ESMN — European Solar Magnetometry Network

# Mid-Term Report

TMR network title: European Network to Measure and Understand Solar Surface Magnetism through Coordinated Use of the Canary Island Telescopes and the SOHO Mission

Network short title: European Solar Magnetometry Network (ESMN)

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Duration of contract: 48 months

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Location of mid-term review meeting: Santa Cruz de Tenerife, Spain

Date and time of meeting: September 30 2000, 09:00—18:30

# Part A. Research Results

## A.1 Scientific Highlights

Solar physics is on the upswing worldwide. The ESMN efforts are an integral part of this advance. In this brief review, I first comment on the general context, then exemplify ESMN achievements.

**Context.** Three developments are, in my view, identifiable as the major reasons behind the current blossoming of solar physics. The first is the stupendous success of the SOHO mission. SOHO is the first cornerstone mission of the ESA Horizon 2000 programme, defined decades ago as the first space mission to observe the sun comprehensively, "from the deep interior to the outer heliosphere" — which it does, reliably and continuously. SOHO has yielded a wide variety of important discoveries that range from below-the-surface helioseismology to *in situ* solar wind composition results. Within the context of solar magnetometry, the MDI instrument represents the first space-borne solar magnetograph providing reliable maps of the solar surface magnetic field without spoiling by atmospheric "seeing" or nighttime interruptions, at regular to high cadence, and over long time spans. It yet lacks in angular resolution and sensitivity, but its trustworthiness has drastically changed solar dynamo pattern studies. MDI also provides magnetogram context to many studies addressing the patterns and dynamics of the solar atmosphere. These are observed with SOHO's ultraviolet EIT imager, SUMER and CDS spectrometers, and the LASCO coronograph. The superb data sequences from these instruments vividly display the fact that the sun represents an MHD and plasma physics laboratory of unparalleled richness in physical processes. In addition, the coronal explosions witnessed by LASCO and other instruments have greatly contributed to the present emphasis on "space weather", the solar modulation of the cosmic ray flux, and the long-term influence of the solar activity cycle on the terrestrial climate. The host of SOHO discoveries is very well documented on the web (http://sohowww.estec.esa.nl/) and on the excellent CD-Roms produced by the SOHO teams. SOHO has rightfully gained high public awareness and gets much attention from the media.

The second reason for the revival of solar physics is the advent of image restoration techniques that, for the first time, enable to correct the deterioration caused by the refractive index variations of the earth atmosphere. This is being done post-detection with phase diverse and speckle reconstruction techniques, and in real time through the application of adaptive optics with fast wave-front sensing. These techniques enable imaging, proxy magnetometry, spectrometry, and spectropolarimetry at the diffraction limit of the telescope, a giant improvement compared with all previous groundbased observing in which the atmospheric seeing limited the best possible quality to effective apertures (the so-called Fried parameter) far smaller than the actual telescope diameters, and that only during brief periods at best. With these new techniques, groundbased solar observation is undergoing revolutionary improvements in angular resolution and in the duration of high-quality sequences. This progress is also well advertised; for example, the UU and KVA teams 'made" the tremendously popular *Astronomy Picture of the Day* website with a sunspot movie from the DOT (http://antwrp.gsfc.nasa.gov/apod/ap000223.html) and an adaptive-optics sunspot image from the SVST (http://antwrp.gsfc.nasa.gov/apod/ap000522.html).

The third reason for the solar physics upswing is the advent of realistic numerical modeling. This progress is perhaps less flashy to outsiders and less easily popularized, but it represents a most important breakthrough in the way solar physics is done. The sun and its atmosphere are simply too complex to be addressed by analytic physics or scenario-type analysis of the type that, by sheer necessity, solar physicists have tried for the best part of the past century after the basic physics of radiative transfer and MHD in solar conditions had been formulated. The sun is really a zoo of widely different processes which all interact at widely different scales to produce a complex mixture of phenomena that cannot be studied by isolating one quantity at a time or defining a mechanism for one that ignores the others, or by simplifying the physics to linearity or stationarity, or even quasi-thermodynamic equilibrium. Numerical simulation now becomes realistic enough, thanks to the increase in processing speed as well as the formulation of clever algorithms, to address a large variety of solar physics problems at the level of sophistication needed for proper physical interpretation.

The rosy solar physics perspective that results from these advances is most evident in the US, where the recently released decadal priority report puts a new large ground-based solar telescope facility squarely on the map (presently called the ATST = "Advanced Technology Solar Telescope", order of four meter diameter and with advanced adaptive optics, to become operational by the next decade) and where NASA has started the AWS = "Living with a Star" initiative that encompasses a host of solar satellites including a Solar Diagnostic Observatory which is basically a souped-up SOHO with larger-format CCD's and much larger telemetry rates. However, what yet lacks in the US (as is also pointed out in the US policy reports) is sufficient and timely education of young solar physicists, mainly because there is a lack of US university involvement in solar physics. This weakness contrasts with the European situation, where relatively small university groups produce many more young researchers.

European solar physics participates in the upswing in characteristic European fashion. SOHO continues to yield beautiful data sequences; a solar orbiter mission is contemplated by ESA. There are no large ground-based plans as ATST in Europe, but a number of smaller-scale telescope projects aiming at rapid development of new technology and relying on international cooperation make it highly likely that the Canary Islands will be the main arena for high-quality ground-based observational solar physics during the coming years. Theoretical solar physics in Europe surpasses the US in both scope and depth. It is most fitting that a second solar physics European network (PLATON) has recently been funded in the Fifth Framework Programme to undertake studies of coronal heating, flares and winds, topics that are highly complementary to the ESMN.

The ESMN participates actively in the three solar physics revolutions that I sketched above. It is obvious that SOHO is not a product of the ESMN, but the ESA group that operates SOHO is an ESMN partner and the Network is fully integrated in SOHO research. In the image restoration revolution, a major advance is expected from the KVA efforts within the ESMN. The KVA group has been at the forefront of adaptive optics development using the SVST = "Swedish Vacuum Solar Telescope" on La Palma, and has recently expanded this effort into a complete overhaul of this telescope — with "last light" mid-August — which will turn it into the NSST = "New Swedish Solar Telescope" exploiting adaptive optics to obtain unprecedented angular resolution. At the neighbouring DOT = "Dutch Open telescope" speckle reconstruction has been selected by the UU team to realize a large-volume high-resolution imager at a number of wavelengths suited to proxy-magnetometry in tomographic fashion. In the numerical revolution, the UiO group is worldwide at the forefront in time-dependent radiation hydrodynamics simulation, while the IAC is exploiting a host of new inversion techniques in diagnostic spectropolarimetry.

**ESMN achievements.** The ESMN annual reports over the past two years (together covering May 1, 1998 — April 30, 2000) detail the ESMN accomplishments comprehensively on the basis of the task lists set in the contract. There is no point in copying these item lists into this report; instead, I take a somewhat wider perspective in order to demonstrate that the network is "advancing the international state-of-art" by highlighting three topics that illustrate the general comments made above: advances on sunspot oscillations as an example of solar physics quests, advances in solar magnetometry techniques since these are the backbone of the network programme, and the ESMN schools because training young researchers is our primary task.

**Sunspot dynamics: archetypical solar physics.** The ESMN multi-telescope campaigns synthesize space observations with SOHO[1] and the Canary Island telescopes. An outstanding topic that has emerged from these campaigns and from corresponding theoretical studies is the nature of sunspot oscillations. The timing of this emphasis is not surprising since the sun is presently in the maximum phase of the solar activity cycle — the ESMN timeframe is centered on the activity maximum which means that solar magnetism presents its richest variety of phenomena, structures, and processes right now.

Sunspot oscillations occur in the photosphere, the overlying chromosphere, and even high up in the transition region to the corona. The JOP's (Joint Observing Programme) led by ESMN young[2] researcher Karin Muglach at the AIP therefore combine photospheric and chromospheric diagnostics from the Canary Island telescopes with higher-layer EUV data obtained from space, in both cases relying on image sequences to obtain sunspot dynamics patterning and evolution and on spectroscopy to obtain Dopplershifts. These campaigns are providing as complete a picture of sunspot oscillations as the current state-of-the-art observing permits. For example, they constitute the first science data from the DOT.

On the interpretative side, it is now clear that magneto-acoustic waves propagate upwards in the umbra and turn into shocks at relatively low heights due to the rarefied umbral atmosphere. A brilliant recent PhD study at the IAC (by H. Socas Navarro who won the Spanish prize for the best astronomy thesis over the past two years) utilizes the sophisticated numerical inversion techniques developed at the IAC to obtain the shock properties from umbral Stokes polarimetry. At the AIP, neural-network polarimetric inversion is being added to the array of analysis techniques. Another approach, "forward modeling" instead of inversion, is undertaken at UiO in which a radiation-hydrodynamics simulation code is fed with actual SVST observations from partner KVA in the form of observed photospheric Dopplershifts to generate a simulation piston that enables detailed comparison between the observed and computed shock response if the umbral atmosphere higher up. This technique has earlier revolutionized the understanding of the quiet-sun chromospheric structure and is also applied at UiO to spectral sequences from SUMER on SOHO in other JOP's.

