ESMN

European
Solar Magnetometry
Network

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http://esmn.astro.uu.nl

FINAL REPORT

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Summary

The *European Solar Magnetometry Network* ESMN has become a well-established entity in European solar physics. This report summarises its achievements during the four years of its existence.

ESMN devoted 1151 personmonths of effort on its science programme to:

- *(a) chart the topology of solar magnetic structures;*
- *(b) identify the basic processes underlying their dynamical behaviour;*
- *(c) measure solar activity patterns,*

and implementation tasks to:

- *(d) improve solar magnetometry;*
- *(e) obtain comprehensive high-resolution solar magnetometry data;*
- *(f) achieve observationally constrained numerical modelling.*

All tasks have been successfully addressed; various breakthroughs are reported below. ESMN trained 18 EC-funded ESMN Fellows (young visiting researchers), distributed over the 8 partner teams across Europe, in advanced solar magnetometry to a total of 320 personmonths.

An ESMN re-incarnation as the *European Solar Magnetism Network* is under negotiation under the Fifth Framework Programme and is likely to start up later this year. It will capitalise on the ESMN-1 achievements by exploiting the new observational and interpretational magnetometry techniques to deepen our understanding of solar magnetism and to provide high-level training in these techniques.

Section 1: ESMN RESULTS

1.1 ESMN scientific highlights

Solar physics is on the upswing worldwide. The ESMN efforts have been an integral part of this advance. Three developments are behind the current blossoming of solar physics: the stupendous success of the SOHO mission in space, the development of advanced image restoration and polarimetry techniques at groundbased optical telescopes, and the advent of realistic numerical modelling. The ESMN participated heartily in all three; three highlights are selected here[1].

SOHO and sunspots. SOHO is the first cornerstone mission of the ESA Horizon 2000 programme, is the first space mission to observe the sun comprehensively "from the deep interior to the outer heliosphere", and does so reliably and continuously[2]. SOHO has yielded a wide variety of important discoveries that range from below-the-surface helioseismology to *in situ* solar wind composition results, and has rightfully gained high public awareness with much attention from the media.

Within the context of ESMN solar magnetometry, SOHO was the backbone in many multi-partner multi-telescope ESMN observing campaigns. In particular, the MDI magnetograph and the CDS and SUMER spectrometers on SOHO reliably provided maps of the magnetic fields on the solar surface and spectral diagnostics of the highly dynamical higher layers (the "chromosphere" and the "transition region" to the hot outer solar corona). A particular topic that received much attention in the ESMN campaigns are sunspot fine structure, oscillations, and plumes. Sunspots have been studied since Galileo but there is much yet to learn and understand about them. Many ESMN papers (Section 3, starting on page 27) address their structure and dynamics. A surprising result is that although sunspots are relatively long-lived, they display dynamic changes and oscillations at very short time scales, down to a few minutes, from the deep photosphere to high up in the transition region (in the so-called "plumes"). Complex pistoning and wave interference plus intricate geometry, in particular in the filamentary penumbrae surrounding the dark umbrae, together cause a rich display of magnetohydrodynamic physics. Most of the pertinent ESMN papers address these dynamical variations observationally, but there are also initial numerical simulations studying global-mode excitation and wave scattering.

Canary Island telescopes and spectropolarimetry. The magnetic field patterning and its evolution at the solar surface are dictated by the subsurface dynamo and convective flows but in turn they dictate the structure, dynamics, and heating of the outer atmosphere. This switch in field role occurs in the optically observable photosphere–chromosphere regime, so that ground-based imaging permits charting the magnetic "foot-

[1] More information is avilable in the yearly and Mid-Term ESMN reports, available on the ESMN website http://esmn.astro.uu.nl.

[2] A major scare to the ESMN programme and solar physics worldwide was SOHO's "vacation" during the first ESMN year when SOHO was effectively lost through human error. Fortunately, it was found back through radar detection with the Arecibo radio telescope and brought back to life, with all instruments surviving the extremes of cold and heat to which they had been exposed in the meantime. The first-year ESMN report gives more detail. Since then, and notwithstanding loss of gyros, SOHO performs flawlessly. It will be kept in full operation the coming years.

point" topology and dynamics. The five optical solar telescopes at the two Canary Island observatories (La Palma and Tenerife, respectively the Dutch DOT, Swedish SVST/NSST, German GCT and VTT, and French-Italian THEMIS) together form the worlds premier high-resolution telescope park in solar physics.

Breakthrough successes in telescope design and utilisation were achieved with the DOT and the SVST-to-NSST replacement. The DOT (Dutch Open Telescope) and NSST (New Swedish Solar Telescope) stand close together on La Palma, are both operated from the Swedish building, and together push the angular resolution limit to unprecedented sharpness (0.1–0.2 arcsec, or 70–150 km on the Sun). Each telescope combines a pioneering design with superb optics and advanced imaging techniques. They do this in utterly different ways. The DOT is a fully open telescope and relies on speckle interferometry for image reconstruction, a technique implemented at the DOT by UU Fellow Peter Sütterlin. The NSST is the first meter-class vacuum telescope equipped with adaptive optics. During the ESMN period the DOT grew from an open-principle testbed to a research facility regularly producing speckle-restored movies of superb quality[3]. The decision to replace the former Swedish SVST was taken only after the ESMN start, but the NSST realisation was so fast that first light and high-quality was achieved this spring and first images were already in hand by the end of the ESMN period[4]. Intensive collaboration between the Dutch and Swedish teams contributed much to both telescopes. Each telescope constitutes a major ESMN success story; together, they form a complementary and unrivalled facility for high-resolution solar physics the coming years.

On Tenerife, a major advance was the installation of the Spanish TIP (Tenerife Infrared Polarimeter) at the German VTT (Vacuum Tower Telescope). The infrared holds large promise for high-precision spectropolarimetry because the Zeeman separation of magnetically split spectral line components increases with the square of the wavelength whereas the width of the lines due to thermal motions increases linearly: with increasing wavelength, the Zeeman components become more distinct and easier to measure. The first measurements are in; this new instrument holds large promise for high-precision and sensitive solar magnetometry.

Magnetohydrodynamic oscillation modelling. The advent of realistic numerical modelling represents an important breakthrough in the way solar physics is done. The sun and its atmosphere are too complex to be addressed by analytic physics or scenario-type analysis. Many processes interact at widely different scales to produce a complex mixture of phenomena that cannot be studied by isolating one quantity at a time. Numerical simulation now becomes sufficiently realistic to address solar physics problems at the level of sophistication needed for proper physical interpretation. In this numerical revolution, the group at Oslo is world leader in in time-dependent radiation hydrodynamics simulation while the Stockholm Fellows excel in magnetoconvection simulation.

A particular striking success is the ESMN simulation effort on magnetically bounded internetwork oscillations led by the Oslo Fellow (Colin Rosenthal) with a Stockholm one (Bertil Dorch) contributing. Their analysis clarifies a long debate on the patchy, intermittent patterns displayed by internetwork oscillations over the solar surface. It establishes that wave

[3] Website: `http://dot.astro.uu.nl`
[4] Website: `http://www.astro.su.se/groups/solar/`

reflection against outward spreading "magnetic canopies" and subsequent wave interference controls the apparent patterning to large extent. Their work exemplifies the strength of physically correct simulation of complex solar phenomena. A comparable breakthrough results from coronal loop dynamics modelling by Stockholm Fellow Boris Gudiksen in his PhD research.

1.2 Accomplished ESMN research

Objectives. All ESMN objectives were addressed. In Project Programme order:

- science objectives: (magnetic structure topology, magnetic structure dynamics, dynamo patterning): a large body of research at each partner with much collaboration between partners. The papers listed in Section 3 effectively constitute a complete report, excepting those analyses not yet in press. Together, they illustrate that the ESMN research effort has made a large impact in solar physics, that it covered all objectives, and that it often was done in multiple-partner collaborations. Overall rating: well done!
- THEMIS optimisation: new primary mirror installed; much progress in telescope alignment; highly sensitive polarization measurements obtained; green light for and design of an new Italian Fabry Perot polarimeter; green light for and start of an adaptive optics programme; development of suited inversion codes. Rating: good progress, with great hopes for adaptive optics.
- DOT optimisation: successful implementation of speckle imaging; installation of a large-volume speckle data acquisition system; design and partial installation of a multi-wavelength imaging system; collection of superb speckle movies; initial science papers written; successful negotiation for extended funding. Rating: the DOT "took the world" with the superb quality of its speckle-restored movies – largely thanks to the expertise and effort of UU Fellow Peter Sütterlin.
- magnetometry calibration: large progress in the development of Stokes profile inversion codes at OP and IAC. The neural-networking technique pioneered at AIP proved so effective that it now spreads worldwide. Rating: excellent.
- liquid-crystal magnetometry: both Canary Island spectropolarimeters were installed (IAC); the TIP is now in heavy use at the VTT while the La Palma one awaits a new spectrometer at the NSST. AIP installed successfully another new liquid-crystal polarimeter at the GCT. Rating: excellent.
- MOF magnetometry: the MOF is a resonance-cell magneto-optical filter pioneered by the OAC. The planned change-over from sodium to potassium resonance cells was achieved; the OAC achieves valuable solar magnetometry and oscillation physics with its full-disk MOF. However, installation of a small-field high-resolution MOF duplicate at the DOT was put to lower priority when UU tested an alternative Ba II 4554 Lyot filter from Irkutsk, Russia, at the SVST, in a NATO-supported collaboration. Its outstanding success led to an INTAS-supported programme to install this filter in the DOT. (This programme effectively annexes groups at Kiev in the Ukraine and at Irkutsk in Russia onto the ESMN, with the IAC and UU as direct Western partners.)

Conclusion: no MOF in the DOT during ESMN or in the near future. The idea seemed excellent at the time but by now the Ba II filter looks even better.

- G-band magnetometry: brought to new heights first in the DOT movies, very recently in yet-undisclosed imagery from the NSST. KVA and UU diagnosed G-band formation in joint papers, as did colleagues at the IAC. Upshot: proxy G-band magnetometry at the 0.1–0.2 arsec resolution limit is now starting!
- IPM magnetometry: IPM is the Italian Panoramic Monochromator, a Fabry-Perot tunable narrow-band imaging system with polarimetric capability. The Italian partners in the THEMIS consortium have requested and been granted funding to completely rebuild the IPM into a highly advanced system (called ISIS) based on initial experiments with the original IPM, showing that state-of-the-art hardware will bring considerable resolution and sensitivity improvement. Conclusion: ISIS will bring Fabry-Perot magnetometry to much larger height than was anticipated for IPM.
- image restoration: speckle reconstruction installed at the DOT with great success, leading to the decision to do all DOT observing in speckle mode. Adaptive optics is being employed at the VTT, was recently (already) tested successfully on the NSST, and is under design for THEMIS. Conclusion: all solar telescopes aiming at high angular resolution must employ image restoration. The DOT is the first one regularly relying on speckle reconstruction; the NSST will exploit adaptive optics to be the first solar telescope reaching the 0.1 arcsec limit.
- campaign coordination: well done (the many campaigns are listed in Section 1.3), in particular by AIP (Fellow Karin Muglach), OP and ESA.
- on-line imagery: this task was fulfilled already soon after the start of ESMN through worldwide image serving. ESA's SOHO team played and plays an important role; the OP group furnishes valuable daily filtergrams. Rating: accomplished.
- multi-telescope campaigns: lots, see Section 1.3.
- data archiving: ongoing developments in which many teams take part (including the Italian Arthemis and the French BASS archives). Eventually data archiving must produce the worldwide Virtual Solar Observatory. Upshot: considerable progress but still evolutionary – no wonder since this holds for all information technology.
- data reduction: extensive development of polarimetric inversion codes at OP, IAC and AIP. Neural network techniques (AIP) a highly promising prospect. Rating: excellent progress, but in fact the field is only starting.
- boundary conditions: much effort, in particular at UiO using SOHO data to generate observed solar surface dynamics as realistic piston in driving chromospheric oscillations and in establishing umbral flash oscillation boundary conditions from SVST spectrometry. In general, the emphasis is turning to derivation of the coronal field geometry from solar surface magnetometry – a nontrivial task since the coronal field is neither force-free nor potential. The recent breakthrough analysis of KVA Fellow (PhD student) Boris Gudiksen exemplifies this line of research. Rating: hot topic the coming years in which ESMN led the way.
- comparisons with modelling: the third highlight selected above (Colin Rosenthal's (UiO) work on internetwork oscillations, also involving Bertil Dorch at KVA) illus-

trates the force of detailed data–modelling comparison. Again a technique which will become very important and was pioneered in ESMN.

Schedule. No marked deviations except for the Third ESMN School, which became a joint ESMN–PLATON Spring School held at Dwingeloo in the very last month of the ESMN period (details in Section 1.3). Its late timing turned out a good idea since in the meantime, it had become clear that ESMN will continue as the *"European Solar Magnetism Network"* so that the school became effectively a suitable Fellow-recruiting opportunity — apart from being an excellent school in its own right.

Milestones. In the order listed in the Project Programme:

– successful completion of the training programme?

  Yes. The total amount of ESMN Fellow personmonths is 320, only one percent below the Contract value of 324 personmonths (specification in Section 2.2 on page 13). Toward the end of ESMN, premature leaving of some Fellows was compensated by short-term Fellow hiring, a mechanism that was experienced as actually useful in its own right.

  The main deficit comes from partner OAC (7.5 personmonths, see table in Section 2.2). It became clear already well before the Mid-Term Review that living in Naples imposes (or is perceived as imposing) a considerable constraint, and the rather low salary imposed by the OAC administration at the ESMN start as corresponding to "local conditions" was no help either (its low value was the motivation to assign more personmonths of hiring to OAC originally). The suggestion to ESMN at the Mid-Term review was to also look for qualified predocs, and this tactic indeed remedied the situation somewhat, also at the IAC after Fellow Olaf Dittmann left prematurely.

  An item on the training programme that did not materialise was the concept of midterm switches and frequent secondments[5] between partners. The idea to switch midterm looked very attractive when writing the proposal, but in practice not so at all to any of the ESMN Fellows, with the nationality rules a primary stumble block. Secondments were seen as catering to a non-existing need because the frequent ESMN campaigns and already busy exchange visit, conference and workshop schedules moved the Fellows around a good deal already.

  All other items on the training programme were satisfactorily executed. Detail is given under Networking (Section 1.3) and in the Fellow travel lists in Section 2.5 on page 20 ff.

– successful magnetometry implementation (tasks d–f)?

  Yes, see Section 1.2 above. The total ESMN effort amounts to 1151 personmonths, well over the Contract deliverable of 948 personmonths (see Effort Table in Section 2.1 on page 12). The 203 month excess compensates for the small 4 month deficit in Young Visiting Researcher training. The total effort devoted to ESMN tasks exceeded the Contract value at each partner.

  The relatively large excess at KVA (234 delivered over 144 deliverable personmonths) is due to the fact that nearly the whole group, excepting the Fellows, turned most of

[5] Effectively, one secondment took place in the case of Jack Ireland (who was ESA as well as OAC Fellow, but specifically hired at each place).

its attention to realisation of the NSST, a major magnetometry task not yet defined as objective in the Project Programme at contract negotiation time but effectively a principal ESMN one that was completed with admirable speed and efficiency already within the ESMN duration (with considerable input from partners UU and UiO).

– breakthrough results on solar magnetism (tasks a–c)?

  Yes. The papers listed in Section 3 on pages 27 ff do not only contain much high-quality solar physics but also break-through results, as illustrated in the highlights in Section 1.1 above.

– fruitful linkages to industry?

  Yes, and perhaps no. The technological interactions in the design and construction of the NSST, the installation of the advanced speckle system at the DOT, and the construction of the three new liquid-crystal spectropolarimeters involved much generally positive contact with industry (and even produced a paper in Section 3). For example, the construction of the drives of the new NSST turret (KVA) was supervised by Hammerschlag (DOT builder and mechanical expert, UU) on the Flender factory floor, just as he had done with the DOT drives earlier (more detail in Mid-Term and Year 3 reports[6]).

  Arguably on the negative side, the ESMN lost a Fellow prematurely to industry when IAC Postdoc Olaf Dittmann chose to leave astronomy for a permanent position with the Zeiss company. It is not unlikely that more ESMN-trained researchers will end up in industry, in view of the current shortage of tenured positions in academia versus the shortage of bright young physicists in industry. To us such migrations represent a non-fruitful brain drain from our endeavour, but in wider context they can be seen as a boon to society.

– successful public outreach?

  A marked success. The yearly reports give particulars; overall, the ESMN has contributed well over a hundred public lectures, complete astronomy courses, many popular-science articles, much WWW presence (in particular re SOHO, and also including the ESMN outreach page maintained by KVA Fellow Bertil Dorch), and various TV programmes. For example (Year 3 report), the 2001 SOHO anniversary had 70 public events taking place in 47 cities in 14 European countries with much media attention; the April 2001 X-20 flare produced 8,311,334 requests to the SOHO web servers with over 686 Gbytes served in April 2001 alone. In Year 4 NSST First Light generated dozens of newspaper articles around the world.

[6]In Year 4 KVA's contacts with industry culminated in the NSST construction, involving Svenska Bearing AB, Gothenburg, Sweden (Parts), Opteon Oy, Turku, Finland (optics polishing) and Digitalmekanik AB, Stockholm, Sweden (NSST main contractor for design, structure, mirror support). Discussions with COMPAQ (KVA collaborator Mark Shand) emphasized deployment of a high-order adaptive optics system (36 instead of 19 cells). UU debated multi-processor speckle reconstruction with computer experts from five vendors. OAC interacted with EIS SRL on the VAMOS MOF.

1.3 Principal ESMN networking activities

ESMN Schools

1. "Radiative Transfer and Radiation Hydrodynamics", ESMN Summer School, Oslo, Norway, June 1–11, 1999, was an in-depth school on radiative transfer and radiation hydrodynamics, adding elaborate numerical exercises to high-level lectures during two intensive weeks. The students (postdocs and graduates) also presented their own research. The school was filled to capacity (40 students). Most students were well below 35 years of age, with an excellent spread over field of interest, background, nationality, and gender. Two of the four teachers and fifteen students came from ESMN partners. More detail is given in the Year 2 report, a link is available on the ESMN website.
2. "Astrophysical Spectropolarimetry", XIIth Canary Islands Winter School of Astrophysics, Instituto de Astrofísica de Canarias, Tenerife, Spain, November 13–24, 2000. The School was co-sponsored by the IAC, the EC, the Spanish Ministry of Science, IBERIA, the local governments of La Palma and Tenerife, and the ESMN. There were 62 participants from 17 countries including 6 ESMN Fellows. There were hands-on polarimetry training sessions at the telescopes of the Teide Observatory on Tenerife and the Roque de los Muchachos Observatory on La Palma. A book "Astrophysical Spectropolarimetry" resulted, published by Cambridge University Press. It provides an unsurpassed introduction to spectropolarimetry in astrophysics. More detail is given in the Year 3 report; a link is available on the ESMN website.
3. "Solar Magnetism", ESMN–PLATON Spring School, Dwingeloo, The Netherlands, April 1–7, 2002. The school was co-organised with the EC PLATON sister network. There were 9 teachers, mostly from ESMN and PLATON partner institutes, and 22 students (limited by the lecture room capacity) from 10 EC countries and 1 Associated State, 13 coming from ESMN and PLATON partner institutes. Predocs rather than postdocs were selected because the school was a recruiting agent for the coming "European Solar Magnetism Network" RTN continuation of the ESMN. The course covered solar magnetism in depth, both the theoretical and the observational aspects. The students presented their own graduation and PhD projects. The school excursion brought them to the Westerbork Synthesis Radio Telescope and the EC-funded Joint Institute for VLBI in Europe. Prof. Harvey Butcher, Director of the large ASTRON facility (radio and optical astronomy) at Dwingeloo and President of the European Astronimical Society presented plans for the international LOFAR project and its solar physics capabilities. A link to the school website is available on the ESMN website.

Collaborative ESMN observing campaigns

1. "Chromospheric dynamics", SOHO Joint Observing Program JOP 72, May 1998, combining SOHO and SVST, partners ESA, KVA, UU;
2. "Filaments and arch filament systems", September 1998, combining TRACE, YOHKOH (US and Japanese satellites) with VTT, GCT, THEMIS and SVST, partners OP (leader), KVA and IAC;

3. “Active region oscillations”, September 1999, combining VTT, GCT, SVST and DOT with SOHO and TRACE, partners AIP (leader), KVA, UU and ESA;
4. “Arch filament systems”, May and October 1999, combining THEMIS and VTT with SOHO, TRACE and YOHKOH, partners OP (leader), UiO, ESA;
5. “Arch filament oscillations”, May 1–5, 2000, using THEMIS and SOHO, teams OP (leader) and ESA;
6. “Chromospheric Magnetism: the Na I D lines”, June 2000, LPSP polarimeter of the IAC at the SVST, teams IAC (leader) and KVA;
7. “Non-thermal particles in solar flares”, July 12–19, 2000, THEMIS MTR mode (multi-line spectropolarimetry). Teams OP (PI) and OAC.
8. “Chromospheric magnetism: the Ca II IR triplet”, September 2000, using an OP stellar polarimeter at the GCT, teams IAC (leader) and OP;
9. “Oscillations in sunspots and active regions”, September 19–29, 2000. AIP (leader), IAC, UU and ESA, using VTT, GCT, DOT, SOHO and TRACE;
10. “Active regions”, October 6–15, 2000, combining THEMIS and VTT with SOHO, YOHKOH and TRACE. Teams OP (leader) and ESA;
11. “Spectroscopic diagnostics of filaments and prominences”, May 21–28, 2001, combining the Pic du Midi solar telescope with SOHO telescopes (CDS, SUMER, TRACE) and other groundbased observatories. Teams OP (leader) and ESA;
12. “Sources of coronal oscillations”, SOHO Joint Observing Program JOP 144, 5–13 June, 2001, combining CDS and MDI onboard SOHO with TRACE and the MOF at the Kanzelhöhe Solar Observatory, Austria. Teams OAC (leader), ESA, and non-ESMN teams (including the PLATON sister network);
13. “The Magnetic Field of Sunspots”, June 16 – July 1, 2001, combining VTT and GCT. Teams AIP (leader) and IAC.
14. “Active Region Irradiance”, SOHO Joint Observing Program JOP 145, July 18 – August 6, 2001, combining SOHO (CDS and MDI) with TRACE. Teams ESA (leader) and AIP;
15. “Onset of flaring activity and coronal mass ejections”, October 1–11 and October 17–23, 2001, combining VTT with SOHO (CDS, SUMER, TRACE) and other groundbased observatories. Teams OP (leader) and ESA.
16. “Chromospheric and photospheric network”, April 21–May 3, 2002, combining DOT, NSST (first science campaign) and TRACE. UU (leader) and KVA, with Lockheed-Martin (USA);

ESMN conferences

1. ESMN meeting “Solar Atmosphere Dynamics”, February 29 – March 2, 2000, Oslo, Norway.
2. ESMN Workshop “Helium Line Formation in a Dynamical Solar Atmosphere”, April 5–7 2000, Naples, Italy;

3. ESMN Workshop: "Astrophysical Flows and Magnetic Fields", April 18–19 2001, Stockholm, Sweden.
4. ESMN Mid-Term Meeting: Santa Cruz, Tenerife, Spain, September 29–30, 2000;
5. ESMN Workshop "Chromospheric Dynamics", ESTEC, Noordwijk, The Netherlands, May 21–22, 2001.

ESMN planning meetings at international conferences

1. Second ASPE Euroconference, Potsdam, Germany, October 1998 (ESMN kick-off);
2. First ESMN School, Oslo, Norway, June 1999 (ESMN outreach start);
3. 9th European Meeting on Solar Physics, Florence, Italy, September 1999;
4. 11th Cool Stars Workshop, Puerto de la Cruz, Tenerife, Spain, October 1999;
5. AAS/SPD meeting, Lake Tahoe, USA, June 2000;
6. IAU Symposium 203 and IAU General Assembly, Manchester, UK, August 2000;
7. 20th NSO/Sacramento Peak Summer Workshop, Sunspot, USA, September 2000;
8. 1st SOLSPA Euroconference, Santa Cruz, Tenerife, Spain, September 2000;
9. SOHO/GONG Workshop, Santa Cruz, Tenerife, Spain, October 2000;
10. XIIth Canary Islands Winter School, Tenerife, Spain, November 2000;
11. THEMIS conference, Rome, Italy, March 2001;
12. Solar Orbiter Conference, Puerto de la Cruz, Tenerife, Spain, May 2001;
13. 12th Cool Stars Workshop, Boulder, USA, August 2001;
14. 2nd SOLSPA Euroconference, Vico Ecquense, Italy, September 2001;
15. Stellar Atmospheric Modeling Conference, Tübingen, Germany, April 2002.

1.4 Benefits of working together

Astronomy is a highly international endeavour, and solar physics leads astronomy in international collaboration (the International Astronomical Union is rooted in a solar physics organisation; the most active part of the European Astronomical Society is its Solar Physics Section which existed long before). Thus, it is preaching to the converted to attend solar physicists on the benefits of working together. We have to – the sun is international, and since it shines on all countries in succession, we need collaboration already to follow it in its daily path along our sky. In addition, solar physics is understaffed in the sense that there are more exciting science problems to work on than researchers doing so, making collaboration rather than competition common practice.

That said, the ESMN has given its eight teams an extra sense of international coherence. Many of us meet frequently – providing the motivation to let ESMN planning meetings coincide with conferences – but the focused ESMN effort and work plan has indeed given us the European-community sense that the EC aims for in its Framework Programmes. Many of us also tended to collaborate more with US colleagues than with European colleagues.

The many multi-partner authorships listed in Section 3 show that this is no longer the case. Above all, the addition of the Young Visiting Researchers to our groups have added a true sense of across-the-border vitality and inspiration.

A point of concern remains the future of the ESMN-trained and other solar-physics trained youngsters. The tradition of pursuing a science career outside one's own country has been strong in the Northern countries (most Dutch solar physicists work in the US; there are four world-famous Swedish solar physicists in Europe of which only one lives in Sweden) but does not (yet) extend to say France and Spain whose young scientists tend to desire a career at home or prefer to leave the field. Thus, the community is not yet truly international in the post-postdoc stage. TMR-like programmes fostering internationalism across Europe may have to consider permanent-job constraints and exchange options as well as predoc and postdoc diffusion.

1.5 ESMN interactions with industry

Details on the ESMN interaction with industry have been given in the yearly and Mid-Term reports and above. The advanced technology needed to build and equip the Canary Island telescopes brings the instrumentalists in the ESMN teams in close contact with industry experts at a level of mutual respect and knowledge sharing. Some partners will exploit these contacts in future instrumentation projects (DOT, NSST, THEMIS adaptive optics, GREGOR, and ESA's future Solar Orbiter Mission).

There are no plans to commercialise or patent ESMN inventions. (The tradition in solar physics is to freely spread new techniques; even most data are made public immediately, without the one-year proprietary period customary in the rest of astronomy.)

1.6 ESMN contribution to training and mobility

The 18 ESMN Fellows have been trained at the forefront of solar physics science techniques, varying from instrument construction and data acquisition to numerical simulation and theoretical interpretation. Many of them have grown into mature scientists during these years. In addition, they have become even more part of the European solar physics community than they have been before – in terms of mobility they indeed have been moved around.

The ESMN's greatest training success may perhaps surface eventually if some of the ESMN Fellows develop into fully self-propelled leading scientists. Some of them show the markings of being well on their way to a prominent science career. Generally, as noted in earlier reports, the ESMN has been very happy with the quality – and in some cases expertise – of its Fellows. The Network hopes that those Fellows now wrestling with the career-or-country choice (at least four do, some spouse-constrained) will find a way to remain in the field.

However, even when ESMN-trainees will leave the field for other endeavours, their ESMN experience will be a pro on their conto, not only formally but also in having tasted advanced research, having been part of a highly international community, and having delved in exciting but difficult science problems requiring enough inspiration and concentration to make ESMN trainees "problem solvers" suited to many tasks in society.

Section 2: ESMN FACTS

This Section contains tables that provide the information requested in Annex B form in the *Reporting Guidelines*. Since these tables follow the format established in earlier ESMN Reports in order to provide greater detail in effort breakdown, the Network has decided to subsititute the Annex B template with the tables given below.

The overview table in Section 2.1 below splits the personmonth efforts over the four ESMN years.

The Fellow table in Section 2.2 provides all factual information requested on the Annex B template in a more compact format, except for the lists of refereed Fellow papers. These are given, with all other ESMN papers per Fellow, in Section 2.4 on pages 17 ff.

The personmonth efforts are split over all team members per ESMN partner in the team tables in Section 2.3 on pages 13 ff.

2.1 ESMN effort overview

Entries: [number researchers /] total manmonths / ESMN-paid manmonths

Partner	Proposal	Year 1	Year 2	Year 3	Year 4	Totals
UU	118/36	7/21/0	7/38/12	7/39/12	5/36/12	134/36
IAC	150/36	5/25/1.5	5/45/12	8/52.2/12	10/48.3/12	170.5/37.5
OAC	141/48	5/26/3.6	8/35/12	11/50/13.4	11/48.5/11.5	159.5/40.5
UiO	101/36	6/16/4.6	6/30/12	6/36/12	6/25/7.4	107/36
KVA	144/72	7/50/4	7/58/18	7/64/24	8/62/24	234/70
AIP	111/36	5/23/4	5/38/12	5/42/12	6/29/12	132/40
OP	114/36	8/24/0	6/36/10	8/36/12	9/36/14	132/36
ESA	69/24	5/14/0	5/15/0	7/29/12	7/24/12	82/24
ESMN	948/324	199/17.7	295/88	348.2/109.4	308.8/104.9	1151/320

2.2 ESMN Fellows

Team	Fellow	ISO	Type	Speciality	Birth date	Start date	MM
UU	Peter Sütterlin	DE	post	P-08	10/02/1963	01/05/1999	36
IAC	Olaf J. Dittmann	DE	post	P-08 M45	08/11/1965	03/03/1999	26.5
	Cristina Gabellieri	IT	pre	P-08	28/02/1978	01/03/2002	2
	Laura Merenda	IT	pre	P-08	17/04/1976	01/06/2001	7
	Klaus Pushmann	AT	pre	P-08	23/01/1968	01/03/2002	2
OAC	Regina Aznar Cuadrado	ES	post	P-08	16/06/1971	14/01/2002	3.5
	Carla S. Gil	PT	pre	P-08	11/03/1977	15/03/2001	6
	Jack Ireland	GB	post	P-08	09/12/1969	06/02/2001	7
	Etienne Vogt	FR	post	P-08	02/10/1969	11/01/1999	24
UiO	Colin S. Rosenthal	GB	post	P-08	27/03/1964	11/12/1998	36
KVA	S. Bertil F. Dorch	DK	post	P-08	10/04/1971	01/01/1999	40
	Boris Gudiksen	DK	pre	P-08	10/06/1973	01/11/1999	30
AIP	Karin Muglach	AT	post	P-08	22/11/1965	01/01/1999	40
OP	Marcelo Lopez Fuentes	ES	pre	P-08	27/06/1967	15/01/2002	2
	Kostas Tziotziou	GR	post	P-08	20/11/1967	01/07/1999	34
ESA	Jack Ireland	GB	post	P-08	09/12/1969	01/05/2000	1
	Eoghan O'Shea	IR	post	P-08	17/08/1972	01/06/2000	19
	Axel Settele	DE	post	P-08	10/02/1971	07/01/2002	4
Totals	18 (5 female)	10					320

2.3 ESMN effort per team member

UU (Utrecht)

Name	Position	Funding	Months
Felix Bettonvil	Scientist/Engineer	UU/NWO	30
Rob Hammerschlag	Scientist/Engineer	UU	31
Max Kuperus	Professor	UU	3
Thijs Krijger	PhD Student	NWO	14
Jan Kuijpers	Senior Scientist	UU/KUN	3
Rob Rutten	Senior Scientist	UU	16
Peter Sütterlin	Post Doc	ESMN	36
Cornelis Zwaan	professor Emeritus	UU	1
8			134

NWO = Nederlandse Organisatie voor Wetenschappelijk Onderzoek
KUN = Katholieke Universiteit Nijmegen

Emeritus Professor Cornelis Zwaan deceased on June 16, 1999. Professor Jan Kuijpers moved to the Katholieke Universiteit Nijmegen per 01/01/2001 to become full-time rather than part-time professor there. Professor Max Kuperus retired on 01/12/2001.

IAC (La Laguna)

Name	Position	Funding	Months
Andrés Asensio Ramos	PhD Student	IAC	12
Luis Bellot Rubio	Support Astronomer	IAC	3
Manolo Collados Vera	Profesor Titular	ULL	26
Olaf Dittmann	Post Doc	ESMN	26.5
Cristina Gabellieri	Pre Doc	ESMN	2
Rafael Manso Sainz	PhD Student	IAC	12
Valentin Martínez Pillet	Research Scientist	IAC	20
Laura Merenda	Pre Doc	ESMN	7
Klaus Pushmann	Pre Doc	ESMN	2
Ines Rodriguez Hidalgo	Research Scientist	IAC	6
Jorge Sánchez Almeida	Research Scientist	IAC	27
Javier Trujillo Bueno	Científico Titular	CSIC	27
12			170.5

CSIC = Consejo Superior de Investigaciones Científicas
ULL = University of La Laguna

OAC (Naples)

Name	Position	Funding	Months
Vincenzo Andretta	Research Astronomer	OAC, MURST	16
Regina Aznar Cuadrado	Post Doc	ESMN	3.5
Carla Gill	Pre Doc	ESMN	6
Maria Teresa Gomez	Research Astronomer	OAC, MURST	6
Jack Ireland	Post Doc	ESMN	7
Pier Francesco Moretti	Post Doc	OAC, MURST	14
Maurizio Oliviero	Research Astronomer	OAC	21
Kevin Reardon	Graduate Researcher	OAC, MURST	11
Giuseppe Severino	Associate Astronomer	OAC, MURST	22
Thomas Straus	Research Astronomer	OAC, MURST	21
Alfredo Tripicchio	Graduate Researcher	OAC, MURST	8
Etienne Vogt	Post Doc	ESMN	24
12			159.5

MURST = Ministero dell'Universita e della Ricerca Scientifica e Tecnologica

UiO (Oslo)

Name	Position	Funding	Months
Mats Carlsson	Professor	UiO	24
Oddbjorn Engvold	Professor	UiO	5
Viggo Hansteen	Professor	UiO	16
Per Maltby	Professor	UiO	4
Andrew McMurry	Post Doc	NFR	20
Colin Rosenthal	Post Doc	ESMN	36
Roar Skartlien	Post Doc	NFR	2
7			107

NFR = Norsk Forskningsråd

KVA (Stockholm)

Name	Position	Funding	Months
Henrik Blomberg	MSc student	SU/KTH	9
Pete Dettori	Science Engineer	KVA	24
Bertil Dorch	Post Doc	ESMN	40
Boris Gudiksen	Pre Doc	ESMN	30
Dan Kiselman	Research Associate	KVA	26
Mats Löfdahl	Research Associate	KVA	20
Luc Rouppe van der Voort	PhD student	KVA	35
Göran Scharmer	Professor	KVA	36
Wang Wei	Science Engineer	KVA	14
9			234

SU = Stockholm University
KTH = Royal Institute of Technology

AIP (Potsdam)

Name	Position	Funding	Months
Horst Balthasar	Staff Scientist	AIP	35
Thorsten Carroll	PhD Student	DLR	7
Axel Hofmann	Staff Scientist	AIP	19
Volker Landgraf	PhD Student	DFG	2
Karin Muglach	Post Doc	ESMN	40
Axel Settele	PhD Student	DFG	7
Jürgen Staude	Professor	AIP	22
7			132

DLR = Deutsche Luft- und Raumfahrt
DFG = Deutsche Forschungsgemeinschaft

OP (Paris)

Name	Position	Funding	Months
Guillaume Aulanier	Post Doc	CNES	4
Veronique Bommier	Chargé de Recherches	CNRS	1
Pascal Demoulin	Astronome Adjoint	MEN	7
Marcelo Lopez Fuentes	Pre Doc	ESMN	2
Jean-Marie Malherbe	Astronome	MEN	15
Nicole Mein	Maitre de Conferences	MEN	3
Pierre Mein	Astronome	MEN	27
Jean Rayrole	Astronome	MEN	2
Sylvie Sahal-Bréchot	Directeur de Recherche	CNRS	7
Brigitte Schmieder	Astronome	MEN	22
Meir Semel	Directeur de Recherche	CNRS	8
Kostas Tziotziou	Post Doc	ESMN	34
12			132

MEN = Ministère de l'Education Nationale
CNRS = Centre National de la Recherche Scientifique

Dr. Pierre Mein retired officially in 2000 but remains active in ESMN research. Dr. Jean-Marie Malherbe took over his role as OP ESMN coordinator. The change was notified in writing. Drs. Nicole Mein and Jean Rayrole also retired during the ESMN period.

ESA (Noordwijk/GSFC)

Name	Position	Funding	Months
Paal Brekke	Staff Scientist	ESA	4
Bernhard Fleck	Staff Scientist	ESA	8
Bernard Foing	Staff Scientist	ESA	2
Stein Haugan	Staff Scientist	ESA	4
Scott McIntosh	Fellow	ESA	16
Jack Ireland	Post Doc	ESMN	1
	Fellow	ESA	24
Axel Settele	Post Doc	ESMN	4
Eoghan O'Shea	Post Doc	ESMN	19
8			82

2.4 ESMN Fellow papers (citations refer to Section 3)

– Regina Aznar Cuadrado(OAC)

Cuadrado et al. (2002)

– Olaf Dittmann (IAC)

Dittmann et al. (2001)

– Bertil Dorch (KVA)

1. Kiselman and Dorch (1999)
2. Dorch et al. (1999) – refereed journal
3. Archontis and Dorch (1999)
4. Dorch (2000a)
5. Dorch (2000b) – refereed journal
6. Nordlund et al. (2000b) – refereed journal
7. Dorch and Nordlund (2000a) – refereed journal
8. Dorch and Nordlund (2000b)
9. Dorch (2000)
10. Bogdan et al. (2001)
11. Dorch and Nordlund (2001) – refereed journal
12. Dorch et al. (2001) – refereed journal
13. Dorch and Nordlund (2001)
14. Rosenthal et al. (2001)
15. Rosenthal et al. (2002) – refereed journal
16. Bogdan et al. (2002) – refereed journal

– Marcelo Lopez Fuentes (OP)

None

- Cristina Gabellieri (IAC)

  None

- Carla Gil (OAC)

  Gil (2001) – Master's thesis University of Porto

- Boris Gudiksen (KVA)
  1. Dorch et al. (2001) – refereed journal
  2. Gudiksen and Nordlund (2002) – refereed journal

- Jack Ireland (ESA/OAC)
  1. De Moortel et al. (2002a) – refereed journal
  2. De Moortel et al. (2002b) – refereed journal
  3. De Moortel et al. (2002c) – refereed journal
  4. De Moortel et al. (2002d) – refereed journal
  5. Ireland and De Moortel (2002) – refereed journal
  6. Fludra and Ireland (2002)

- Laura Merenda (IAC)
  1. Trujillo Bueno et al. (2002) – refereed journal

- Karin Muglach (AIP)
  1. Muglach and Sütterlin (1998)
  2. Muglach et al. (1998)
  3. Foing et al. (1998)
  4. Andretta et al. (1998)
  5. Muglach and Fleck (1999)
  6. Martens and Muglach (1999)
  7. Andretta et al. (1999)
  8. Muglach et al. (2000) – refereed journal
  9. Balthasar et al. (2000) – refereed journal
  10. Schmidt et al. (2000) – refereed journal
  11. Balthasar et al. (2000)
  12. Muglach and Schmidt (2001) – refereed journal
  13. Carroll et al. (2001)
  14. Muglach and O'Shea (2001)
  15. O'Shea et al. (2001)
  16. O'Shea et al. (2002a) – refereed journal
  17. Georgakilas et al. (2002) – refereed journal
  18. Settele et al. (2002) – refereed journal
  19. Muglach (2002)

20. Carroll et al. (2002)
21. O'Shea et al. (2002b)

– Klaus Pushmann (IAC)

  None

– Eoghan O'Shea (ESA)

1. Banerjee et al. (2001b) – refereed journal
2. Banerjee et al. (2001d) – refereed journal
3. Williams et al. (2001) – refereed journal
4. O'Shea et al. (2001)
5. O'Shea et al. (2001a) – refereed journal
6. O'Shea et al. (2001b)
7. Banerjee et al. (2001a)
8. Banerjee et al. (2001c) – refereed journal
9. Muglach and O'Shea (2001)
10. O'Shea et al. (2002a) – refereed journal
11. O'Shea et al. (2002b)

– Axel Settele (ESA)

  Settele et al. (2002) – refereed journal

– Colin Rosenthal (UiO)

1. Rosenthal and Julien (2000) – refereed journal
2. Rosenthal et al. (2000)
3. McIntosh et al. (2001) – refereed journal
4. Rosenthal et al. (2001)
5. Bogdan et al. (2001)
6. Rosenthal et al. (2002) – refereed journal
7. Bogdan et al. (2002) – refereed journal

– Peter Sütterlin (UU)

1. Muglach and Sütterlin (1998)
2. Sütterlin et al. (1999) – refereed journal
3. Rutten et al. (2000)
4. Sütterlin and Wiehr (2000) – refereed journal
5. Balthasar et al. (2001) – refereed journal
6. Sütterlin et al. (2001)
7. Rutten et al. (2001)
8. O'Shea et al. (2001)
9. Rutten et al. (2001)
10. Sobotka and Sütterlin (2001) – refereed journal

11. Sütterlin (2001) – refereed journal
12. Sütterlin et al. (2001) – refereed journal
13. Sütterlin et al. (2001)

- Kostas Tziotziou (OP)
  1. Tziotziou et al. (2000)
  2. Tziotziou et al. (2001a) – refereed journal
  3. Tziotziou et al. (2001b)
  4. Heinzel et al. (2001) – refereed journal
  5. Tziotziou et al. (2002a)
  6. Tziotziou et al. (2002b) – refereed journal

- Etienne Vogt (OAC)
  1. Vogt and Hénoux (1999) – refereed journal
  2. Vogt et al. (1999)
  3. Balança and Vogt (1999)
  4. Emslie et al. (2000a) – refereed journal
  5. Emslie et al. (2000b)
  6. Vogt et al. (2001) – refereed journal

2.5 Travel and conference participation by ESMN Fellows

These entries detail all ESMN-related journeys of the ESMN Fellows, also travel funded from other sources. The order is alphabetical by person.

Regina Aznar Cuadrado (OAC)

1. "SOHO-11. From Solar Min to Max: Half a Solar Cycle with SOHO" A symposium dedicated to R.M. Bonnet, Davos, Switzerland, March 11–15, 2002

Olaf Dittmann (IAC)

1. ESMN Summer School on Radiative Transfer and Radiation Hydrodynamics, Oslo, June 1–11 1999
2. Collaborative visit to OP team, Paris, France, August 8-17, 2000.
3. "Advanced Solar Polarimetry — Theory, Observation and Instrumentation", 20th NSO/Sacramento Peak Summer Workshop, Sunspot, New Mexico, September 11–15, 2000
4. ESMN Mid-Term Meeting, Santa Cruz, Tenerife, Spain, September 29–30, 2000
5. "Astrophysical Spectropolarimetry", XIIth Canary Islands Winter School of Astrophysics, Instituto de Astrofísica de Canarias, Tenerife, Spain, November 13–24, 2000
6. "THEMIS and the new frontiers of solar atmosphere dynamics", THEMIS conference, Rome, Italy, March 19–21, 2001
7. Observing campaign at Observatorio del Teide: May 2001

Bertil Dorch (KVA)

1. Annual Workshop of the Solar-section of the Danish Astron. Soc., Arden, Denmark, May 1, 1999
2. "Solkurs", Workshop for Gynmasium Lectures, Haslev, Denmark, May 5–7, 1999
3. ESMN summer school, Institutt for Teoretisk Fysikk, Oslo, Norway, June 1 – 11, 1999
4. Swedish Astronomer Day, Stockholm, Sweden, October 15 – 16, 1999
5. The Parallel Super-computing Center Anniversary, PDC, Stockholm, Sweden, November 1, 1999
6. "Simulations Visualization on the Grid", PDC, Stockholm, Sweden, December 15 – 17, 1999
7. "Physics of Accretion and Associated Outflows", TAC, Copenhagen, Denmark, January 5 – 8, 2000
8. ESMN meeting, Institut for Teoretisk Fysikk, Oslo, Norway, February 29 – March 2, 2000
9. "Recent Insights into the Physics of the Sun and Heliosphere — Highlights from SoHO and Other Space Missions," IAU Symposium 203, at IAU General Assembly, Manchester, UK, August 7–19, 2000
10. "The Solar Cycle and Terrestrial Climate," 1st SOLSPA Euro-conference, Santa Cruz, Tenerife, Spain, September 25–30, 2000
11. ESMN mid-term meeting, Santa Cruz, Tenerife, Spain, October 1, 2000
12. 1-day symposium on "Boiling stars — Convection, radiation, and magnetic fields at stellar surfaces," Lund, Sweden, April 6, 2001
13. Workshop on "Astrophysical Flows and Magnetic Fields," Saltsjöbaden, Sweden, April 18–19, 2001
14. "Cool Stars, Stellar Systems, and the Sun", University of Colorado, Boulder, USA, July 30 – August 3, 2001

Carla Gil (OAC)

1. "THEMIS and the new frontiers of solar atmosphere dynamics", THEMIS conference, Rome, Italy, March 19–21, 2001

Boris Gudiksen (KVA)

1. "Simulations Visualization on the Grid", PDC, Stockholm, Sweden, December 15 – 17, 1999
2. "Physics of Accretion and Associated Outflows", TAC, Copenhagen, Denmark, January 5 – 8, 2000
3. ESMN meeting, Institut for Teoretisk Fysikk, Oslo, Norway, February 29 – March 2, 2000
4. "Recent Insights into the Physics of the Sun and Heliosphere — Highlights from SoHO and Other Space Missions," IAU Symposium 203, at IAU General Assembly, Manchester, UK, August 7–19, 2000

5. Advanced Summer School in Solar Physics, Mullard Space Science Laboratory, London, UK, September 4–8, 2000
6. ESMN mid-term meeting, Santa Cruz, Tenerife, Spain, October 1, 2000
7. Workshop on "Dynamos in the Laboratory, Computer and the Sky," Copenhagen, Denmark, March 15–17, 2001
8. 1-day symposium on "Boiling stars — Convection, radiation, and magnetic fields at stellar surface," Lund, Sweden, April 6, 2001
9. Workshop on "Astrophysical Flows and Magnetic Fields," Saltsjöbaden, Sweden, April 18–19, 2001
10. "Cool Stars stellar and the Sun", University of Colorado, Boulder, USA, July 30 – August 3, 2001
11. "Astronomer's Day 2001", Chalmers University of Technology, Gothenburg, Sweden, November 16–17, 2001
12. "Solar magnetism and related astrophysics", ITP, Santa Barbara, California, USA, January 19–25, 2002

Jack Ireland (ESA/OAC)

1. "THEMIS and the new frontiers of solar atmosphere dynamics", THEMIS conference, Rome, Italy, March 19–21, 2001
2. SOHO Joint Observing Program (JOP) 144, "Sources of coronal oscillations", Kanzelhoehe Solar Observatory, Austria, 5–13 June, 2001
3. "SOHO-11. From Solar Min to Max: Half a Solar Cycle with SOHO" A symposium dedicated to R.M. Bonnet, Davos, Switzerland, March 11–15, 2002

Laura Merenda (IAC)

1. Observing campaign at Observatorio del Teide: July 2001

Karin Muglach (AIP)

1. 8^{th} SOHO Workshop, Paris, France, June 22–25, 1999
2. 11^{th} Cambridge Workshop on "Cool Stars, Stellar Systems and the Sun", Puerto de la Cruz, Tenerife, Spain, October 4–8, 1999
3. Workshop "75 Jahre Einsteinturm – Sonnenforschung in Geschichte und Gegenwart", Potsdam, Germany, December 7–8, 1999
4. Workshop "Helium Line Formation in a Dynamical Solar Atmosphere", Napoli, Italy, April 5–7, 2000
5. "Recent Insights into the Physics of the Sun and Heliosphere — Highlights from SoHO and Other Space Missions", IAU Symposium 203, IAU General Assembly, Manchester, UK, August 7–19, 2000
6. "Advanced Solar Polarimetry — Theory, Observation and Instrumentation", 20th NSO/Sacramento Peak Summer Workshop, Sunspot, New Mexico, September 11–15, 2000
7. International observing campaign, Teide Observatory, Tenerife, September 18–27, 2000

8. ESMN Mid-Term Meeting, Santa Cruz, Tenerife, Spain, September 29–30, 2000
9. "Astrophysical Spectropolarimetry", XIIth Canary Islands Winter School of Astrophysics, Instituto de Astrofísica de Canarias, Tenerife, Spain, November 13–24, 2000
10. GREGOR Meeting, Potsdam, Germany, February 22–23, 2001
11. "THEMIS and the new frontiers of solar atmosphere dynamics", THEMIS conference, Rome, Italy, March 19–21, 2001
12. "MHD Waves in Astrophysical Plasmas", Palma de Mallorca, INTAS Workshop, Palma de Mallorca, Spain, May 9–11, 2001
13. ESMN meeting at ESTEC, Noordwijk, The Netherlands, May 21–22, 2001
14. Observing campaign, Teide Observatory, Tenerife, July 14 – August 5, 2001, including a collaborative visit to the Instituto de Astrofísica de Canarias, Tenerife, Spain
15. "Solar-Terrestrial Magnetic Activity and Space Environment", COSPAR colloquium, Beijing, China, September 10–12, 2001
16. Collaborative visit to the Kiepenheuer Institut für Sonnenphysik Freiburg, Germany, November 8, 2001
17. Collaborative visit to the Naval Reseach Laboratory, Washington DC, USA, November 26–30, 2001
18. Collaborative visit to the Goddard Space Flight Center, Greenbelt, MD, USA, November 29, 2001
19. Collaborative visit to the High Altitude Observatory, Boulder, CO, USA, December 3–4, 2001
20. SOHO 11, Davos, Switzerland, March 11-15, 2002
21. Collaborative visit to the California State University Northridge, Northridge, LA, USA, April 8–14, 2002
22. GREGOR Meeting, Potsdam, Germany, April 25–26, 2002

Eoghan O'Shea (ESA)

1. SOHO observing campaign JOP097, NASA Goddard Space Flight Center, Greenbelt, USA, September 11–25, 2000
2. ESMN Mid-Term Meeting, Santa Cruz, Tenerife, Spain, September 29–30, 2000
3. "Helio- and Asteroseismology at the Dawn of the Millenium', SOHO/GONG workshop, Santa Cruz, Tenerife, Spain, October 2–6, 2000
4. Collaborative visit to the IAC, La Laguna, Tenerife, October 23 – Novermber 10, 2000
5. 'Astrophysical Spectropolarimetry", XIIth Canary Islands Winter School of Astrophysics, Instituto de Astrofísica de Canarias, Tenerife, Spain, November 13–24, 2000
6. Visit to Goddard Space Flight Centre (NASA), Greenbelt, Maryland, U.S.A., as SOHO spacecraft planner (Joint Observing Program 145), 18–28 July, 2001
7. Collaborative trip to and colloquium at the Astrophysical Insitute Potsdam (AIP), 30 August 2001.

Axel Settele (ESA)

1. Collaborative visit to AIP team, Potsdam, Germany, February 4–16, 2002.

Colin Rosenthal (UiO)

1. Collaborative visit to Saltsjöbaden, Sweden, April 10–12, 2000
2. "Recent Insights into the Physics of the Sun and Heliosphere — Highlights from SoHO and Other Space Missions", IAU Symposium 203, IAU General Assembly, Manchester, UK, August 7–19, 2000
3. ESMN Mid-Term Meeting, Santa Cruz, Tenerife, Spain, September 29–30, 2000
4. Collaborative visit to HAO/NCAR, Boulder, USA, February 11–16, 2001
5. ESMN Workshop "Astrophysical Flows and Magnetic Fields", Saltsjöbaden, Sweden, April 18–19, 2001
6. "New Developments in Astrophysical Fluid Dynamics", Caussens, France, June 21–25, 2001

Peter Sütterlin (UU)

1. Nederlandse Astronomenconferentie, Elspeet, The Netherlands, May 6–8, 1999
2. ESMN Summer School on Radiative Transfer and Radiation Hydrodynamics, Oslo, Norway, June 1–11 1999
3. 8^{th} SOHO Workshop, Paris, France, June 22–25, 1999
4. Observing campaign, DOT, Roque de Los Muchachos Observatory, La Palma, Spain, September 10–20, 1999
5. Collaborative trip to AIP, Potsdam, Germany, April 26–29, 2001.
6. Nederlandse Astronomenconferentie, Dalfsen, The Netherlands, May 16–18, 2000
7. Observing campaign, DOT, Roque de Los Muchachos Observatory, La Palma, Spain, June 28 – July 17, 2000
8. "Advanced Solar Polarimetry — Theory, Observation and Instrumentation", 20th NSO/Sacramento Peak Summer Workshop, Sunspot, New Mexico, September 11–15, 2000
9. Observing campaign, DOT, Roque de Los Muchachos Observatory, La Palma, Spain, September 20
10. ESMN Mid-Term Meeting, Santa Cruz, Tenerife, Spain, September 29–30, 2000
11. Observing campaign, THEMIS, Izaña, Tenerife, Spain, October 16–25, 2000
12. Observing campaign, DOT, Roque de Los Muchachos Observatory, La Palma, Spain, October 26 – November 12, 2000
13. "Astrophysical Spectropolarimetry", XIIth Canary Islands Winter School of Astrophysics, Instituto de Astrofísica de Canarias, Tenerife, Spain, November 13–24, 2000
14. Observing campaign, DOT, Roque de Los Muchachos Observatory, La Palma, Spain, November 26 – December 13, 2000
15. "THEMIS and the new frontiers of solar atmosphere dynamics", THEMIS conference, Rome, Italy, March 19–21, 2001

16. Observing campaign, DOT, Roque de Los Muchachos Observatory, La Palma, Spain, February 17–24, 2001
17. DOT Evaluation Committe visit to the DOT, Roque de Los Muchachos Observatory, La Palma, Spain, March 31 – April 4, 2001
18. ESMN workshop, ESTEC, Noordwijk, The Netherlands, May 21–22, 2001
19. Observing campaign, DOT, Roque de Los Muchachos Observatoy, La Palma, Spain, October 4 – November 1, 2001
20. Collaborative visit and invited talk, AIP, Potsdam, Germany, November 11–16, 2001
21. Observating campaign, DOT, Roque de Los Muchachos Observatory, La Palma, Spain, November 20 – December 7, 2001
22. "Solar Magnetism", ESMN-PLATON Spring School, Dwingeloo, The Netherlands, April 2–6, 2002
23. ESMN observing campaign, DOT, Roque de Los Muchachos Observatory, La Palma, Spain, April 20–30, 2002

Kostas Tziotziou (OP)

1. Workshop THEMIS, Meudon, France, December 1–3 1999
2. Collaborative visit to UU, Utrecht, The Netherlands, April 13–18 2000
3. Observing campaign, Teide Observatory, Tenerife, Spain, August 16–21, 2000
4. "The Solar Cycle and Terrestrial Climate", 1st SOLSPA Euroconference, Santa Cruz, Tenerife, Spain, September 25–29, 2000
5. ESMN Mid-Term Meeting, Santa Cruz, Tenerife, Spain, September 29–30, 2000
6. Collaborative visit to the IAC, La Laguna, Tenerife, Spain, October 2–16, 2000
7. MEDOC Prominence Workshop, Orsay, France, October 23–26, 2000
8. "Astrophysical Spectropolarimetry", XIIth Canary Islands Winter School of Astrophysics, Instituto de Astrofísica de Canarias, Tenerife, Spain, November 13–24, 2000
9. Collaborative visit to Athens University Astronomy Department, Athens, Greece, December 19–23, 2000
10. "THEMIS and the new frontiers of solar atmosphere dynamics", THEMIS conference, Rome, Italy, March 19–21, 2001
11. Conference Programme National Soleil Terre, Orsay, France, April 3–5, 2001
12. Collaborative visit to the Athens Observatory, Athens, Greece, June 6–15, 2001
13. 5th Hellenic Astronomical conference, Heraklion, Crete, Greece, September 18–23, 2001
14. "The Solar Cycle and Terrestrial Climate", 2nd SOLSPA Euroconference, Vico Ecquense, Italy, September 24–30, 2001
15. Collaborative visit to the IAC, La Laguna, Tenerife, Spain, October 1–24, 2001
16. Collaborative visit to Ondřejov Observatory, Ondřejov, Czech Republic, January 16–25, 2001
17. Collaborative visit to ITA, Oslo, Norway, February 4–11, 2001

18. Workshop THEMIS, Toulouse, France, April 16–21, 2001

Etienne Vogt (OAC)

1. ESMN Summer School on Radiative Transfer and Radiation Hydrodynamics, Oslo, Norway, June 1–11 1999
2. 9^{th} European Meeting on Solar Physics: Magnetic Fields and Solar Processes, Florence, Italy, September 12–18, 1999
3. Workshop of the "Programme National Soleil-Terre", Nouan Le Fuzelier, France, February 1–3, 2000
4. Collaborative visit to OP, Meudon, France, May 1–28, 2000
5. THEMIS observing campaign, "Non-thermal particles in solar flares" Teide Observatory, Tenerife, Spain, July 12–19, 2000
6. "The Solar Cycle and Terrestrial Climate", 1st SOLSPA Euroconference, Santa Cruz, Tenerife, Spain, September 25–29, 2000
7. ESMN Mid-Term Meeting, Santa Cruz, Tenerife, Spain, September 29–30, 2000
8. "Astrophysical Spectropolarimetry", XIIth Canary Islands Winter School of Astrophysics, Instituto de Astrofísica de Canarias, Tenerife, Spain, November 13–24, 2000
9. Collaborative visit to the IAC, La Laguna, Tenerife, Spain, November 25–30, 2000

Section 3: ESMN PUBLICATIONS

Andretta, V., Jordan, S. D., Muglach, K., Garcia, A., Jones, H. P., Penn, M. J., and Soltau, D.: 1999, “The Helium Spectrum in the Quiet Sun: The January 16/17 and May 7–13, 1997 Coordinated SOHO/Ground-based Observational Campaigns”, 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, 336
- *Andretta: OAC; Muglach: AIP Fellow*
- *Objective (a)*

Andretta, V., Jordan, S. D., Muglach, K., Garcia, A., Jones, H. P., and Soltau, D.: 1998, “Investigating the Formation of the Helium Spectrum in the Solar Atmosphere”, in R. A. Donahue and J. A. Bookbinder (Eds.), *Workshop on Cool Stars, Stellar Systems and the Sun*, Astron. Soc. Pac. Conf. Ser. 154, 559–667
- *Andretta: OAC; Muglach: AIP Fellow*
- *Objective (b)*

Archontis, V. and Dorch, B.: 1999, “A Fast ABC Dynamo”, in A. Ferriz-Mas and M. Nunez (Eds.), *Stellar Dynamos: Non-linearity and Chaotic Flows*, Vol. 178 of *ASP Conf. Ser.*, 1–11
- *Dorch: KVA Fellow*
- *Objectives (b), (f)*

Asplund, M., Carlsson, M., Garcia Perez, A. E., and Kiselman, D.: 2000, “Oxygen Line Formation in 3D Hydrodynamical Model Atmospheres”, *Oxygen Abundances in Old Stars and Implications to Nucleosynthesis and Cosmology, 24th meeting of the IAU, Joint Discussion 8, August 2000, Manchester, England.* 8
- *Carlsson: UIO; Kiselman: KVA*
- *Objective (f)*

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: OAC Fellow*
- *Objective (a)*

Balthasar, H., Collados, M., and Muglach, K.: 2000, “Magnetic Field Oscillations in Sunspots and Active Regions”, in *Helio– and Asteroseismology at the Dawn of the Millenium*, Procs. of SOHO 10/GONG 2000 workshop, ESA SP-464, ESA Publ. Div., ESTEC, Noordwijk, 163–167
- *Balthasar, Muglach (AIP Fellow): AIP; Collados: IAC*
- *Objective (b)*

Balthasar, H., Collados, M., and Muglach, K.: 2000, “Oscillations in a Solar Pore”, *Astronomische Nachrichten* **321**, 121–127
- *Balthasar, Muglach (AIP Fellow): AIP; Collados: IAC*

- *Objectives (a), (b)*
- *Refereed journal*
- *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 μm, 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.
- *Acknowledgement:* This research is part of the TMR–ESMN (European Solar Magnetometry Network) supported by the European Commission. The VTT on Tenerife is operated by the Kiepenheuer-Institut für Sonnenphysik (Germany) in the Spanish Observatorio del Teide of the Instituto de Astrofísica de Canarias. We would like to thank the TRACE instrument team for their help and advice, especially the TRACE operators J. Wolfson, D. Myers and M. Wills-Davey.

Balthasar, H., Martínez Pillet, V., Schleicher, H., and Wöhl, H.: 1998, "Velocity Oscillations in Active Sunspot Groups", *Solar Phys.* **182**, 65–72

- *Balthasar: AIP; Martínez Pillet: IAC*
- *Refereed journal; copy added to Year 1 report*
- *Objective (a)*

Balthasar, H., Sütterlin, P., and Collados, M.: 2001, "Penumbral Finestructure: Need for Larger Telescopes", *Astronomische Nachrichten* **322**, 367–370

- *Balthasar: AIP; Sütterlin: UU Fellow; Collados: IAC*
- *Objective (a), (d)*
- *Refereed journal*
- *Abstract:* We obtained at the same time G-band images at the Dutch Open Telescope (DOT) on La Palma and spectropolarimetric data in the near infrared at the German Vacuum Tower Telescope (VTT) on Tenerife. The spectropolarimetric data show interesting correlations. Bright filaments have a smaller magnetic field strength, and higher Evershed velocities occur in dark structures. This result is in agreement with some previous observations, but also in contradiction to others. However, we suffer from the fact that the resolution limit of the VTT at a wavelength of 1.565 mum corresponding to 400 km. Spatial power spectra derived from the DOT data indicate a typical width of 250 km for the penumbral filaments. Obviously a solar telescope with an aperture of at least 1.5 m is needed to obtain sophisticated results for penumbral structures.
- *Acknowledgement:* One of us (H.B) is very grateful to the colleagues from the Instituto de Astrofísica de Canarias (IAC), especially Dr. L. Bellot Rubio, for the SIR-code and their help with it. We appreciate the assistance of Dr. K. Muglach during the observations and helpful discussions. This research is part of the TMR–ESMN (European Solar Magnetometry Network) supported by the European Commission. The Vacuum Tower Telescope in Tenerife is operated by the Kiepenheuer-Institut für Sonnenphysik

(Germany) in the Spanish Observatorio del Teide of the IAC. The Dutch Open Telescope project is funded by the University of Utrecht, the Netherlands Graduate School for Astronomy NOVA and the Netherlands Organization for Scientific Research NWO; it is operated in the Spanish Observatorio del Roque de los Muchachos of the IAC.

Banerjee, D., O'Shea, E., Doyle, J., Goosens, M., and Fleck, B.: 2001a, "On the Nature of Network Oscillations", in A. Wilson (Ed.), *Helio- and Asteroseismology at the Dawn of the Millenium*, Procs. SOHO 10/GONG 2000 Workshop, ESA SP-464, ESA Publ. Div., ESTEC, Noordwijk, 175–178
- *O'Shea (ESA Fellow) and Fleck: ESA*
- *Objective (b)*

Banerjee, D., O'Shea, E., Doyle, J., and Goossens, M.: 2001b, "Long period oscillations in the inter-plume regions of the Sun", *Astronomy & Astrophysics* **371**, 691–700
- *O'Shea: ESA Fellow*
- *Objective (b)*
- *Refereed journal*
- *Abstract:* We examine long spectral time series of inter-plume lanes observed on the 14th and 15th March 2000 with the Coronal Diagnostic Spectrometer (CDS) on-board SoHO. The observations were obtained in lines over a wide temperature range, from the chromosphere to the corona. The statistical significance of the oscillations was estimated by using a randomisation method. Our observations indicate the presence of compressional waves with periods of 20-50 min or longer, both off-limb and on-disk and up to 70 min further out to at least 25 arcsec off-limb. To our knowledge this is the first time that long period oscillations in the inter-plume regions close to the limb of the Sun have been detected. We interpret these oscillations as outward propagating slow magneto-acoustic waves which may contribute significantly to the heating of the lower corona by compressive dissipation and which may also provide some of the enough energy flux required for the acceleration of the fast solar wind. These slow waves may have been produced at the network boundaries in the coronal hole.
- *Acknowledgement:* We would like to thank the referee for his valuable suggestions. Research at Armagh Observatory is grant-aided by the N. Ireland Dept. of Culture, Arts and Leisure. D. B. wishes to thank the ONDERZOEKSRAAD of K.U. Leuven for a fellowship (F/99/42) and EOS is a member of the European Solar Magnetometry Network (www.astro.su.se/∼dorch/esmn/). We would like to thank the CDS and EIT teams at Goddard Space Flight Center for their help in obtaining the present data. CDS and EIT are part of SOHO, the Solar and Heliospheric Observatory, which is a mission of international cooperation between ESA and NASA. This work was supported by PPARC grant PPA/G/S/1999/00055. The original wavelet software was provided by C. Torrence and G. Compo, and is available at URL: http://paos.colorado.edu/research/wavelets.

Banerjee, D., O'Shea, E., Doyle, J. G., and Goossens, M.: 2001c, "The Nature of Network Oscillations", *Astronomy & Astrophysics* **371**, 1137–1149
- *O'Shea: ESA Fellow*
- *Objective (b)*
- *Refereed journal*

• *Abstract:* We examine time-series of spectral data obtained from the Coronal Diagnostic Spectrometer (CDS) and the Solar Ultraviolet Measurements of Emitted Radiation instrument (SUMER) onboard the Solar Heliospheric Observatory (SOHO) spacecraft, in the period 30-31 July 1996. The observations were obtained in lines, ranging in temperature from 12 000 K to 106 K, covering the low chromosphere to the corona. We report here on a time series analysis, using wavelet methods, of small individual network regions in the quiet Sun. The wavelet analysis allows us to derive the duration as well as the periods of the oscillations. The statistical significance of the oscillations was estimated by using a randomisation method. The oscillations are considered to be due to waves, which are produced in short bursts with coherence times of about 10-20 min. The low chromospheric and transition region lines show intensity and velocity power in the 2–4 mHz range. The coronal line Mg x does not show any statistically significant power in this range. In general, it is thought likely that the chromosphere and possibly the transition region oscillates in response to forcing by the p-modes, but they are also influenced strongly by the presence of magnetic fields. The observed 2-4 mHz network oscillations can thus be interpreted in terms of kink and sausage waves propagating upwards along thin magnetic flux tubes. We perform a linear numerical computation comparing the results with our observations.

Banerjee, D., O'Shea, E., Doyle, J. G., and Goossens, M.: 2001d, "Signatures of very long period waves in the polar coronal holes", *Astronomy & Astrophysics* **380**, L39–L42

• *O'Shea: ESA Fellow*

• *Objective (a)*

• *Refereed journal*

• *Abstract:* We examine long spectral time series of a coronal hole observed on the 7th March 2000 with the Coronal Diagnostic Spectrometer (CDS) on-board SoHO. The observations were obtained in the chromospheric He I, and a series of higher temperature oxygen lines. In this letter we report on the presence of long period oscillations in a polar coronal hole region on the disk. Our observations indicate the presence of compressional waves with periods of 20-30 min or longer.

• *Acknowledgement:* DB wishes to thank the ONDERZOEKSRAAD of K.U. Leuven for a fellowship (F/99/42). EOS is a member of the European Solar Magnetometry Network (www.astro.su.se/∼dorch/esmn/). We would like to thank the CDS and EIT teams at Goddard Space Flight Center for their help in obtaining the present data. CDS and EIT are part of SoHO, the Solar and Heliospheric Observatory, which is a mission of international cooperation between ESA and NASA. Research at Armagh Observatory is grant-aided by the N. Ireland Dept. of Culture, Arts and Leisure. This work was supported by PPARC grant PPA/G/S/1999/00055. The original wavelet software was provided by C. Torrence and G. Compo, and is available at URL: http://paos.colorado.edu/research/wavelets

Bogdan, T. J., Rosenthal, C. S., Carlsson, M., Hansteen, V. H., McMurry, A., Zita, E. J., Johnson, M., J., P.-P. S., McIntosh, S. W., Nordlund, A., Stein, R. F., and Dorch, S. B. F.: 2002, "Waves in sunspots and starspots: The critical role of mode mixing and interference", *Astronomische Nachrichten* , in press

• *Rosenthal: UiO fellow; McIntosh: ESA Fellow; Dorch: KVA Fellow,*

• *Objective (c)*
• *Refereed journal*
• *Abstract:* Time-dependent numerical simulations of of nonlinear wave propagation in a two-dimensional (slab) magnetic field geometry show wave mixing and interference to be important aspects of oscillatory phenomena in starspots and sunspots. Discrete sources located within the umbra generate both fast and slow MHD waves. The latter are compressive acoustic waves which are guided along the magnetic field lines and steepen with increasing height in the spot atmosphere. The former are less compressive, and accelerate rapidly upward through the overlying low-β portion of the umbral photosphere and chromosphere ($\beta \equiv 8\pi p/B^2$). As the fast wave fronts impinge upon the $\beta \approx 1$ penumbral "magnetic canopy" from above, they interfere with the outward-propagating field-guided slow waves, and they also mode convert to (non-magnetic) acoustic-gravity waves as they penetrate into the weak magnetic field region which lies between the penumbral canopy and the base of the surrounding photosphere. In a three-dimensional situation, one expects additional generation, mixing and interference with the torsional Alfvén waves.

Bogdan, T. J., Rosenthal, C. S., Carlsson, M., McIntosh, S., Dorch, B., Hansteen, V., McMurry, A., Nordlund, Å., and Stein, R. F.: 2001, "Wave Propagation in a Magnetized Atmosphere", in *American Geophysical Union, Spring Meeting 2001*, 41
• *Rosenthal (UiO Fellow), Carlsson, Hansteen, McMurry: UiO; Dorch: KVA Fellow,*
• *Objectives (b), (f)*

Brekke, P., Brynildsen, N., Kjeldseth-Moe, O., Maltby, P., and Wilhelm, K.: 2000, "Signatures of Magnetic Reconnection and Observed EUV Emission Line Profiles in An Active Region", *Advances in Space Research* **26**, 457–460
• *Brekke: ESA, Brynildsen, Kjeldseth-Moe, Maltby: UIO*
• *Refereed journal*
• *Objective (b)*

Brekke, P., Kjeldseth-Moe, O., Fredvik, T., Haugan, S. V. H., Tarbell, T. D., and Gurman, J. B.: 1999a, "A Transition Region Eruption Observed with CDS, TRACE and EIT", *American Astronomical Society Meeting* **31**, 918
• *Kjeldseth-Moe, Fredvik: UIO; Brekke, Haugan: ESA*
• *Objective (a)*

Brekke, P., Kjeldseth-Moe, O., Tarbell, T., and Gurman, J.: 1999b, "Jets and Eruptions in the Transition Region Observed with CDS, EIT and TRACE", in *ASP Conf. Ser. 183: High Resolution Solar Physics: Theory, Observations, and Techniques*, 357
• *Kjeldseth-Moe: UIO; Brekke: ESA*
• *Objective (a)*

Brynildsen, N., Brekke, P., Fredvik, T., Haugan, S. V. H., Kjeldseth-Moe, O., Maltby, P., Harrison, R. A., and Wilhelm, K.: 1998a, "SOHO Observations of the Connection Between Line Profile Parameters in Active and Quiet Regions and the Net Red Shift in EUV Emission Lines", *Solar Physics* **181**, 23–50
• *Brynildsen, Fredvik, Kjeldseth-Moe, Maltby: UIO; Brekke, Haugan: ESA*

• *Refereed journal*
• *Objective (a)*

Brynildsen, N., Brekke, P., Haugan, S. V. H., Kjeldseth-Moe, O., and Maltby, P.: 1999a, "EUV Observations of Sunspot Regions with CDS on SOHO", in *ASP Conf. Ser. 184: Third Advances in Solar Physics Euroconference: Magnetic Fields and Oscillations*, 266–270
• *Brynildsen, Kjeldseth-Moe, Maltby: UIO; Brekke, Haugan: ESA*
• *Objective (a)*

Brynildsen, N., Brekke, P., Haugan, S. V. H., Kjeldseth-Moe, O., Maltby, P., and Wikstøl, Ø.: 2000, "Structure and Dynamics in the Atmosphere Above Sunspot Regions", *Advances in Space Research* **25**, 1743–1746
• *Brekke: ESA, Brynildsen, Kjeldseth-Moe, Maltby, Wikstøl : UIO*
• *Refereed journal*
• *Objective (b)*

Brynildsen, N., Maltby, P., Brekke, P., Fredvik, T., Haugan, S. V. H., Kjeldseth-Moe, O., and Wikstol, O.: 1998b, "Flows in Sunspot Plumes Detected with SOHO", *Astrophysical Journal* **504**, L135
• *Brynildsen, Maltby, Fredvik, Kjeldseth-Moe, Wikstol: UIO; Brekke, Haugan: ESA*
• *Refereed journal*
• *Objective (a)*

Brynildsen, N., Maltby, P., Brekke, P., Fredvik, T., Haugan, S. V. H., Kjeldseth-Moe, O., and Wikstol, O.: 1998c, "Flows in Sunspot Plumes Detected with Solar and Heliospheric Observatory", *Astrophysical Journal* **502**, L85
• *Brynildsen, Maltby, Fredvik, Kjeldseth-Moe, Wikstol: UIO; Brekke, Haugan: ESA*
• *Refereed journal*
• *Objective (a)*

Brynildsen, N., Maltby, P., Brekke, P., Haugan, S. V. H., and Kjeldseth-Moe, O.: 1999b, "SOHO Observations of the Structure and Dynamics of Sunspot Region Atmospheres", *Solar Physics* **186**, 141–191
• *Brynildsen, Maltby, Kjeldseth-Moe: UIO; Brekke, Haugan: ESA*
• *Refereed journal*
• *Objective (a)*

Carroll, T., Balthasar, H., Muglach, K., and Nickelt, I.: 2001, "Inversion of Stokes Profiles with Artificial Neural Networks", in *Advanced Solar Polarimetry - Theory, Observation, and Instrumentation*, Procs. of the 20^{th} NSO/SP Summer Workshop, ASP Conf. Ser. Vol. 236, Astronomical Society of the Pacific, 390 Ashton Av., San Francisco, CA, USA, 511–519
• *Muglach: AIP Fellow*
• *Objective (d)*

Carroll, T., Muglach, K., Balthasar, H., and Collados, M.: 2002, "Application of Artificial Neural Networks to Solar Infrared Stokes Spectra", *Il Nuovo Cimento* , in press

- *Carroll, Muglach (AIP Fellow), Balthasar: AIP; Collados: IAC*
- *Refereed journal*
- *Abstract:* In this paper we have for the first time applied the new Stokes inversion approach of using artificial neural networks to measured Stokes data of a solar pore. We have demonstrated that this method is capable to produre the same results as other conventional methods, but at a much faster speed.
- *Acknowledgement:* We would like to thank P. Sütterlin for providing the pore model atmosphere. We would also like to thank our collegues from the IAC for providing the SIR–code, especially L. Bellot Rubio for his help getting started with it. This research is part of the TMR–ESMN (European Solar Magnetometry Network) supported by the European Commission. The VTT on Tenerife is operated by the Kiepenheuer-Institut für Sonnenphysik (Germany) at the Spanish Observatorio del Teide of the Instituto de Astrofísica de Canarias.

Cuadrado, R. A., Poletto, G., Teriaca, L., and Suess, S. T.: 2002, "The fall 2001 polar SOHO-Ulysses quadrature campaign: preliminary results", in A. Wilson (Ed.), *SOHO-11: From Solar Minimum to Maximum*, ESA Special Publication SP-508, Estec, Noordwijk, , in press
- *Aznar Cuadrado: OAC Fellow*
- *Objective (d), (e)*

De Moortel, I., Hood, A., and Ireland, J.: 2002a, "Coronal seismology through wavelet analysis", *Astronomy & Astrophysics* **381**, 311–323
- *Ireland: ESA and OAC Fellow*
- *Objective (a)*
- *Refereed journal*
- *Abstract:* This paper expands on the suggestion of De Moortel & Hood (2000) that it will be possible to infer coronal plasma properties by making a detailed study of the wavelet transform of observed oscillations. TRACE observations, taken on 14 July 1998, of a flare-excited, decaying coronal loop oscillation are used to illustrate the possible applications of wavelet analysis. It is found that a decay exponent n 2 gives the best fit to the double logarithm of the wavelet power, thus suggesting an $e^{\epsilon t^2}$ damping profile for the observed oscillation. Additional examples of transversal loop oscillations, observed by TRACE on 25 October 1999 and 21 March 2001, are analysed and a damping profile of the form $e^{\epsilon t^n}$, with n 0.5 and n 3 respectively, is suggested. It is demonstrated that an $e^{\epsilon t^n}$ damping profile of a decaying oscillation survives the wavelet transform, and that the value of both the decay coefficient ϵ and the exponent n can be extracted by taking a double logarithm of the normalised wavelet power at a given scale. By calculating the wavelet power analytically, it is shown that a sufficient number of oscillations have to be present in the analysed time series to be able to extract the period of the time series and to determine correct values for both the damping coefficient and the decay exponent from the wavelet transform.

De Moortel, I., Hood, A., Ireland, J., and Walsh, R.: 2002b, "Longitudinal intensity oscillations in coronal loops observed with TRACE: II. Discussion of measured parameters", *Solar Physics* , in press
- *Ireland: ESA and OAC fellow*

• *Objective (b)*
• *Refereed journal*
• *Abstract:* In this paper, we give a detailed discussion of the parameters of longitudinal oscillations in coronal loops, described in Paper I. We found a surprising absence of correlations between the measured variables, with the exception of a relation between the estimated damping length and the period of the intensity variations. Only for 2 out of the 38 cases presented in Paper I did we find a significant perturbation in the 195 Å TRACE data. The loops supporting the propagating disturbances were typically stable, quiescent loops and the total luminosity of the analysed structures generally varied by no more than 10 %. The observed density oscillations are unlikely to be flare-driven and are probably caused by an underlying driver exciting the loop footpoints. It was demostrated that the rapid damping of the perturbations could not simply be explained as a consequence of the decreasing intensity along the loops. However, we found that (slightly enhanced) thermal conduction alone could account for the observed damping lengths and wavelengths, and, additionally, explain the correlation between propagation period and damping length.
• *Acknowledgement:* The authors would like to thank the TRACE team for mission operations and assistance with the data analysis. I. De Moortel acknowledges support from the Particle Physics and Research Council. J. Iireland would like to thank the European Solar Magnetometry Network and L'Osservatorio di Astronomica di Capodimonte, Napoli, Italy for their support of this work.

De Moortel, I., Ireland, J., R.W., W., and Hood, A. W.: 2002c, "The detection of 3 & 5 minute period oscillations in coronal loops", *Astronomy & Astrophysics* **287**, L13–16
• *Ireland: ESA and OAC Fellow*
• *Refereed journal*
• *Objective (a)*

De Moortel, I., Ireland, J., Walsh, R., and Hood, A.: 2002d, "Longitudinal intensity oscillations in coronal loops observed with TRACE: I. Overview of measured parameters", *Solar Physics* , in press
• *Ireland: ESA and OAC Fellow*
• *Objective (a)*
• *Refereed journal*
• *Abstract:* In this paper we aim to give a comprehensive overview of geometric and physical properties of longitudinal oscillations in large coronal loops. The 38 examples of propagating disturbances were obtained from the analysis of high cadence, 171 Å TRACE data (JOP 83 & JOP144). The majority of these outward propagating oscillations are found in the footpoints of large diffuse coronal loop structures, close to active regions. The disturbances travel outward with a propagation speed of the order of $v \approx 122 \pm 43$ km/s. The variations in intensity are estimated to be roughly 4.1 ± 1.5 % of the background loop brightness and the propagating disturbances are found to be damped very quickly, typically within 8.9 ± 4.4 Mm along the loop. Using a wavelet analysis, periods of the order of 282 ± 93 seconds are found and the energy flux was estimated as 342 ± 126 ergs/cm^{2}s. We found highly filamentary behaviour in the lower part of the coronal loops and showed that the intensity oscillations can be present for

several consecutive hours, with a more or less constant period. It is evident that the longitudinal oscillations are a widespread, regularly occurring coronal phenomena. A companion paper is devoted to the interpretation and discussion of the results.
• *Acknowledgement:* The authors would like to thank the TRACE team for mission operations and assistance with the data analysis. I. De Moortel acknowledges support from the Particle Physics and Research Council. J. Iireland would like to thank the European Solar Magnetometry Network and L'Osservatorio di Astronomica di Capodimonte, Napoli, Italy for their support of this work.

Deng, Y. Y., Schmieder, B., Engvold, O., DeLuca, E., and Golub, L.: 2000, "Emergence of sheared magnetic flux tubes in an active region observed with the SVST and TRACE", *Solar Physics* **195**, 347–366
• *Engvold: UiOl; Schmieder: OP*
• *Objectives (a), (b)*
• *Refereed journal*
• *Abstract:* The active region NOAA AR 8331 was a target of an international ground-based observational campaign in the Canaries and coordinated with space instruments (TRACE and Yohkoh). We focus our study on observations obtained with the SVST at LaPalma, and with TRACE. On 10 September 1998, arch-filament systems were observed with high spatial and temporal resolution, from the lower to the upper atmosphere of the Sun, during five hours. Flux tubes emerged with increasing shear, which apparently led to energy release and heating in the overlying corona. A model for filament formation by the emergence of U-shaped loops from the subphotosphere, as proposed by Rust and Kumar (1994), is supported by the present observations. The coronal response to these events is visualized by rising, medium-scale loop brightenings. The low-lying X-ray loops show short-lived, bright knots which are thought to result from interaction between different loop systems.

Dittmann, O., Trujillo Bueno, J., Semel, M., and López Ariste, A.: 2001, "Scattering Polarization Observations with the Tenerife Gregory Coudé Telescope", in *Advanced Solar Polarimetry: Theory, Observations and Instrumentation*, Procs. of the 20th Sacramento Peak Summer Workshop, ASP Conference Series, San Francisco, 125–132
• *Dittmann (IAC Fellow), Trujillo Bueno: IAC; Semel: OP*
• *Objectives (a), (d)*

Dorch, B.: 2000, "Aktive stjerner med pletter", *Aktuel Astronomi* **4**, 24–27
• *Dorch: KVA Fellow*
• *Popular science outreach article*

Dorch, B.: 2000a, "Astrophysical MHD Simulation and Visualization", in M. H. Björn Engquist, Lennart Johnsson and F. Short (Eds.), *Simulation and Visualization on the Grid*, Vol. 13 of *Lecture Notes on Computational Science and Engineering*, 209–220
• *Dorch: KVA Fellow*
• *Objective (f)*

Dorch, B.: 2000b, "On the Structure of the Magnetic Field in a Kinematic ABC Flow Dynamo", *Physica Scripta* **61**, 717–722

- *Dorch: KVA Fellow*
- *Objectives (b), (f)*
- *Refereed journal*
- *Abstract:* The kinematic induction equation of MHD is solved numerically in the case of the normal "111" ABC flow using a general staggered mesh method. Careful 3-D visualizations of the topology of the magnetic field reveal that previous conclusions about the modes of operation of this type of kinematic dynamo must be revised. The two known windows of dynamo action at low and high magnetic Reynolds number, correspond to two distinct modes, both relying crucially on the replenishing of the magnetic field near a discontinuity at the beta-type stagnation points in the flow. One of these modes display double magnetic structures that were previously found only to obscure the physics of the dynamo: They turn out, however, to play an important part in the process of amplifying the magnetic field. Invariant properties of the mode in the second magnetic Reynolds number window support the case for the normal ABC flow as a fast dynamo.

Dorch, B., Archontis, V., and Nordlund, Å.: 1999, "3D Simulations of Twisted Flux Ropes", *Astronomy & Astrophysics* **352**, L79–L82

- *Dorch: KVA Fellow*
- *Objectives (b), (f)*
- *Refereed journal*
- *Abstract:* Several numerical simulations of buoyant 2D and 3D twisted flux ropes have been performed. It is found that the apex region of an anchored 3D flux rope behaves similarly to the simpler case of a 2D horizontal twisted flux tube while the overall structure of such a 3D flux rope developes quite differently. Upon emergence a characteristic S-shape of the magnetic field lines is displayed in agreement with observations in soft X-ray.

Dorch, B., Gudiksen, B., Abbett, W., and Nordlund, Å.: 2001, "Flux-loss of buoyant ropes interacting with convective flows", *Astronomy & Astrophysics* **380**, 794–798

- *Dorch: KVA Fellow; Gudiksen: KVA Fellow*,
- *Objectives (b), (f)*
- *Refereed journal*
- *Abstract:* We present 3-d numerical magneto-hydrodynamic simulations of a buoyant, twisted magnetic flux rope embedded in a stratified, solar-like model convection zone. The flux rope is given an initial twist such that it neither kinks nor fragments during its ascent. Moreover, its magnetic energy content with respect to convection is chosen so that the flux rope retains its basic geometry while being deflected from a purely vertical ascent by convective flows. The simulations show that magnetic flux is advected away from the core of the flux rope as it interacts with the convection. The results thus support the idea that the amount of toroidal flux stored at or near the bottom of the solar convection zone may currently be underestimated.
- *Acknowledgement:* BD and BG acknowledges support through an EC-TMR grant to the European Solar Magnetometry Network.

Dorch, B. and Nordlund, Å.: 2000a, "3-D Simulations of Buoyant Magnetic Flux Tubes", *Astronomy & Astrophysics* **353**, 1139

• *Dorch: KVA Fellow*
• *Refereed journal*
• *Objectives (b), (f)*

Dorch, B. and Nordlund, Å.: 2000b, "The solar dynamo: Flux pumping by stratified convection", in *The solar cycle and terrestrial climate*, 1st. SOLSPA Euro-conference (Eds. M. Vázquez and b. Schmieder) ESA SP-436, ESA Publ. Div., ESTEC, Noordwijk, 305–308
• *Dorch: KVA Fellow*
• *Objective (b), (c), (f)*

Dorch, B. and Nordlund, Å.: 2001, "Convective Pumping of Magnetic Fields: On the Flux Storage Problem for Solar-like Dynamos", in *Recent Insights into the Physics of the Sun and Heliosphere — Highlights from SoHO and Other Space Missions*, IAU Symp. 203 (Eds. P. Brekke, B. Fleck and Joe B. Gurman), ASP Conf. Series, 186–188
• *Dorch: KVA Fellow*
• *Objectives (b), (f).*

Dorch, B. and Nordlund, Å.: 2001, "On the transport of magnetic fields by solar-like stratified convection", *Astronomy & Astrophysics* **365**, 562–570
• *Dorch: KVA Fellow*
• *Objective (b), (c), (f)*
• *Refereed journal*
• *Abstract:* The interaction of magnetic fields and stratified convection was studied in the context of the solar and late type stellar dynamos by using numerical 3-d MHD simulations. The topology of stratified asymmetric and over-turning convection enables a pumping mechanism that may render the magnetic flux storage problem obsolete. The inclusion of open boundary conditions leads to a considerable flux loss unless the open boundary is placed close to the physical boundary. Simulations including solar-like latitudinal shear indicates that a toroidal field of several tens of kilo-Gauss may be held down by the pumping mechanism.
• *Acknowledgement:* This work was supported in part by the Danish Research Foundation, through its establishment of the Theoretical Astrophysics Center. Computing time at the UNI•C computing center was provided by the Danish Natural Science Research Council. BD acknowledges support through an EC-TMR grant to the European Solar Magnetometry Network.

Emslie, A. G., Miller, J. A., Vogt, E., Hénoux, J. C., and Sahal-Bréchot, S.: 2000a, "Hα Polarization during a Well-observed Solar Flare: Proton Energetics and Implications for Particle Acceleration Processes", *Astrophysical Journal* **542**, 513–520
• *Vogt: OAC Fellow; Hénoux, Sahal-Bréchot: OP*
• *Objective (b)*
• *Refereed journal*
• *Abstract:* Observations of polarization of chromospheric lines in solar flares can constrain the energy flux in accelerated protons. In this paper, we analyze recently-reported observations of Hα linear polarization obtained during a rather well-observed flare on 1989 june 20. Modeling of the magnitude and orientation of the Hα polarization

provides a constraint on the flux of low energy (> 200 keV) protons, while simultaneous gamma-ray and hard X-ray observations provide constraints on the fluxes of > 10 MeV protons and > 50 keV electrons, respectively. These, plus information on the energetics of the low-temperature and high-temperature thermal emissions, permit evaluation of both the absolute and relative roles of electrons and protons in the flare energy budget. We find that accelerated protons with energies > 200 keV can contain a significant portion of the total energy released during the flare, consistent with a steep extrapolation of the proton spectrum to such relatively low energies. We discuss these results in light of a unified electron/proton stochastic particle acceleration model, and show that the energetics are indeed consistent with this large proton energy content.

Emslie, A. G., Miller, J. A., Vogt, E., Hénoux, J. C., and Sahal-Bréchot, S.: 2000b, "Hα Polarization Observations and Flare Energetics", in *AAS/Solar Physics Division Meeting*, Vol. 32, 0253
- *Vogt: OAC Fellow; Hénoux, Sahal-Bréchot: OP*
- *Objective (b)*

Fludra, A. and Ireland, J.: 2002, "Coronal heating in active regions", in A. Wilson (Ed.), *SOHO-11: From Solar Minimum to Maximum*, ESA Special Publication SP-508, Estec, Noordwijk, , in press
- *Ireland: OAC and ESA Fellow*
- *Objectives (d), (e)*

Foing, B. H., Muglach, K., Wiik, J.-E., Beaufort, T., Orlando, S., Duvet, L., and Desteve, C.: 1998, "Polar Plumes and Streamers from 1994 and 1998 Eclipses", in *Solar Jets and Coronal Plumes*, ESA SP-421
- *Foing: ESA; Muglach: AIP Fellow; Wiik: UiO*
- *Objective (c)*

Fredvik, T., Kjeldseth-Moe, O., Brekke, P., and Haugan, S. V. H.: 1999, "Time Variation of Active Region Loops Observed with CDS on SOHO", *American Astronomical Society Meeting* **31**, 918
- *Fredvik, Kjeldseth-Moe: UIO; Brekke, Haugan: ESA*
- *Objective (a)*

Georgakilas, A., Muglach, K., and Christopoulou, E.: 2002, "UV observations of periodic annular intensity variations propagating around sunspots", *Astrophysical Journal* , in press
- *Muglach: AIP Fellow*
- *Refereed journal*
- *Objective (a)*

Gil, C. S. C.: 2001, "Diagnostic Lines in Stellar Atmospheres", *Master's Thesis, University of Porto*
- *Gil: OAC Fellow*
- *Objective (f)*
- *Master's research done at OAC*

Gudiksen, B. and Nordlund, Å.: 2002, "Bulk heating and slender magnetic loops in the solar corona", *Astrophysical Journal* in press

- *Gudiksen: KVA Fellow*
- *Objectives (b), (f)*
- *Refereed journal*
- *Abstract:* The heating of the solar corona and the puzzle of the slender high reaching magnetic loops seen in observations from the Transition Region And Coronal Explorer (TRACE) has been investigated through 3D numerical simulations, and found to be caused by the well observed plasma flows in the photosphere displacing the footpoints of magnetic loops in a nearly potential configuration. It is found that even the small convective displacements cause magnetic dissipation sufficient to heat the corona to temperatures of the order of a million Kelvin. The heating is intermittent in both space and time—at any one height and time is spans several orders of magnitude, and localized heating causes transonic flows along field lines, which explains the observed non-hydrostatic equilibrium of loops that are bright in emission measure.
- *Acknowledgement:* The work of ÅN was supported in part by the Danish Research Foundation, through its establishment of the Theoretical Astrophysics Center. Computing time at the Center for Parallel Computers, KTH, was provided by the Swedish National Allocations Committee. BG acknowledges support through an EC-TMR grant to the European Solar Magnetometry Network.

Hansen, I., Engvold, O., Schmieder, B., Mein, N., and Mein, P.: 1999, "Bright Rims and Dopplershifts in Hα 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*
- *Objective (a)*

Haugan, S. V. H., Brekke, P., Fredvik, T., Kjeldseth-Moe, O., Wilhelm, K., and Gurman, J. B.: 2000, "Observed Variability and Dynamics of Active Region Loops", in *AAS/Solar Physics Division Meeting*, Vol. 32, 0205

- *Haugan, Brekke: ESA, Fredvik, Kjeldseth-Moe: UIO*
- *Objective (b)*

Heinzel, P., Schmieder, B., and Tziotziou, K.: 2001, "Why Are Solar Filaments More Extended in Extreme-Ultraviolet Lines than in Hα", *Astrophysical Journal Letters* **561**, L223–L227

- *Tziotziou: OP Fellow*
- *Objectives (a),(f)*
- *Refereed journal*
- *Abstract:* A long solar filament was observed simultaneously in the Hα line by THEMIS/MSDP and in selected EUV lines by the Coronal Diagnostic Spectrometer on SOHO. Co-alignment of optical and EUV images reveals that the dark EUV filament is much more extended than the Hα filament. Assuming that the EUV filament represents Lyman continuum absorption of the background EUV-line radiation, a straightforward explanation of this effect is suggested. Based on non-LTE filament models, we demonstrate that the ratio of the Lyman continuum to Hα opacity can

reach a factor of 50-100, and thus the EUV filament is still well visible while the Hα line contrast diminishes below the detection limit. This kind of interpretation leads to an important conclusion that the cool filament material in which the Lyman continuum absorption takes place is more abundant than one would expect from Hα disk observations. This then may have significant consequences on the filament structure and on formation models, as well as on mass considerations related to coronal mass ejections.

• *Acknowledgement:* P. H. thanks A. Gabriel (CDS planner) and the MEDOC staff for their help during the campaign, and B. S. acknowledges the support of the THEMIS staff and of J.-M. Malherbe during her observations. P. H. was supported by CNRS and by grants S-1003006 and A3003902 of the Academy of Sciences of the Czech Republic. K. T. acknowledges support through an EC-TMR grant to the European Solar Magnetometry Network. We thank U. Anzer and the referee for their comments.

Innes, D. E., Inhester, B., Srivastava, N., Brekke, P., Harrison, R. A., Matthews, S. A., Noëns, J. C., Schmieder, B., and Thompson, B. J.: 1999, "Multi-wavelength observations of the onset phase of a coronal mass ejection", *Solar Phys.* **186**, 337–361

• *Brekke: UiO; Schmieder: OP*

• *Refereed journal; copy added to Year 1 report*

• *Objective (a)*

Ireland, J. and De Moortel, I.: 2002, "Application of wavelet analysis to transversal coronal loop oscillations", *Astronomy & Astrophysics* , in press

• *Ireland: ESA and OAC fellow*

• *Objectives (b), (d)*

• *Refereed journal*

• *Abstract:* There as yet remain few examples of well observed, transversal oscillations in coronal loops. Such oscillations have the potential to yield much information on the nature of the solar corona, as demonstrated by the analysis of Nakariakov et al. (1999) of a transversely oscillating loop observed in the TRACE 171Å passband on 14th July, 1998. Their analysis extracts a decaying loop oscillation signal from the data which is then considered in the light of the substantial body of theoretically and computationally derived knowledge of the dynamics of coronal loops. The analysis presented in this paper approaches the reduction of the same dataset using wavelet techniques described by De Moortel & Hood (2000) and De Moortel et al. (2002). The authors show that the value of the decay exponent N in a decaying oscillating time series of the form $\exp(-kt^N)$ is measurable from a wavelet transform of the time series (for some decay constant k and time t). The application of these techniques shows that the value of the decay exponent in the 14th July, 1998 is not well determined by the data, i.e., the associated error is very large. Since the value of the decay exponent implies the presence of particular decay mechanisms and not others, the large error associated with the exponent value implies that a wide range of mechanisms should be considered when discussing the physics behind this event. Comments are also made on the time dependence of the wavelet scale. Two additional examples of transversal coronal loop oscillations are also analysed.

• *Acknowledgement:* JI would like to thank the Solar MHD Group of the University

of St. Andrews, the European Solar Magnetometry Network and L'Osservatorio di Astronomica di Capodimonte, Napoli, Italy for their support of this work.

Jimenez, A., Cortes, T. R., Severino, G., Marmolino, C., and the VIRGO, GOLF, and MDI Teams: 1999, "Phase differences and gains between intensity and velocity low degree acoustic modes measured by SOHO", *Astrophys. J.* **525**, 1042–1055
- *Roca Cortes: IAC; Severino: OAC*
- *Refereed journal; copy added to Year 2 report*
- *Objective (a)*

Kiselman, D. and Dorch, B.: 1999, "Solens Yta", *Ytor på djupet, Naturvetenskapliga forskningsrådets årsbok* 27–38
- *Dorch: KVA Fellow*
- *Objective (e)*
- *Popular science article*

Kiselman, D., Rutten, R., and Plez, B.: 2001, "The formation of G-band bright points I: Standard LTE modelling", in *Recent Insights into the Physics of the Sun and Heliosphere — Highlights from SoHO and Other Space Missions*, IAU Symp. 203, ASP Conf. Series, San Francisco, California, 287–290
- *Kiselman: KVA; Rutten: UU*
- *Objective (a)*

Kjeldseth-Moe, O. and Brekke, P.: 1998, "Time Variability of Active Region Loops Observed with the Coronal Diagnostic Spectrometer (Cds) on SOHO", *Solar Physics* **182**, 73–95
- *Kjeldseth-Moe: UIO; Brekke: ESA*
- *Refereed journal*
- *Objective (a)*

Kjeldseth-Moe, O. and Brekke, P.: 1999, "The Time Variable Solar Atmosphere - Dynamical and Variable Active Region Loops Observed with CDS on SOHO.", in *ASP Conf. Ser. 184: Third Advances in Solar Physics Euroconference: Magnetic Fields and Oscillations*, 286–290
- *Kjeldseth-Moe: UIO; Brekke: ESA*
- *Objective (a)*

Krijger, J. M., Rutten, R. J., Lites, B. W., Straus, T., Shine, R. A., and Tarbell, T. D.: 2001, "Dynamics of the solar chromosphere. III. Ultraviolet brightness oscillations from TRACE", *Astronomy & Astrophysics* **379**, 1052–1082
- *Krijger, Rutten: UU; Straus: OAC*
- *Objective (b)*
- *Refereed journal*
- *Abstract:* We analyze oscillations in the solar atmosphere using image sequences from the Transition Region and Coronal Explorer (TRACE) in three ultraviolet passbands which sample the upper solar photosphere and low chromosphere. We exploit the absence of atmospheric seeing in TRACE data to furnish comprehensive Fourier diagnostics (amplitude maps, phase-difference spectra, spatio-temporal decomposi-

tion) for quiet-Sun network and internetwork areas with excellent sampling statistics. Comparison displays from the ground-based ionCaii H spectrometry that was numerically reproduced by Carlsson & Stein are added to link our results to the acoustic shock dynamics in this simulation. The TRACE image sequences confirm the dichotomy in oscillatory behaviour between network and internetwork and show upward propagation above the cutoff frequency, the onset of acoustic shock formation in the upper photosphere, phase-difference contrast between pseudo-mode ridges and the interridge background, enhanced three-minute modulation aureoles around network patches, a persistent low-intensity background pattern largely made up of internal gravity waves, ubiquitous magnetic flashers, and low-lying magnetic canopies with much low-frequency modulation. The spatio-temporal occurrence pattern of internetwork grains is found to be dominated by acoustic and gravity wave interference. We find no sign of the high-frequency sound waves that have been proposed to heat the quiet chromosphere, but such measurement is hampered by non-simultaneous imaging in different passbands. We also find no signature of particular low-frequency fluxtube waves that have been proposed to heat the network. However, internal gravity waves may play a role in their excitation.
• *Acknowledgement:* We are indebted to T. J. Bogdan, B. Fleck, P. G. