundances in metal-poor stars can only ascertained through full hydrodynamical surface convection modeling but that even then the lithium abundance remains smaller than the primordial big-bang value.

Joint NIS–INTAS publications (numbers refer to the complete list on p. 5 ff)

- International journals: [7] [8] [10] [11] [23] [24] [31] [39]
- National journals: [32]
- Conference proceedings: [3] [4] [6] [9] [29] [30] [33] [34]

Non-joint publications (numbers refer to the complete list on p. 5 ff)

- International journals: [12] [15] [20] [21] [27] [28]
- National journals: [5] [13] [16] [17] [19] [35] [36] [37]
- Conference proceedings: [1] [2] [14] [18] [22] [25] [26] [38]

Summary of scientific output

Scientific output	All publications			Joint publications
	Published	In press	Submitted	
International journal	14	0	0	8
National journal	9	0	0	1
Proceedings	12	4	0	8

All papers with INTAS acknowledgement (ordered alphabetically per first author)

[1] Andriyenko, O. V.: 2005, "Neutral manganese 539.5 nm line profiles in spots, plages and quiet regions on the Sun", in V. I. Kurkin (Ed.), *Astrophysics and physics of near-Earth space*, Internat. Baikal School on Fundamental Physics, ISEP SD RAN, Irkutsk, 153

[2] Chornogor, S. N., Kashapova, L. K., Sych, R. A., and Andriyenko, O. V.: 2005, "Preflare HXR and chromospheric line emission in NOAA 0652 on 25th July 2004", in *Thee Dynamic Sun: Challenges for Theory and Observations*, Procs. 11th European Solar Physics Meeting, ESA SP-600, 115.1.

[3] Israelian, G., Shchukina, N., Rebolo, R., Basri, G., and Gonzalez Hernandez, J. I.: 2003, "Oxygen abundances in ultra-metal-poor giants CS29498-043 and CS22949-037", in A. McWilliam and M. Rauch (Eds.), *Origin and Evolution of the Elements*, Vol. 4, Carnegie Observatories Astrophysics Series, 27I

[4] Israelian, G., Shchukina, N., Rebolo, R., Basri, G., Gonzalez Hernandez, J. I., and Kajino, T.: 2004, "Oxygen and magnesium abundance in the ultra-metal-pool giants CS29498-043 and CS22949-037: Challenges in models of atmospheres", *Astronomy & Astrophysics* **419**, 1095

[5] Khomenko, E. V.: 2002, "Local oscillations and their modification in inhomogeneous solar atmosphere", *Kinematika i Fizika Nebesnyh Tel* **18**, 559

[6] Khomenko, E. V. and Collados, M.: 2005, "Simulations of Acoustic Waves in Sunspots", in D. E. Innes, A. Lagg, and S. A. Solanki (Eds.), *ESA SP-596: Chromospheric and Coronal Magnetic Fields*, 40.1

[7] Khomenko, E. V., Collados, M., and Bellot Rubio, L. R.: 2003a, "Magneto-acoustic waves in sunspots", *Astrophysical Journal* **588**, 606

[8] Khomenko, E. V., Collados, M., Solanki, S. K., Lagg, A., and Trujillo Bueno, J.: 2003b, "Quiet-Sun inter-network magnetic fields observed in the infrared", *Astronomy & Astrophysics* **408**, 1115

[9] Khomenko, E. V., Collados, M., Solanki, S. K., Lagg, A., and Trujillo Bueno, J.: 2007, "Quiet-Sun inter-network magnetic fields observed in the infrared", in *Bulletin Crimean Astrophysical Observatory*, Vol. 99, in press

[10] Khomenko, E. V., Martínez González, M. J., Collados, M., Vögler, A., Solanki, S. K., Ruiz Cobo, B., and Beck, C.: 2005, "Magnetic flux in the internetwork quiet Sun", *Astronomy & Astrophysics* **436**, L27

[11] Khomenko, E. V., Shelyag, S., Solanki, S. K., and Vögler, A.: 2005, "Stokes diagnostics of simulations of magnetoconvection of mixed-polarity quiet-Sun regions", *Astronomy & Astrophysics* **442**, 1059

[12] Kostik, R. and Khomenko, E. V.: 2002, "The effect of acoustic waves on spectral-line profiles in the solar atmosphere: observations and theory", *Astronomy Reports (Soviet Astronomy)* **46**, 925

[13] Kostik, R. I.: 2005, “Fine structure of convective motions in the solar photosphere”, in P. Berczik and O. Bolotina (Eds.), *Astronomy in Ukraine – Past, Present and Future*, Kinematika Fizika Nebesnyh Tel. Suppl. Ser. 2005 – N5, 134

[14] Kostik, R. I. and Khomenko, E. V.: 2004a, “Convective and wave motions in a thermal plume”, in A. V. Stepanov, E. E. Benevolenskaya, and A. G. Kosovichev (Eds.), *Multi-Wavelength Investigations of Solar Activity*, Procs. IAU Symposium 223, Cambridge University Press, 271

[15] Kostik, R. I. and Khomenko, E. V.: 2004b, “Oscillations in solar atmospheric structures”, *Journal of Physical Studies* **8**, 279

[16] Kostik, R. I. and Khomenko, E. V.: 2005, “Bright features in the solar photosphere”, in P. Berczik and O. Bolotina (Eds.), *Astronomy in Ukraine – Past, Present and Future*, Kinematika Fizika Nebesnyh Tel. Suppl. Ser. 2005 – N5, 141

[17] Kostik, R. I. and Khomenko, E. V.: 2007, “Convective and wave motions in rare-observed solar phenomenon”, in *Bulletin Crimean Astrophysical Observatory*, Vol. 99, in press

[18] Kostik, R. I., Osipov, S. N., Khomenko, E. V., and Lebedev, N. I.: 2004, “Helioseismology space and ground based studies”, in A. V. Stepanov, E. E. Benevolenskaya, and A. G. Kosovichev (Eds.), *Multi-Wavelength Investigations of Solar Activity*, Procs. IAU Symposium 223, Cambridge University Press, 273

[19] Kostik, R. I., Osipov, S. N., Khomenko, E. V., and Lebedev, N. I.: 2005, “Helioseismology space and ground-based studies”, in P. Berczik and O. Bolotina (Eds.), *Astronomy in Ukraine – Past, Present and Future*, Kinematika Fizika Nebesnyh Tel. Suppl. Ser. 2005 – N5, 138

[20] Kostik, R. I. and Shchukina, N. G.: 2004, “Fine structure of convective motions in the solar photosphere: Observations and theory”, *Astronomy Reports (Soviet Astronomy)* **48**, 769

[21] Kostik, R. I., Shchukina, N. G., and Khomenko, E. V.: 2006, “Fine structure of wave motions in the solar photosphere: Observations and theory”, *Astronomy Reports (Soviet Astronomy)* **50**, 588

[22] Kushtal, G. I., Skomorovski, V. I., Domyshev, G. N., Sadokhin, V. P., , and Opsikov, I. A.: 2007, “Birefringent filter of Šolc type with wide field of view”, in *The Solar Activity and its Influence on the Earth*, Transactions Ussuriisk Astrophysical Observatory, Vol. 10, Dalnauka, Vladivostok, 57

[23] Trujillo Bueno, J., Shchukina, N., and Asensio Ramos, A.: 2004, “A substantial amount of hidden magnetic energy in the quiet Sun”, *Nature* **430**, 326

[24] Meléndez, J., Shchukina, N. G., Vasiljeva, I. E., and Ramírez, I.: 2006, “Permitted oxygen abundances and the temperature scale of metal-poor turnoff stars”, *Astrophysical Journal* **642**, 1082

[25] Rutten, R. J.: 2003, “Waves in the chromosphere: observations”, in R. von Fay-Siebenbürgen, K. Petrovay, J.-L. Ballester, and M. Aschwanden (Eds.), *Turbulence, Waves and Instabilities in the Solar Plasma*, NATO ASI Series II 124, Kluwer, Dordrecht, 137

[26] Rutten, R. J.: 2005, "MAO–SIU solar physics collaborations", in P. Berczik and O. Bolotina (Eds.), *Astronomy in Ukraine – Past, Present and Future*, Kinematika Fizika Nebesnyh Tel. Suppl. Ser. 2005 – N5, 11

[27] Rutten, R. J., Hammerschlag, R. H., Bettonvil, F. C. M., Sütterlin, P., and de Wijn, A. G.: 2004, "DOT tomography of the solar atmosphere I. Telescope summary and program definition", *Astronomy & Astrophysics* **413**, 1183

[28] Rutten, R. J. and Krijger, J. M.: 2003, "Dynamics of the solar chromosphere IV. Evidence for atmospheric gravity waves from TRACE", *Astronomy & Astrophysics* **407**, 735

[29] Shchukina, N. G. and Trujillo Bueno, J.: 2003, "Towards a reliable diagnostics of 'turbulent' magnetic fields via the Hanle effect in the SrI 4607 A line", in J. Stenflo and J. Trujillo Bueno (Eds.), *Third International Workshop on "Solar Polarization"*, Vol. 307, ASP Conf. Ser., 336

[30] Shchukina, N. G. and Trujillo Bueno, J.: 2007, "Hanle diagnostics of weak magnetic fields", in *Bulletin Crimean Astrophysical Observatory*, Vol. 99, in press

[31] Shchukina, N. G., Trujillo Bueno, J., and Asplund, M.: 2005, "The impact of non-LTE effects and granulation inhomogeneities on the derived iron and oxygen abundances in metal-poor halo stars", *Astrophysical Journal* **618**, 939

[32] Shchukina, N. G., Vasiljeva, I. E., and Trujillo Bueno, J.: 2003a, "Stellar granulation and the NLTE formation of the FeI lines: the metal-poor halo star HD140283", *Kinematika i Fizika Nebesnyh Tel* **19**, 441

[33] Shchukina, N. G., Vasiljeva, I. E., and Trujillo Bueno, J.: 2007, "Line formation problem and abundance determinations in the metal-poor stars: Fe I, Fe II, O I and Mg I lines", in *Bulletin Crimean Astrophysical Observatory*, Vol. 99, in press

[34] Shchukina, N. G., Vasiljeva, I. E., Trujillo Bueno, J., and Asplund, M.: 2003b, "Non-LTE determination of iron and oxygen abundances using 3D hydrodynamical models: the metal-poor star HD140283", in N. E. Piskunov, W. W. Weiss, and D. F. Gray (Eds.), *Modelling of Stellar Atmospheres*, IAU Symp. 210, B10

[35] Sheminova, V. A.: 2003, "The line Fe I lambda 1564.8 nm and distribution of solar magnetic fields", *Kinematika i Fizika Nebesnykh Tel* **19**, 107

[36] Sheminova, V. A.: 2004, "2-D MHD model of solar magnetogranulation. Dynamics of magnetic elements", *Kinematika i Fizika Nebesnykh Tel* **20**, 3

[37] Sheminova, V. A.: 2005, "On the origin of the extremely asymmetric Stokes V profiles in an inhomogeneous atmosphere", *Kinematika i Fizika Nebesnykh Tel* **21**, 172

[38] Sheminova, V. A., Rutten, R. J., and Rouppe van der Voort, L. H. M.: 2005, "The temperature gradient in and around solar magnetic fluxtubes", in P. Berczik and O. Bolotina (Eds.), *Astronomy in Ukraine – Past, Present and Future*, Kinematika Fizika Nebesnyh Tel. Suppl. Ser. 2005 – N5, 110

[39] Sheminova, V. A., Rutten, R. J., and Rouppe van der Voort, L. H. M.: 2005, "The wings of Ca II H and K as solar fluxtube diagnostics", *Astronomy & Astrophysics* **437**, 1069

1.3 Impact and Applications

The major impact of the work funded by INTAS within our project is the intensification of our East–West collaborations. This is exemplified by Khomenko's (CR3) present long-term postdoc at La Laguna (CR1), Shchukina's frequent visitorship there, the continuing other CR3–CR1, CO–CR3 and CO–CR2 collaborations, the fact that Sheminova (CR3) will soon gain a formal Doctor of Science degree (the high-level one of the Eastern system, as a German 'Habilitation") partially based on her work with Team CO, and the invitation for the project coordinator to be the opening reviewer at the symposium celebrating the sixtieth birthday of the Main Astronomical Observatory of the Academy of Sciences of the Ukraine in Kiev in the summer of 2004 (paper [26]).

More in general, solar physics is part of astronomy and largely a pure science. However, the sun is not only our archetypical example star and the source of life-giving daylight on our planet. The sun also impacts the terrestrial environment with "space weather", i.e., for the high-energy particle showers and radiation bursts from which we ourselves are shielded by the Earth's atmosphere but which do have economical consequences in our modern technological habitat. Our work was not directly related to space weather but since solar activity has solar magnetism at its roots, fundamental research into the nature of solar magnetism is certainly worthwhile and ultimately also important in space-weather context. Thus, our work has important overtones of more direct utility than one expects from pure-science astrophysics.

This said, it is clear that the applications of our work remain within our own science for the coming years. Much of the work within Task2 by the CR1–CR3 collaborations targeted diagnostics and analysis of magnetism in the solar photosphere. Especially weak-field solar magnetism is a realm of solar physics research presently opening up. The eventual completion of Task 1 should lead to deployment of the Ba II 4554 Å line in polarimetric diagnostics within this field (scattering depolarisation, Hanle effect, atomic hyperfine structure as Zeeman diagnostic).

We intend to continue all collaborations pursued in the INTAS project.

1.4 Summary of results

The project consisted of extended working visits of scientists of the Main Astronomical Observatory in Kiev (Ukraine) and of the Institute of Solar-Terrestrial Physics in Irkutsk (Russia) to the Instituto de Astrofísica de Canarias in La Laguna (Spain) and to the Sterrekundig Instituut of Utrecht University in The Netherlands.

Overall, the project targeted the solar photosphere (the layer where sunlight escapes), in particular its structuring imposed by solar magnetism. The various collaborations addressed magnetic solar phenomena across a wide range of sizes and field strengths, from full sunspots via strong-field but slender magnetic elements down to the elusive weak internetwork fields. The most important result (publication in Nature) is that the latter weak fields are present in the solar atmosphere to a much larger extent then was believed so far.

Other directly related topics are the presence and rôle of magneto-acoustic waves inside sunspots and acoustic waves in less-magnetic solar plasma, and the effects of inhomogeneities on the determination of elemental abundances both in the sun and in other stars.

The project resulted in 39 articles in the astrophysical literature. Five selected papers are specified below. They are all electronically available from NASA's Astrophysics Data System at `http://adsabs.harvard.edu/default_service.html` through selecting pertinent author names.

[7] Khomenko, E. V., Collados, M., and Bellot Rubio, L. R.: 2003a, "Magneto-acoustic waves in sunspots", *Astrophysical Journal* **588**, 606

[8] Khomenko, E. V., Collados, M., Solanki, S. K., Lagg, A., and Trujillo Bueno, J.: 2003b, "Quiet-Sun inter-network magnetic fields observed in the infrared", *Astronomy & Astrophysics* **408**, 1115

[23] Trujillo Bueno, J., Shchukina, N., and Asensio Ramos, A.: 2004, "A substantial amount of hidden magnetic energy in the quiet Sun", *Nature* **430**, 326

[39] Sheminova, V. A., Rutten, R. J., and Rouppe van der Voort, L. H. M.: 2005, "The wings of Ca II H and K as solar fluxtube diagnostics", *Astronomy & Astrophysics* **437**, 1069

[21] Kostik, R. I., Shchukina, N. G., and Khomenko, E. V.: 2006, "Fine structure of wave motions in the solar photosphere: Observations and theory", *Astronomy Reports (Soviet Astronomy)* **50**, 588

1.5 Role and Impact of INTAS

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

Main achievement of the project	Very important	quite so	less so	not so
exciting science	+			
new international contacts		+		
additional prestige for my lab				+
additional funds for my lab				+
helping scientists in NIS	+			

We aim to let the project continue in the future in all its facets, i.e., continued CR3 visits to and stays at CR1 and CO, and continued involvement of the CR2 partners in CO's Dutch Open telescope.

The collaboration between the project Contractors will also continue in the future.

2 MANAGEMENT

2.1 Meetings and visits

In the list and summary table below we list the INTAS-funded travels only. Many more meetings, exchanges, and extended stays at other teams took place, but all on funding from other sources. The various items correspond directly to the expenditures listed on the cost statements. These concerned East ⇒ West travels exclusively.

Visit A – Khomenko, Kostik, and Shchukina (CR3) to La Laguna (CR1)
September 21, 2002 — November 22, 2002
Purpose: tasks T2 and T4.

Visit B – Kostik and Shchukina (CR3) to La Laguna (CR1)

April 4, 2003 — June 3, 2003
Purpose: tasks T2 and T4.

Visit C – Khomenko (CR3) to La Laguna (CR1)
April 25, 2003 — June 28, 2003
Purpose: tasks T2 and T4.

Visit D – Sheminova (CR3) to Utrecht (CO)
December 1 2003 – December 19, 2003
Purpose: tasks T2 and T4.

Visit E – Andriyenko and Osipov (CR3) to La Laguna (CR1)
July 10 2004 – August 7, 2004
Purpose: task T3.

Visit F – Sheminova (CR3) to Utrecht (CO)
November 29, 2004 - December 17, 2004
Purpose: tasks T2 and T4.

Visit G – Skomorovsky and Domishev (CR2) to Utrecht (CO)
March 26 2005 – April 29, 2005
Purpose: task T1

Visit H – Skomorovsky and Domishev (CR2) to La Palma (CO)
November 2, 2005 – December 5, 2005
Purpose: task T1

Summary (INTAS-funded travel only):

Visits	Number of scientists	Number of person days
East $\Longrightarrow$ West	8	610

2.2 Collaboration

Intensity of Collaboration	high	rather high	rather low	low
West $\Longleftrightarrow$ East	CR1–CR3	CO–CR3		CR1–CR2
		CO–CR2		
West $\Longleftrightarrow$ West			CO–CR1	
East $\Longleftrightarrow$ East			CR2–CR3	

Related international collaborations: teams CO and CR1 participated in the EC–RTN "European Solar Magnetism Network" ESMN. Tasks T2 and T4 overlapped with various ESMN activities.

2.3 Time Schedule

The collaboration followed the Work Programme except for the long delays that occurred in DOT instrumentation including Task 1. The latter first caused a phasing shift, moving spending on the CR1–CR3 collaborations forward in order to save allocation for the DOT-oriented work during the final years, That activity required formal extension of the project duration for which we are very grateful. As described above, Task T1 became even further delayed through technical problems not solved at the time of writing, even though we also delayed this report in the hope that they would be solved. However, our efforts in Tasks 2 and 4 made up by being fulfilled well in time and at a level far beyond the initial expectation.

2.4 Problems encountered

The table below is the same as the corresponding table in the First and Second Periodic Reports. After the serious problem reported in the First Periodic Report there were no further difficulties with the Schengen rule. (The technical problems encountered in Task 1 are not of the type that should be specified here.)

Problems encountered	major	minor	none	not applicable
Team co-operation			excellent	
Transfer of funds			fast!	
Telecommunication		slow internet		
Transfer of goods				none
Other	Schengen rule			

2.5 Actions required

Closure of the project including transfer of the overheads.

3 FINANCES

3.1 This grant

Contractor		Cost category						TOTAL
Nr.	Contractor	Individual Labour	Overheads	Travel & Subsistence	Consum.	Equip.	Other Costs	€
CO	UU	–	2 000	–	–	–	–	2 000
CR1	IAC	–	2 000	–	–	–	–	2 000
CR2	ISTP	–	–	12 924	–	–	–	12 924
CR3	MAO	–	–	36 396	–	–	–	36 396
TOTAL		–	4 000	49 320	–	–	–	53 320

The first two items are overheads not yet received. The last two items cover all travels by the Kiev team (CR3, Visits A through F) and the Irkutsk team (CR2, Visits G and H), respectively. Detailed travel costs breakdowns with full documentation (all tickets etc.) are held at Utrecht by the co-ordinator, as well as the signed Cost Statements by the CR2 and CR3 team leaders. All spending was in accordance with the Work Programme, except for the phasing shift specified above.

3.2 Other funding

Our collaborations have received much funding from other sources. Initially, some of our joint work was started on NATO Collaborative Research Grants. Earlier, members of the CR3 team (Kiev) worked in Utrecht on Dutch funding and in La Laguna on Spanish funding. Since their INTAS visits to La Laguna, Khomenko and Shchukina (CR3) have spent much time at La Laguna on Spanish funding. Andriyenko (CR3) has mounted an eclipse expedition to observe the Ba II 4554 Å line during the March 26, 2006 total solar eclipse at the CR3's Terskol Observatory (Caucasus) on private funding from team CO. A third team member of CR2, Galina Kushtal, joined CR2's travel to the DOT on DOT funding.

Scanned copy of the signed Summary Cost Statement:

SUMMARY COST STATEMENT (Annex II, General Conditions Part D(2))

For the final report only! A signed copy of the Summary Cost Statement must be submitted to INTAS duly signed by the Coordinator

For the period from July 1, 2001 to December 31, 2005

INTAS Ref. No: 201-84

Project Title: High Resolution Physics of the Solar Photosphere

Contractor		**Cost Category**						**TOTAL (Euro)**
	Name of Contractor	Labour/Individual Grants	Overheads	Travel and Subsistence	Equipment	Consumables	Other Costs	
1	R.J. RUTTEN		2000					2000
2	M. COLLADOS		2000					2000
3	V. SKOMOROVSKI			12924				12924
4	R.I. KOSTIK			36396				36396
5								
6								
TOTAL (Euro)			4000	49320				53320

<u>Attention:</u>

Please only use amounts in Euro[4] in this Summary Cost Statement based on the Cost Statements per Contractor. Identify main cost items such as equipment (> 1000 Euro), significant purchases of consumables (>1000 Euro), project meetings and other project related travel etc. as specified in the Contractor's Individual Cost Statements.

Please specify in the Summary Cost Statement of the Final Report the use of the full INTAS Project grant including the final payment of 10 % still to be received. The final payment covers costs advanced by the Contractors, pending Individual Grants or, within their allowable maximum, Overhead Costs.

<u>Remarks:</u> Apology for late submission

<u>Coordinator's Certificate</u>

I hereby certify that the above costs to my best knowledge are true and honest, have been incurred and fall within the definition of allowable costs as specified in Articles 11, 12 and 13 of the General Conditions to the Co-operation Agreement and were necessary for the execution of the project. The above Summary Cost Statement has been compiled based on each of the Contractor's Cost Statements submitted to me which are available for audit.

Name of the Co-ordinator: ROBERT J. RUTTEN

Date and original signature of the Co-ordinator: March 8, 2007 [signature]