In summary, the ESMN sunspot oscillation studies characterize ESMN science as well as solar physics in general by the variety of techniques involved: from instrumentation and observing campaigns to sophisticated inversion and numerical simulation.

[1]and the newer TRACE mission, a small US satellite that does not contain any spectrometer but images the sun at some selected wavelengths with higher angular resolution than SOHO.

[2]She complains in her essay below that she is getting old....

**Solar magnetometry: towards the diffraction limit.** The instrumentation needed for solar magnetometry represents a major area of ESMN effort. The developments at THEMIS (OP and OAC), of the three new liquid-crystal spectrometers (IAC and KVA) at other Canary Island telescopes, the GREGOR plan for rebuilding the GCT, the multi-wavelength speckle registration system being realized at the DOT, and the OAC VAMOS imaging polarimeter are all important and interesting projects worth more extensive description than given in the yearly reports — but also here I will limit myself, to what I regard as the most captivating magnetometry highlight: the NSST project. It started well after the ESMN start and may reach the stage of science data taking well before the ESMN termination.

Basically, the NSST is a doubling of the SVST, which during the past decade was the sharpest imager in solar physics. The SVST was (past tense, the doublet objective lens came down on August 28) a vacuum refractor with 48 cm aperture diameter in which the combination of excellent La Palma seeing, utter optical quality and design simplicity, and very advanced computer control and data acquisition (thanks to the KVA–COMPAQ cooperation, see Shand *et al.* abstract in the Appendix) led to unprecedented image sharpness — now parallelled by the adjacent DOT which is actually operated from the SVST building — which put the SVST at the root of much high-resolution solar physics, in particular in cooperation with partners UiO and UU and the Lockheed-Martin group.

At double the aperture (96 cm, singlet objective) the NSST has to and will rely on adaptive optics to obtain commensurate angular resolution. Even at La Palma, the seeing is rarely better than the diffraction limit of a 10 cm telescope. At the DOT aperture of 45 cm speckle reconstruction works well, but at meter-class aperture adaptive optics is needed. The successful KVA adaptation of this technique at the SVST was the prime motivation to start the NSST project. In view of the superb quality of the SVST, the skills, high motivation and goal-oriented approach of the KVA team I am certain that the NSST will be first to make the breakthrough to meter-size diffraction-limited resolution in solar physics. In particular, it will permit filter- and spectropolarimetry at 0.1 arcsec resolution — an order of magnitude improvement over what solar physics was used to sofar.

**ESMN schools: advanced training for young astrophysicists .**

A major component of the training programme of the ESMN consists of the three summer/winterschools that it has undertaken to organise. The first one was held in Oslo last year. Let me quote from its web announcement:

> *The aim of the summer school is to give a basic understanding of radiation, spectroscopic diagnostics, radiative transfer and radiation hydrodynamics in the context of stellar atmospheres. Special emphasis will be given to applications through practical work with numerical methods.*

and from the present “Virtual school” webpage that resulted:

> *A summer school, “Radiative Transfer and Radiation Hydrodynamics”, was held at the Institute of Theoretical Astrophysics, University of Oslo, Norway, from 1st to 11th June, 1999. The school was organised as part of the EU European Solar Magnetometry Network. Over 35 students from many countries gathered in Oslo for two weeks of lectures and exercises, designed to provide a thorough grounding in the problems and techniques of radiative transfer and radiation hydrodynamics. This page is an attempt to provide a virtual recreation of that experience.*

I was one of the teachers and I feel that indeed, "we got a thorough grounding in the techniques of radiation transfer and radiation hydrodynamics" — I learned a lot, and I much appreciated the high motivation and large interest of the (mostly far younger) participants. To me, this school was the prime ESMN highlight sofar.

In the meantime, the promise to organise the second ESMN school has motivated the IAC partners to propose the planned topic (techniques of spectropolarimetry) for a larger-scale school in the well-known series of Canary Island Winter Schools. They succeeded in this effort, and this school, "Astrophysical Spectro-Polarimetry", will take place in November on Tenerife. I aim to organise the third school during the early summer of 2001.

## A.2 Joint Publications and Patents

**Publications.** Only those are listed here that stem directly from ESMN collaboration, not from earlier joint efforts. They are listed alphabetically rather then in order of importance, in order to be politically correct and not upset network partners with personal coordinator preferences. Most are in conference proceedings — in this field, refereed journal papers habitually follow at a lag of one or more years. The corresponding abstracts are collected in the Appendix.

Balança, C. and Vogt, E.: 1999, "Diagnostic of proton beams in solar flares", in A. Wilson (Ed.), *Magnetic Fields and Solar Processes*, Procs. Ninth European Meeting on Solar Physics, ESA SP-448, ESA Publ. Div., ESTEC, Noordwijk, 749–751
*Balança: OP; Vogt (ESMN YVR): OAC.*

Balthasar, H., Collados, M., and Muglach, K.: 2000, "Oscillations in a Solar Pore", *Astronomische Nachrichten* **321**, 121–127
*Balthasar, Muglach (ESMN YVR): AIP, Collados: IAC.*

Hansen, I., Engvold, O., Schmieder, B., Mein, N., and Mein, P.: 1999, "Bright Rims and Dopplershifts in H$\alpha$ Filaments", in A. Wilson (Ed.), *Magnetic Fields and Solar Processes*, Procs. Ninth European Meeting on Solar Physics, ESA SP-448, ESA Publ. Div., ESTEC, Noordwijk, 491–496
*Hansen, Engvold: UiO, Schmieder, Mein, Mein: OP.*

Martens, P. C. H. and Muglach, K.: 1999, "Scientific Highlights from the Solar & Heliospheric Observatory", in K. N. Nagendra and J. O. Stenflo (Eds.), *Proceedings of the 2nd Solar Polarization Workshop*, Kluwer Academic Publishers, Dordrecht, 325
*Martens: ESA, Muglach (ESMN YVR): AIP.*

Martínez Pillet, V., Collados, M., Sanchez Almeida, J., Gonzalez, V., Cruz-Lopez, A., Manescau, A., Joven, E., Paes, E., Diaz, J. J., Feeney, O., Sanchez, V., Scharmer, G. B., and Soltau, D.: 1999, "LPSP & TIP: Full Stokes Polarimeters for the Canary Islands Observatories", in T. Rimmele, R. R. Radick, and K. S. Balasubramaniam (Eds.), *High Resolution Solar Physics: Theory, Observations and Techniques*, Proc. 19th Sacramento Peak Summer Workshop, ASP Conf. Series 183, 264–272
*Martínez Pillet, Collados, Sanchez Almeida: IAC; Scharmer: KVA*

Muglach, K. and Fleck, B.: 1999, "Waves in the Quiet Sun's Chromosphere", in J.-C. Vial and B. Kaldeich-Schuermann) (Eds.), *Plasma Dynamics and Diagnostics in the Solar Transition*

*Region and Corona*, ESA SP-446, 499–502
*Muglach (ESMN YVR): AIP,Fleck: ESA.*

Muglach, K., Fleck, B., Schühle, U., Stolpe, F., Foing, B. H., and Wilhelm, K.: 2000, “Dynamics of Chromospheric and Transition Region Lines Observed with SOHO/SUMER and the GCT/Tenerife”, *Adv. Space Research* **25**, 1731–1734
*Muglach (ESMN YVR): AIP, Fleck, Foing: ESA.*

Muglach, K. and Sütterlin, P.: 1999, “Simultaneous Observations with the GCT and SoHO: High Velocity Events in the Upper Chromosphere”, in C. E. Alissandrakis and B. Schmieder (Eds.), *Second Advances in Solar Physics Euroconference: Three-Dimensional Structure of Solar Active Regions*, Astron. Soc. Pac. Conf. Ser. 155, 341
*Muglach (ESMN YVR): AIP, Sütterlin (ESMN YVR): UU.*

Schmieder, B., DeLuca, E., Mein, N., Mein, P., Malherbe, J. M., Wilken, V., Staiger, J., Engvold, O., and Hanssen, I.: 1999a, “Emerging Flux and Heating of Coronal Loops in Active Regions”, in A. Wilson (Ed.), *Magnetic Fields and Solar Processes*, Procs. Ninth European Meeting on Solar Physics, ESA SP-448, ESA Publ. Div., ESTEC, Noordwijk, 653–658
*Schmieder, Mein, Mein, Malherbe: OP, Engvold, Hanssen: UiO.*

Schmieder, B., Kotrc, P., Heinzel, P., Kucera, A., and Andretta, V.: 1999b, “Diagnostics constraints on prominence parameters from SOHO and groundbased observations”, in A. Wilson (Ed.), *Magnetic Fields and Solar Processes*, Procs. Ninth European Meeting on Solar Physics, ESA SP-448, ESA Publ. Div., ESTEC, Noordwijk, 439–444
*Schmieder: OP, Andretta: OAC.*

Shand, M., Scharmer, G. B., and Wei, W.: 1999, “Correlation tracking and Adaptive Optics Control Using Off-The-Shelf Workstation Technology”, in T. Rimmele, R. R. Radick, and K. S. Balasubramaniam (Eds.), *High Resolution Solar Physics: Theory, Observations and Techniques*, Proc. 19th Sacramento Peak Summer Workshop, ASP Conf. Series 183, 231–238
*Shand: COMPAQ; Scharmer, Wei: KVA.*
*This paper resulted from the KVA–COMPAQ industrial connection.*

Wiik, J. E., Dammasch, I. E., Schmieder, B., and Wilhelm, K.: 1999, “Multiple-Thread Model of a Prominence Observed by SUMER and EIT on SOHO”, *Solar Phys.* **187**, 405–426
*Wiik: UiO, Schmieder: OP.*

**Patents.** None. (None of the partners has ever applied for one; astronomical instrumentation is only rarely developed with claim to proprietorship.)

# B. Comparison with the Project Programme

## B.1 Research Objectives

The ESMN research objectives:

(a) to chart the topology of solar magnetic structures at all scales of emergence at the solar surface

(b) to identify the basic processes underlying the dynamical behaviour of solar magnetic structures

(c) to measure solar activity patterns to constrain the solar dynamo mechanism

remain highly relevant to solar physics, astrophysics in general, and sun-earth studies. They are achievable, the more so with the new developments both within and outside the Network that were unforeseen at the contract start (NSST, GREGOR, ATST, new space missions).

## B.2 Methodological Approach and Work Plan

The Network science objectives (a)–(c) are pursued with only slight differences in the task distribution from the contract specification:

| Science Objective | Task | Teams |
|---|---|---|
| (a) Magnetic-Structure Topologies | (a1) flux tubes | KVA + UU |
| | (a2) network | UU + IAC + OP |
| | (a3) sunspots | AIP + KVA + UiO + IAC + UU |
| | (a4) active regions | all |
| (b) Magnetic-Structure Dynamics | (b1) flux tubes | IAC + KVA + UU |
| | (b2) network | UU + OAC |
| | (b3) sunspots | all |
| | (b4) active regions | ESA + OP + OAC |
| (c) Dynamo Patterning | (c1) high-resolution patterns | KVA + UU + OAC + OP |
| | (c2) pattern evolution | ESA + OP |
| | (c3) dynamo constraints | AIP + OAC |

The methodological implementation objectives (d)–(f) are also pursued with only minor modifications compared to the contract specification, but with one significant addition: the realization of the NSST (d9). This telescope wasn't even planned at the time of the contract but its realization proceeds sufficiently fast that completion is foreseen within the contract period. Partners UU and IAC assist KVA in this ambitious and highly promising project (table next page).

| Implementation Objective | Task | Teams |
|---|---|---|
| (d) Magnetometry Techniques | (d1) THEMIS optimisation | OP + others |
| | (d2) DOT optimisation | UU + KVA |
| | (d3) magnetometry calibration | OP + IAC + AIP |
| | (d4) liquid-crystal magnetometry | IAC + KVA + AIP |
| | (d5) MOF magnetometry | OAC + UU |
| | (d6) G–band magnetometry | KVA + UU |
| | (d7) IPM magnetometry | OAC + OP |
| | (d8) image restoration | KVA + others |
| | (d9) NSST realisation | KVA + UU + IAC |
| (e) Comprehensive Observing | (e1) campaign coordination | KVA + ESA + others |
| | (e2) on-line imagery | ESA + OP + OAC |
| | (e3) multi-telescope campaigns | all teams |
| | (e4) data archiving & dissemination | OAC + ESA + others |
| | (e5) data reduction | all teams |
| (f) Numerical Modelling | (f1) boundary conditions | UiO + KVA + others |
| | (f2) comparison with modelling | UiO + AIP + KVA |

## B.3 Schedule and Milestones

The scheduling chart on the next page shows changes with respect to the contract schedule in black. These are, respectively:

(d1) THEMIS optimisation. THEMIS became fully operational during the first two ESMN years as scheduled, but plans for further optimisation using new techniques, in particular adaptive optics, are being formulated. These will extend beyond the ESMN termination.

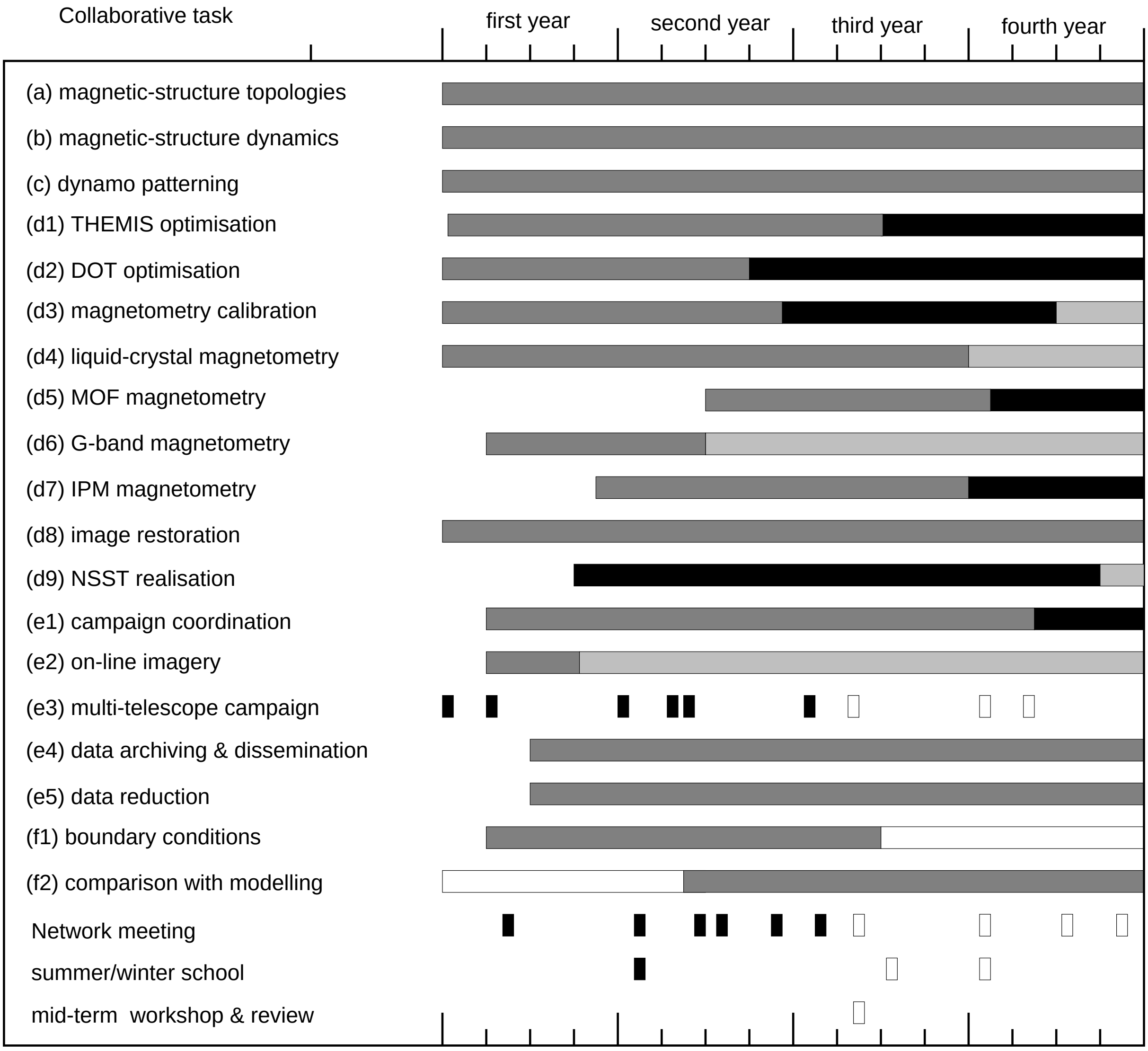
(d2) DOT optimisation. This task was contingent on financing. A DOT three-year verification period became funded by various agencies in the autumn of 1998. The plans also grew in ambition by incorporating fast large-volume data acquisition (0.5 Tb/day) for comprehensive speckle restoration at multiple wavelengths. This effort will also extend beyond ESMN termination — again contingent on external funding.

(d3) Magnetometry calibration. These interpretative efforts have grown in scope, in particular due to the IAC successes in the formulation of direct inversion methods. The development phase is now scheduled longer than in the contract.

(d5) MOF magnetometry. The MOF hardware realization is contingent on external funding that will be applied for this autumn, not before as planned earlier because of the reorganization of Italian astronomy including the funding of the OAC. Accommodation on the DOT is now foreseen for the spring of 2002 and is contingent on DOT funding.

(d9) NSST realisation. This task is new. The project advances very fast. Scientific usage of the new telescope is foreseen before the ESMN termination.

(e1) Campaign coordination. With THEMIS and DOT operational, NSST coming on line and the SOHO mission alive and well, the ESMN partners will remain motivated to conduct or participate in multi-telescope campaigns until the end of the ESMN period.




## B.4 Research Effort of the Participants

| Partner | UU | IAC | OAC | UiO | KVA | AIP | OP | ESA | total |
|---|---|---|---|---|---|---|---|---|---|
| person-months in contract | 118 | 150 | 141 | 101 | 144 | 111 | 114 | 69 | 948 |
| person-months delivered | 70 | 84 | 72 | 55 | 125 | 72 | 68 | 34 | 580 |
| contract fulfillment in percent | 59 | 56 | 51 | 54 | 87 | 65 | 60 | 49 | 61 |

The two extremes are for ESA who hired a young researcher per June 1, 2000 so that its deliverance will grow, and KVA which at its conception of the NSST drastically reset its course so that presently, practically everyone in that group is now working fulltime within the ESMN programme.

## B.5 Cohesion with Less Favoured Regions

Partners AIP, OAC and IAC are from less-favoured EC regions. They are less so in terms of solar physics! AIP and OAC have long traditions in solar physics and cannot be regarded as backward or underdeveloped by any yardstick in this field. The IAC history is shorter but this group is now one of the largest and most productive in solar physics worldwide.

Hence, no special effort is made by the Network to "integrate" these groups into the joint research. Note, however, that AIP plays a major role in multi-telescope campaign planning, that OAC has strong ties to OP, IAC and ESA, and that IAC is actually the hub of European solar physics since all Canary Island telescopes involve IAC partnerships. AIP hosted the initial ESMN kick-off meeting, OAC hosted a very successful ESMN research workshop last April, and IAC frequently hosts solar physics conferences including an upcoming solar-terrestrial Euroconference and an international solar meeting immediately before and after the ESMN mid-term review meeting, in the same building. The IAC will also host the next ESMN school, integrated in its prestigious XIIth Canary Island Winter School. The OP maintains an office at the IAC that is effectively staffed at 10 personmonths/year.

## B.6 Network Organisation and Management

**Coordination.** The ESMN coordination is fully electronic, relying on password-protected web-accessible directories that contain all ESMN administration. Applications are also all handled electronically, requiring curricula vitae, research statements, etc. to be provided as computer-readable files and requesting letters of recommendation by email. Confidential information is also electronically available to the partners through password protection.

A persistent problem in network management, from the proposal stage to the present, is that the EU uses Microsoft software exclusively as if it were contracted by that company. The network's academic software environment consists of Unix in various forms on workstations and Linux on PC's, and mostly cannot process .doc MS-Word files. Distilling instructions and forms and adapting the latter is often a cumbersome process requiring outside help and causing delays as well as problems with electronic transfer.

**Public websites.** The official ESMN homepage is at http://www.astro.uu.nl/∼rutten/tmr. There is also an outreach site at http://www.astro.su.se/∼dorch/esmn. All groups maintain websites, many with telescope and database access links. Some of the courses and exercises of the first ESMN school are available at http://www.astro.uio.no/school–99/VirtualSchool.

**ESMN meetings.** The ESMN policy is to have network planning sessions at major conferences, in addition to ESMN schools and workshops. Sofar:

- October 1998, Potsdam, during the "Third Advances in Solar Physics Euroconference" (130 participants), all partners represented, 20 ESMN members, ESMN kick-off.
- June 1999, Oslo, first ESMN school "Radiative Transfer and Radiation Hydrodynamics", 40 participants of which 17 ESMN members, intensive courses and computer exercises during two weeks.

- September 1999, Florence, during the "Ninth European Meeting on Solar Physics" of the European Physical Society and the European Astronomical Society (236 participants), all partners represented except KVA, 21 ESMN members, ESMN planning.
- October 1999, Tenerife, during the "Eleventh Workshop on Cool Stars, Stellar Systems and the Sun" (250 participants), all partners represented except OAC, 14 ESMN members, ESMN planning.
- April 2000, Naples, ESMN workshop "Helium Line Formation in a Dynamical Solar Atmosphere", 29 participants including 11 ESMN members from 5 partners, three days ESMN science.
- June 2000, Nevada USA, during the annual meeting of the Solar Physics Division of the American Astronomical Society (over 300 participants), planning meeting of three ESMN group leaders.
- August 2000, Manchester, during the International Astronomical Union Symposium 203 "Recent Insights into the Physics of the Sun and Heliosphere – Highlights from SOHO and Other Space Missions", over 200 participants, 10 ESMN members from 5 partners, ESMN planning.

## B.7 Connections to Industry

**COMPAQ.** KVA continued working closely together with Compaq on developing new interface technology for high-speed CCD cameras and adaptive optics control. The cooperation resulted in another joint project with the Ecole Polytechnique (Paris) supervised by Compaq (M. Shand), in a joint paper with M. Shand as first author and in the hiring of a Compaq specialist as systems engineer at KVA.

UU also had intensive contact with COMPAQ in defining the state-of-the-art (0.5 Terabyte/day!) data acquisition and storage system contracted to COMPAQ. The ESMN young researcher at UU (P. Sütterlin) played a key role in these negotiations.

**Flender.** The German firm A. Flender AG (Alfred Flender Strasze, Bocholt) has fabricated the gear wheels for the turret heliostat of the NSST for KVA under supervision by the DOT builder (R.H. Hammerschlag). Earlier, the same firm constructed the DOT drives which combine extreme stiffness with high precision, a feat of mechanical engineering necessitated by the DOT being an open telescope facing strong trade winds. The experience gained with the DOT gear fabrication now led to the NSST contract. The NSST drive fabrication was defined by Hammerschlag with G. Tripp of Flender AG on the basis of DOT technology experience, and the acceptance measurements were also done in cooperation with the DOT team. Flender AG serves a large and varied market of large gear-wheel drives and may extend this to other high-precision requirements using insights gained in these interactions.

**Hoesch Rothe Erde.** A similar case holds for Hoesch Rothe Erde (Beckumerstrasze, Lippstadt, Germany) who constructed large open slew bearings for the NSST drives, also under supervision by R.H. Hammerschlag of the DOT team. His interactions with R. Marquardt of Hoesch Rothe Erde have also transfered DOT insights to this firm that it may advantagely use in securing other high-precision bearings and drives contracts.

**EIS SRL.** For developing the mounting, tracking system, and magnetic holders for VAMOS, the OAC team interacted with EIS SRL (Via A. Silvani 130 I–00139 Rome). In particular, the interaction of P.F. Moretti with P. Canegallo of EIS SRL has extended the know-how of this firm in high-precision tracking of light sources and in the technical realisation of uniform compact magnetic fields.

**Lockheed-Martin.** Both UU and KVA continued their close cooperation with the Lockheed-Martin Solar and Astrophysics Laboratory at Palo Alto, again consisting of observing campaigns at the SVST using hardware and optical expertise of the Lockheed-Martin group, and data reduction and analysis at Lockheed-Martin including a traineeship for a UU graduate student.

**Differences with contract.** As mentioned in the second ESMN annual report, the three new IAC and AIP liquid-crystal spectropolarimeters at the Canary Island telescopes are complete and no longer require industrial liquid-crystal research. The DOT team has postponed development of fiber spectrometry until after the completion of the advanced DOT speckle system. The start of the NSST project brought contacts with Flender and Hoesch Rothe Erde (see above) that were not foreseen in the contract.

# C. Training

## C.1 Employment of ESMN young researchers

| Participant | ESMN young researcher person-months sofar delivered | | | Contract-deliverable ESMN young researcher person-months | | |
|---|---|---|---|---|---|---|
| | predoc (a) | postdoc (b) | total (a + b) | predoc (a) | postdoc (b) | total (a + b) |
| 1. UU | – | 15 | 15 | – | 36 | 36 |
| 2. IAC | – | 16.5 | 16.5 | – | 36 | 36 |
| 3. OAC | – | 18.6 | 18.6 | – | 48 | 48 |
| 4. UiO | – | 19.6 | 19.6 | – | 36 | 36 |
| 5. KVA | 9 | 19 | 28 | 36 | 36 | 72 |
| 6. AIP | – | 19 | 19 | – | 36 | 36 |
| 7. OP | – | 13 | 13 | – | 36 | 36 |
| 8. ESA | – | 2 | 2 | – | 24 | 24 |
| TOTAL | 9 | 122.7 | 131.7 | 36 | 288 | 324 |

For KVA, OP and ESA continuation of the present ESMN young researchers until the ESMN termination implies a deficit of a few person-months compared with the contract deliverable which the ESMN is confident of filling with shorter-term recruitments and secondments.

The main disappointment is the OAC failure to recruit a second postdoc sofar. The position has been repeatedly advertised, not only on the TMR vacancy site but in particular in the electronic newsletters and job registers[3] that are the main source of vacancy information in solar physics and astrophysics, and also as a paper advertisement to about 50 institutions worldwide for posting on vacancy bulletin boards. Enquiries resulted from non-allowable foreigners and from allowable EU citizens but only for graduate studentships, which cannot be accommodated at the OAC since it is not a university institute. Possibly, Naples is seen as a less favourable region to live; it may also be that the generally increasing shortage of information technology personnel lures prospective postdoc candidates to higher salaries. There are recent examples of young solar physicists leaving the field for industrial employment. The positive side of this general-economy development is that the young researchers now being trained by the ESMN may expect a wide choice of career options. The solution the ESMN will seek if no suitable postdoc is found by autumn is to fill the remaining OAC person-months through secondments.

## C.2 Training Programme

The major component of the ESMN training programme consists of the three summer/winter schools described in Section A.1. The first one was highly successful, the second one is part of the well-established IAC series — I hope that I will manage to maintain this high standard for

[3]SolarNews (http://www.gong.noao.edu/SolarNews): January 6, 2000 and June 2, 2000; will appear again in the September issue. Starlink/European Astronomical Society Vacancies (ftp://starlink-ftp.rl.ac.uk:/pub/news/star_jobs): June 1–July 31, 2000. American Astronomical Society Job Register (http://www.aas.org/JobRegister/aasjobs.html): April 1–30, 2000.

the third one.

Another aspect of networking and internationalisation in which the ESMN training programme has a distinct identity consists of the multi-telescope campaigns in which the observationally-oriented young ESMN researchers cooperate in key roles.

The close connection between the observational and the theoretical groups (as for example the interaction between KVA and UiO on sunspot oscillations discussed in Section A.1) brings interdisciplinary flavour.

Of course, the young ESMN researchers take part in the educational programmes at their institutes, such as student supervision, seminars, etc., and as solar physicists they are part of a highly international community with frequent meetings and exchanges. For example, each young researcher has participated in international conferences during the past year.

One training programme item that the ESMN proposed in its contract but has not accomplished sofar is the goal to make postdocs switch between partners halfway the ESMN duration. This sounded as a desirable strategy when the ESMN formulated its proposal, but it doesn't work out as easily as anticipated. The EU nationality rules are an inhibiting factor; the young researchers themselves prefer a stay sufficiently long to not only start but also complete research projects of sufficient ambition to impress their next candidate-employer. Nevertheless, the ESMN prefers not to drop this strategy and will therefore strive for longer-term secondments in the coming years.

## C.1 Factual Information on ESMN young researchers

UU

Name: P. Sütterlin
Nationality: German
Age at start of appointment: 36 (14 months compulsory military service)
Appointment start and likely end dates: 01-05-1999, 30-04-2002
Category of researcher: postdoc
Scientific specialty: observational solar physics, image reconstruction
Place and country of work: Utrecht, The Netherlands
Earlier network connection: none

IAC

Name: O.J. Dittmann
Nationality: German
Age at start of appointment: 33
Appointment start and likely end dates: 15-03-1999, 14-03-2002
Category of researcher: postdoc
Scientific specialty: astronomical polarized radiative transfer
Place and country of work: La Laguna, Tenerife, Spain
Earlier network connection: none

OAC

Name: E. Vogt
Nationality: French
Age at start of appointment: 29

Appointment start and likely end dates: 11-01-1999, 10-01-2001
Category of researcher: postdoc
Scientific specialty: solar polarization diagnostics
Place and country of work: Naples, Italy
Earlier network connection: PhD thesis at OP

UiO
Name: C.S. Rosenthal
Nationality: British
Age at start of appointment: 34
Appointment start and likely end dates: 11-12-1998, 10-12-2001
Category of researcher: postdoc
Scientific specialty: theory of solar oscillations
Place and country of work: Oslo, Norway
Earlier network connection: none

KVA
Name: S.B.F. Dorch
Nationality: Danish
Age at start of appointment: 27
Appointment start and likely end dates: 01-01-1999, 31-12-2001
Category of researcher: postdoc
Scientific specialty: stellar dynamo theory
Place and country of work: Stockholm, Sweden
Earlier network connection: none

KVA
Name: B. Gudiksen
Nationality: Danish
Age at start of appointment: 26
Appointment start and likely end dates: 01-11-1999, 30-04-2002
Category of researcher: predoc (graduate student)
Scientific specialty: MHD theory and simulations
Place and country of work: Stockholm, Sweden
Earlier network connection: none

AIP
Name: K. Muglach
Nationality: Austrian
Age at start of appointment: 33
Appointment start and likely end dates: 01-01-1999, 31-12-2001
Category of researcher: postdoc
Scientific specialty: observational solar physics
Place and country of work: Potsdam, Germany
Earlier network connection: research fellowship at ESA

OP
Name: K. Tziotziou

Nationality: Greek
Age at start of appointment: 32
Appointment start and likely end dates: 01-07-1999, 30-04-2002
Category of researcher: postdoc
Scientific specialty: solar physics
Place and country of work: Meudon, France
Earlier network connection: PhD thesis at UU

ESA
Name: E. O'Shea
Nationality: Irish
Age at start of appointment: 27
Appointment start and likely end dates: 01-06-2000, 30-04-2002
Category of researcher: postdoc
Scientific specialty: solar atmospheric dynamics
Place and country of work: Noordwijk, The Netherlands
Earlier network connection: none

## D. Sketches of the ESMN young researchers

**Olaf Dittmann (IAC).** My background: after finishing my PhD in 1995 I continued to work in modelling polarized radiation. First I focused on active galactic nuclei, later during a one-year stay in Canberra, Australia on magnetized white dwarfs. My research until then was purely theoretical with emphasis on computational modelling.

My network participation: one of my personal objectives in joining the ESMN was to gain experience on the observational side of astronomy. We started a collaboration with M. Semel from the partner institute in Meudon. Using an existing stellar polarimeter of Semel, we were able to adapt it to solar work on the Tenerife Gregory Coudé Telescope. There were several instrumental issues to solve. Still, even the first run was successful. We are now able to reach a sensitivity of $10^{-4}$ using a polarimeter built from standard components, that can be installed on a variety of telescopes. I have been involved in the observations and the reduction of the data as well as in the development of the instrumentation. For this I spent one week at Meudon. The results of this collaboration will first be presented in the Polarisation Workshop in Sunspot this September. Several papers are in preparation. I enjoyed the first ESMN school at Oslo, and look forward to help organising the ESMN mid-term review meeting and the XIIth Canary Island Winter School.

My network experiences to date: my integration into the solar group at the IAC was no problem at all. Aside from the main work with M. Semel smaller collaborations with M. Collados and R. Manso Sainz exist. The extensive experience of the IAC administration with foreign researchers made the transition very smooth. The only problem is the loss of social benefits for families. I think it would be a good idea to work towards some benefits for married researchers with children, since we are required to leave our home country but the spouse is very often not allowed to work in the new place of residence.

**Bertil Dorch (KVA).** Background: I received both my Master's (1995) and Ph.D. (1998) degrees from the Niels Bohr Institute at Copenhagen University. In both cases my supervisor was Dr. Åke Nordlund. Since then I have been associated to the Copenhagen numerical astrophysics group. My Master's Thesis revolved around numerical two-dimensional simulations of buoyant magnetic flux tubes, a subject that I later also pursued in part in my Ph.D. work about the solar dynamo. In the latter I studied essential dynamo ingredients by performing three-dimensional numerical simulations of e.g. generic dynamo processes, twisted magnetic flux loops and the interaction of solar-like convection with magnetic fields. Thus, my scientific background lies within theoretical magneto-hydrodynamics, numerical simulations, supercomputers and visualization.

Network responsibilities: non-scientific duties include maintaining the ESMN public website, administrative work in relation to ESMN annual reports, and co-supervising the KVA ESMN Ph.D. student. On the science side my main project involves three-dimensional numerical simulations of large-scale buoyant flux ropes (twisted tubes) interacting with turbulent stratified convection. These studies aim at understanding the pre-emergence evolution and emergence of the active region magnetic field."

Experience: definitely positive. Especially being close to observers has boosted ideas and been inspiring and likewise has the collaboration with UiO through meetings both in Oslo and Stockholm following the contacts made at the excellent 1st ESMN summer school. Future collaboration with UiO will probably include additional meetings and exchange. Further pleasant experiences has been provided by KVA as a host and by the Swedish National Allocations Committee for High Performance Computing and the Parallel Computer Center in Stockholm that have supplied me with supercomputer time and help on programming issues. My most negative experience was the problem of finding housing in Sweden.

**Boris Vilhelm Gudiksen (KVA).** Background: I finished my Master's studies in the summer 1999 at Copenhagen University under the supervision of Dr. Åke Nordlund. The subject was the interstellar medium in disc galaxies, especially the turbulence and dynamo mechanism driven by supernovas and magnetic fields. During this time I interacted with Dr. Axel Brandenburg and Dr. Anvar Shukurov both at that time at the University of Newcastle (UK). I have since then associated continuously with the people mentioned above.

Network responsibilities: my major task is to complete a PhD thesis on the magnetic structures on the surface of the Sun. Since the ESMN funding is only partial, this will be completed on other funding. My PhD studies will most likely continue until Nov. 1 2003.

Experience: there have been two main problems, one of which is solved at this time. The first is the problem of a very rigid study program at Stockholm University. The study program is divided into 4+4 yrs for a PhD, while the program I come from is a 5+3 year system. It should then be possible to get a reduction in the course work needed, but from past experience this might not be possible, and my application has been under consideration since May. This has kept me away from doing research and instead kept me working with course work on subjects that are irrelevant to my subject since I am reluctant to do course work in the later half of my PhD studies. The second was the difficulty of finding a place to live in Stockholm, now solved. In spite of these problems, the networking has been very rewarding, especially with UiO with whom we (Bertil Dorch, Luc Rouppe van der Voort and myself) interact closely. I furthermore see the close connection with observers from the KVA as a strong union which makes it possible at short notice to make observations of predicted features from numerical simulations. In the future, I hope also to visit and collaborate with Lockheed-Martin.

**Karin Muglach (AIP).** I have studied astronomy at the University in Graz (Austria) and have been doing solar research since my master thesis, concentrating on spectro-polarimetry and the properties of photospheric magnetic fields. After finishing my Ph.D. I started working on dynamics of the upper layers of the solar atmosphere, and through my research fellowship at ESTEC/ESA I got involved in the SOHO mission.

I joined the network because my past experience of working with larger groups of people would be very useful in such a framework. I like to work together with many people and here at the AIP I have access again to ground-based telescopes, while still keeping my connection to the solar space community. Using my organisational skills I became the central coordinator of Joint Observing Campaigns (JOP) that include the telescopes on Tenerife and La Palma, and the SoHO and TRACE satellites, and people of the IAC, UU, KVA, ESA and AIP are participating (details can be found at http://sohowww.nascom.nasa.gov/soc/JOPs/jop097.txt). The aim of the program is to study the dynamics of sunspots and active regions. The first JOP took place in September 1999 and I have just finished the preparations for the second one in September 2000. I also organized a two-day workshop at the AIP with colleagues from UU and KVA visiting to discuss and analyse the data. First results on this campaign are already published and were presented at a number of conferences. Some can also be found on the web-pages of the participants.

In addition to acting as campaign coordinator, I participated in the observations at the VTT with the infrared polarimeter and to analyse the data from the space instruments (SoHO/MDI and TRACE). Together with Thorsten Carroll, a Ph.D. student here at the AIP who has developed the basic tools, we are now working on a direct inversion of the infrared Stokes data with artifial neural networks. First results on this new technique to obtain physical quantities from observed spectra will be presented at a meeting in September.

My only negative remark to the ESMN is that there is an age limit to be hired, so that in the future I will not have this opportunity anymore.

**Eoghan O'Shea (ESA).** Currently I am a research scientist in solar physics based at ESTEC/ESA in the Netherlands. Prior to starting my contract at ESTEC/ESA (June 1 2000) I had been a PPARC postdoctoral research assistant (PDRA) in the QUB for two and a half years. I had originally obtained my doctorate in solar physics from The Queen's University of Belfast (QUB) in 1997, after a three year study period in Armagh Observatory. While in Belfast I studied solar atmospheric dynamics, in particular oscillations in the upper solar atmosphere. In addition, part of my work in Belfast involved the testing and use of different density and temperature diagnostics. Since I joined the European Solar Magnetometry Network (ESMN) in June I have been involved in preparing for a Joint Observing Program (JOP), that I will be carrying out with Karin Muglach (AIP) in September 2000. We are interested in investigating oscillation signatures in sunspots and active regions. This JOP will involve the use of different ground based telescopes, together with instruments on the SOHO and TRACE spacecraft. My responsibilities for this JOP involve being the planner for the Coronal Diagnostic Spectrometer (CDS) onboard SOHO during the first week of the observations. To carry out this task I will be based in the Goddard Space Flight Centre (GSFC) . Since I have only recently joined the network I have not yet had the chance to visit (or network with) many of the other groups involved. However, no doubt, in the future I will have plenty of opportunities to do this.

**Colin Rosenthal (UiO).** Background: prior to taking up my position as a post-doc within the ESMN network I was working as a research fellow in helioseismology. The network attracted me because it offered me the possibility of returning to Europe, and the opportunity to train in a new field of research alongside a ready-made group of international collaborators. In broad terms I believe the network has fulfilled those expectations.

Responsibilities: since taking up my position in Oslo in December 1998 I have begun a research programme aimed at modelling the propagation of waves in the solar atmosphere (Implementation Objective (f) in the network contract). Up to the present time, the project has involved the development of a suitable numerical code, the definition of an appropriate class of problems to be solved, and the theoretical interpretation of the resulting numerical solutions. The major network partner in this endeavour has been the Stockholm group and we have enjoyed successful collaborative visits to each other's institutes. The second stage of this project must involve a more direct comparison of these results with observations and to this end, I intend to arrange further collaborative visits with the observational groups within the network.

Results from the project were presented orally at the International Astronomical Union General Assembly in Manchester in August, and it is intended that a paper in the conference proceedings will provide the basis for the first in a series of journal papers to be submitted by the end of the present calendar year. The Network also received a write-up in the Daily Newspaper of the General Assembly, drawing attention to our activities to the wider astronomical community.

Network experiences: perhaps the most important network activity with which I have been directly involved was as local organiser for the ESMN Summer School held in Oslo in June 1999. 35 students, from within and outside the network, participated in two weeks of intensive lectures and exercise classes designed to provide a thorough grounding in the problems and techniques of radiative transfer and the School has been one of the most important and useful parts of the education and training I have received as a network post-doc.

Collaboration with industry: as part of the Norwegian Research Council's process of tendering for a new Supercomputing facility, the Oslo group prepared a benchmarking version of the 3D Magnetohydrodynamic Code they have been developing. The code was distributed to all companies bidding for the contract, who were invited to report on techniques for optimum parallelisation of the code on their platforms. The results of this exercise are still being analysed.

**Peter Sütterlin (UU).** I am working as a researcher (PostDoc) in astrophysics at the Sterrekundig Instituut Utrecht. My research field is observational solar physics. During my Masters and Ph.D. studies in Freiburg, Germany, I worked in spectropolarimetry, building a magnetothermodynamical model of the atmosphere of solar pores. Subsequently, during three years at Göttingen, Germany, I continued my spectrographic work but also expanded my knowledge of image restoration techniques.

Currently, I am concentrating on two things: image restoration using the speckle masking technique and the physics of solar active regions. At Utrecht I have taken the role of principal scientist in the group that realizes the new camera, data acquisition and observing systems for the Dutch Open Telescope (DOT). It will be a simultaneous five-wavelength imaging system (G band, continuum near the G-band, Ca II K, H-alpha, and continuum near H-alpha) which will consistently use speckle methods to reach diffraction limited resolution over long durations, up to many hours. It is based on the initial speckle tests that I performed at the DOT, including its first scientific observations in September 1999 in a joint ESMN observation campaign on sunspot oscillations with groundbased (VTT, GCT, SVST) and spacebased (TRACE, SOHO) observatories. The results were presented in an miniworkshop at the AIP, at the Dutch Astronomy Conference, and on the internet (APOD).

The ESMN has brought me to Utrecht with good timing, adding my speckle expertise to the DOT team at the right moment and giving me the chance to develop the method for large-volume application at a new telescope. I also am the primary observer at the DOT for the ESMN multi-telescope campaigns, working closely together with Karin Muglach at the AIP. Finally, I participated in the ESMN summer school at Oslo and will join the ESMN winter school on Tenerife.

**Kostas Tziotziou (OP).** My scientific background involves work on non-linear dynamics (integrability and non-integrability of Hamiltonian systems), solitary waves, spin evolution of wind-driven X-ray pulsars, dynamics (spatial and temporal evolution) of stellar coronae and solar corona heating (PhD thesis).

My responsibilities within the network are: a) development of theoretical models for the study of chromospheric features and calculations of non-LTE chromospheric line models, b) development of non-LTE inversion techniques for chromospheric lines, c) application of the aforementioned studies to observed chromospheric features (i.e. filaments) and d) observations with the solar telescope THEMIS and reduction of data.

My experiences from the network have so far been positive. It has provided me the opportunity to expand my scientific knowledge and get directly involved with solar observations. I had the opportunity to meet and collaborate with colleagues from other institutes (UU and IAC) as well as visiting astronomers to our institute who share similar scientific interests and whose scientific work is complementary to my work here in Meudon. A negative remark is that the network doesn't give you the opportunity to also visit and collaborate — when absolutely necessary for your work — with people in universities outside the network.

**Etienne Vogt (OAC).** I'm a young solar physicist working on active regions and solar flares, using the polarization of the solar radiation as a diagnostic tool. My PhD thesis work was done at OP under the supervision of Dr. Jean-Claude Hénoux, in collaboration with Dr. Sylvie Sahal-Bréchot. My work consisted in studying the linear polarization in the H alpha line observed during two solar flares with a spectropolarimeter in Meudon. This polarization is interpreted as impact polarization resulting from the precipitation on the chromosphere of high energy protons accelerated in the corona at the magnetic reconnection site. The observed polarization was compared to theoretical calculations of proton impact polarization on hydrogen atoms using atomic physics tools. I also contributed to the development of an improved version of the Meudon flare polarimeter called PARIS (Polarimeter for Active Regions Instabilities Study).

My current work in the ESMN network includes the calibration of full disk magnetograms obtained with the VAMOS (Velocity and Magnetic Observations of the Sun) instrument at OAC, an instrument based on a magneto-optical filter. In addition, I do further work on impact polarization in solar flares in collaboration with OPM.

My position in the ESMN network allows me to get more research experience by working on a somewhat different subject than my previous work, in a nice place with very kind people. The fact that OP is also part of the network allows me to maintain a strong collaboration and to also continue my previous research, something which is important for obtaining a permanent research position there in future years. Finally, it gives excellent opportunities for meeting other people with similar research interests.

# E. Network Financing

The table on the next page specifies the network financing over the first two years, up to April 30, 2000. The budget represents the distribution that the partners agreed on at the contract definition; this may be modified in terms of redistribution if the need arises, but the ESMN policy is to adhere to it if possible. The Year1 and Year2 entries are the accepted costs from the annual reports. All entries are rounded off to whole ECU's so that the totals may differ by 1–2 ECU from the annual report totals.

The expenditures during the three additional months up to the mid-term report date (July 31, 2000) add about a quarter of each entry in the "Year 2" column to the totals, except for ESA which hired its young ESMN researcher per June 1, 2000. The total network cost per July 31 will therefore have risen with about 100 kECU.

The main discrepancy between the projected and the actual expenditures, apart from the not-yet spent personnel costs at OAC discussed above, is an underinvestment in networking costs (Category B). For UiO, IAC and UU these include the organisation of a summer/winter school (it took place in year 2 for UiO and will take place in year 3 for IAC, year 4 for UU). In most cases, the caution results from the fact that personnel costs are higher than expected at contract time, or the fear that they will end up higher towards the end of the ESMN period. My repeated coordinator warnings that salary increases, inflation, and other cost rises must be handled within the budget may have led to additional caution. Perhaps too much, the mid-term meeting may serve to emphasize green light for more networking expenditure.

# F. Proposed Revision to the Contract

None.

| Partner | Cost Category | ESMN Budget | Year 1 | Year 2 | Total |
|---|---|---|---|---|---|
| UU | A | 121.867 | 0 | 41.783 | 41.783 |
| | B | 40.000 | 1.726 | 3.930 | 5.656 |
| | C | 2.000 | 0 | 37 | 37 |
| | D | 32.773 | 345 | 9.150 | 9.495 |
| | Total | 196.640 | 2.071 | 54.900 | 56.971 |
| IAC | A | 103.032 | 4.095 | 36.045 | 40.140 |
| | B | 28.000 | 0 | 3.761 | 3.761 |
| | C | 2.000 | 0 | 0 | 0 |
| | D | 26.606 | 801 | 7.961 | 8.762 |
| | Total | 159.638 | 4.896 | 47.767 | 52.663 |
| OAC | A | 96.672 | 4.132 | 24.790 | 28.922 |
| | B | 18.000 | 1.613 | 5.089 | 6.702 |
| | C | 2.000 | 0 | 0 | 0 |
| | D | 23.334 | 0 | 5.976 | 5.976 |
| | Total | 140.006 | 5.745 | 35.854 | 41.599 |
| UiO | A | 132.949 | 18.629 | 47.976 | 66.604 |
| | B | 28.000 | 797 | 12.239 | 13.036 |
| | C | 2.000 | 0 | 0 | 0 |
| | D | 32.590 | 3.726 | 12.043 | 15.769 |
| | Total | 195.539 | 23.151 | 72.258 | 95.409 |
| KvA | A | 117.380 | 8.080 | 35.173 | 43.253 |
| | B | 18.000 | 0 | 3.101 | 3.101 |
| | C | 2.000 | 0 | 67 | 67 |
| | D | 27.476 | 1.616 | 7.668 | 9.284 |
| | Total | 164.856 | 9.696 | 46.009 | 55.705 |
| AIP | A | 132.192 | 13.146 | 42.181 | 55.327 |
| | B | 18.000 | 876 | 1.827 | 2.703 |
| | C | 2.000 | 0 | 399 | 399 |
| | D | 30.438 | 2.802 | 8.881 | 11.683 |
| | Total | 182.630 | 16.824 | 53.288 | 70.112 |
| OP | A | 123.318 | 0 | 32.932 | 32.932 |
| | B | 18.000 | 0 | 372 | 372 |
| | C | 2.000 | 0 | 0 | 0 |
| | D | 28.664 | 0 | 6.053 | 6.053 |
| | Total | 171.982 | 0 | 39.357 | 39.357 |
| ESA | A | 62.017 | 0 | 0 | 0 |
| | B | 18.000 | 0 | 0 | 0 |
| | C | 2.000 | 0 | 0 | 0 |
| | D | 16.403 | 0 | 0 | 0 |
| | Total | 98.420 | 0 | 0 | 0 |
| Network | A | 889.427 | 48.081 | 260.880 | 308.961 |
| | B | 186.000 | 5.012 | 30.318 | 35.330 |
| | C | 16.000 | 0 | 503 | 503 |
| | D | 218.284 | 9.290 | 57.733 | 67.023 |
| | Total | 1.309.711 | 62.383 | 349.434 | 411.817 |

## Appendix: Publication Abstracts

Balança, C. and Vogt, E.: 1999, "Diagnostic of proton beams in solar flares", in A. Wilson (Ed.), *Magnetic Fields and Solar Processes*, Procs. Ninth European Meeting on Solar Physics, ESA SP-448, ESA Publ. Div., ESTEC, Noordwijk, 749–751

Abstract: Linear polarization of the hydrogen H$\alpha$ line has been observed in solar flares. This polarization is actually explained as induced by anisotropic collisional excitation of the $n = 3$ level by vertical proton beams with an energy of a few keV or by vertical neutral beams of protons and electrons with the same velocity. At such energies, charge exchange between the proton beam and the local H atoms is important and must be taken into account in the statistical equilibrium equations. Accurate calculations for direct excitation and charge exchange allow the derivation of the polarization H$\alpha$. The double charge exchange is a new process which, when taken into account, leads to a 25% more polarization after the global balance. The modelisation of the proton beams interacting with the hydrogen atoms in the solar atmosphere is discussed. The study of the variation of the incoming protons flux and their initial energy in the chromosphere leads to optimal values improving the model.

Balthasar, H., Collados, M., and Muglach, K.: 2000, "Oscillations in a Solar Pore", *Astronomische Nachrichten* **321**, 121–127

Abstract: Temporal variations of a solar pore were observed at the ground based Vacuum Tower Telescope (VTT) on Tenerife and with the satellite TRACE. At the VTT Stokes $I$ and $V$ of the iron line at 1.56 $\mu$m, originating in the deep photosphere, were measured. TRACE delivered UV images at 170 nm which show chromospheric continuum. In a part of the pore we find oscillations of the magnetic field in the 5 minute range. Velocities derived from shifts of the Stokes $V$ profiles show 5 minutes everywhere in the pore, but the coherence of magnetic field and velocities is low. The intensity at 170 nm varies with 3 minutes, and for a part of the whole time series additionally with 4 minutes.

Hansen, I., Engvold, O., Schmieder, B., Mein, N., and Mein, P.: 1999, "Bright Rims and Dopplershifts in H$\alpha$ Filaments", in A. Wilson (Ed.), *Magnetic Fields and Solar Processes*, Procs. Ninth European Meeting on Solar Physics, ESA SP-448, ESA Publ. Div., ESTEC, Noordwijk, 491–496

Abstract: Bright rims were fist noticed by Royds (1920) and later observed and discussed by d'Azambuja and d'Azambuja (1948). There is as yet no generally accepted theory for the origin of the existence of this phenomenon. The aim of the present study, of which this article is a progress report, is to establish the physical relation and of bright rims to various types of prominences and/or to particular phases in their development. It is also of interest and importance to determine whether and how bright rims differ from plages and other bright solar features.

Martens, P. C. H. and Muglach, K.: 1999, "Scientific Highlights from the Solar & Heliospheric Observatory", in K. N. Nagendra and J. O. Stenflo (Eds.), *Proceedings of the 2nd Solar Polarization Workshop*, Kluwer Academic Publishers, Dordrecht, 325

Abstract: We present a summary of the main scientific results from the ESA/NASA SOHO mission, with a special emphasis on remote sensing observations of the solar atmosphere, that are related to the subject of this conference, solar polarization.

Martínez Pillet, V., Collados, M., Sanchez Almeida, J., Gonzalez, V., Cruz-Lopez, A., Manescau, A., Joven, E., Paes, E., Diaz, J. J., Feeney, O., Sanchez, V., Scharmer, G. B., and Soltau,

D.: 1999, "LPSP & TIP: Full Stokes Polarimeters for the Canary Islands Observatories", in T. Rimmele, R. R. Radick, and K. S. Balasubramaniam (Eds.), *High Resolution Solar Physics: Theory, Observations and Techniques*, Proc. 19th Sacramento Peak Summer Workshop, ASP Conf. Series 183, 264–272

Abstract: Two Stokes Polarimeters have seen first-light at the solar telescopes on the Canary Islands (Spain), one for visible wavelengths and one for the infrared region. Both polarimeters measure all four Stokes parameters simultaneously using a modulation scheme based on Ferroelectric Liquid Crystals. The polarimeters use a polarizing beamsplitter (Savart plate) that produces a double image useful to reduce seeing induced crosstalk and to double the number of detected photons. The visible polarimeter (La Palma Stokes Polarimeter, LPSP) uses a CHIL-CCD camera with a readout rate of 60 Hz. For the Tenerife Infrared Polarimeter (TIP) a NICMOS-3 array is used at a rate of 8 Hz. The LPSP is designed to work at the Swedish Vacuum Solar Telescope (La Palma) and it aims to obtain high spatial resolution (0.5") maps of the polarization signals. TIP will be used at the German telescopes on Tenerife (Vacuum Tower Telescope and Gregory Coude Telescope) and it will be one of the few full Stokes polarimeters available working in the infrared. Both polarimeters obtain 2D maps by scanning the spectrograph slit through the region of interest. First-light results are presented.

Muglach, K. and Fleck, B.: 1999, "Waves in the Quiet Sun's Chromosphere", in J.-C. Vial and B. Kaldeich-Schuermann) (Eds.), *Plasma Dynamics and Diagnostics in the Solar Transition Region and Corona*, ESA SP-446, 499–502

Abstract: First results of long duration wave study observations with the SUMER instrument onboard SOHO are presented. All chromospheric lines show enhanced power in the three minute range. Phase and coherence spectra are presented and briefly discussed.

Muglach, K., Fleck, B., Schühle, U., Stolpe, F., Foing, B. H., and Wilhelm, K.: 2000, "Dynamics of Chromospheric and Transition Region Lines Observed with SOHO/SUMER and the GCT/Tenerife", *Adv. Space Research* **25**, 1731–1734

Abstract: High-resolution spectroscopic observations of the quiet Sun have been carried out in September 1996 at the German Gregory Coudé Telescope (GCT) in Tenerife and in May 1997 with the SUMER instrument onboard SOHO. Time sequences of spectra in the visible and near infrared as well as in the ultraviolet have been taken, covering a range of heights from the solar photosphere up into the transition region. In this contribution we present the dynamical behaviour observed at the various heights in the solar atmosphere.

Muglach, K. and Sütterlin, P.: 1999, "Simultaneous Observations with the GCT and SoHO: High Velocity Events in the Upper Chromosphere", in C. E. Alissandrakis and B. Schmieder (Eds.), *Second Advances in Solar Physics Euroconference: Three-Dimensional Structure of Solar Active Regions*, Astron. Soc. Pac. Conf. Ser. 155, 341

Abstract: We present the first results of a coordinated observing campaign of sunspots with SoHO and the German Gregory Coudé Telescope (GCT) on Tenerife. With the GCT we took simultaneous polarimetric spectra (Stokes $I$ and $V$) in the visible (Fe I 6733 Å) and near infrared (Si I 10828 Å and He I 10830 Å), thus probing the target in the photosphere (with the Fe I and Si I line) as well as in the chromosphere (with the He I line). In addition, the Extreme–ultraviolet Imaging Telescope (EIT) onboard SoHO took a sequence of coronal images in Fe XII 195 Å. We present spatial maps of various line parameters in the different atmospheric layers of the sun. The most prominent features in our observation are very high velocities (mostly redshifts, up to 40 km/s) seen in the He I line.

Schmieder, B., DeLuca, E., Mein, N., Mein, P., Malherbe, J. M., Wilken, V., Staiger, J., Engvold, O., and Hanssen, I.: 1999a, "Emerging Flux and Heating of Coronal Loops in Active Regions", in A. Wilson (Ed.), *Magnetic Fields and Solar Processes*, Procs. Ninth European Meeting on Solar Physics, ESA SP-448, ESA Publ. Div., ESTEC, Noordwijk, 653–658

Abstract: During an international ground-based campaign in the Canaries coordinated with Space instruments (TRACE, Yohkoh) we have observed an active region on September 10, 1998 with high spatial and temporal resolution. New emerging flux has been observed in magnetograms of the GCT, Tenerife and the SVST, La Palma. The arch-filament systems are well developed in H$\alpha$ (VTT/DPSM, SVST). The multi-wavelength observations (SXT/Yohkoh, TRACE) allow us to analyse the behaviour of 3D loops visible in the transition region at coronal temperatures. We discuss on different physical quantities: i.e. temperature, hydrogen column density. The arch filament systems (AFS) correspond to low emission regions observed in wavelengths 171 Å and 195 Å due to absorption by hydrogen and helium in the cool prominence plasma. The emitting plasma around and above the AFS is at a measurable higher temperature than the large extended loops.

Schmieder, B., Kotrc, P., Heinzel, P., Kucera, A., and Andretta, V.: 1999b, "Diagnostics constraints on prominence parameters from SOHO and groundbased observations", in A. Wilson (Ed.), *Magnetic Fields and Solar Processes*, Procs. Ninth European Meeting on Solar Physics, ESA SP-448, ESA Publ. Div., ESTEC, Noordwijk, 439–444

Abstract: The cold material of prominences is observed by CDS as an absorption in coronal lines which have wavelengths shorter than the hydrogen Lyman continuum edge. The coronal emission in these UV lines is partly absorbed by the resonance continua of hydrogen and helium. Some of the authors have already used this kind of observation to derive the dyrogen column density and the optical thickness of the prominence. We apply the same method for a quiescent prominence observed on June 5, 1997 by SOHO/CDS, SOHO/SUMER and groundbased telescopes. H$\alpha$ observations are available from the multichannel spectrograph in Ondrejov; calibrated H$\alpha$ profiles have been reconstructed. We interpret these combined data in terms of recent NLTE prominence modelling (see Schmieder et al. 1999).

Shand, M., Scharmer, G. B., and Wei, W.: 1999, "Correlation tracking and Adaptive Optics Control Using Off-The-Shelf Workstation Technology", in T. Rimmele, R. R. Radick, and K. S. Balasubramaniam (Eds.), *High Resolution Solar Physics: Theory, Observations and Techniques*, Proc. 19th Sacramento Peak Summer Workshop, ASP Conf. Series 183, 231–238

Abstract: The microprocessors used in the off-the-shelf workstations double in performance every eighteen months. The Swedish Vacuum Solar Tower (SVST) uses off-the-shelf workstations for all aspects of its on-line telescope control and data acquisition. Since 1995 workstation performance has been adequate for a correlation tracker of solar granulation controlling a tip-tilt corrector. In 1998 workstation performance permits the construction of a 19 subimage Shack–Hartmann wavefront sensor for adaptive optics and phase diversity based wavefront sensing is becoming feasible. It is argued that workstations provide a cost-effective, upgradable, low-risk and flexible means of instrument construction for solar adaptive optics systems and solar instrumentation in general.

Wiik, J. E., Dammasch, I. E., Schmieder, B., and Wilhelm, K.: 1999, "Multiple-Thread Model of a Prominence Observed by SUMER and EIT on SOHO", *Solar Phys.* **187**, 405–426

Abstract: A quiescent polar crown prominence was observed at Meudon in H$\alpha$ and Ca II lines, and by EIT and SUMER on board SOHO in UV lines from 9 to 10 March 1996. SUMER observed the prominence continously in a scanning mode between 21:40 UT

on 9 March, and 18:13 UT on 10 March, in the nitrogen line N V($\lambda$1238) with a 1 arcsec$^2$ resolution. Altogether 190 prominence images ($121 \times 108$ pixels) were obtained. These are presented in a movie. The prominence is highly dynamic. Large-scale features, such as mixed loop systems and dark cavities are changing on time scales of a few hours. Filamentary structure is evident and is changing within a few frames of the movie. A lifetime of 20–25 min for the fine structure has been found by the autocorrelation method. We have statistically analysed the three moments of the N V line in the prominence: line intensity, Doppler shift and linewidth, in the context of a multiple-thread model. We find that the data are consistent with a model where the prominence is assumed to be an ensemble of small threads. In the brightest parts of the prominence it is possible that there are many unresolved threads (15-20) along the line of sight with diameters smaller than a few hundred kilometers. The filling factor is probably very small and in that case the structures occupy only a fraction of the volume.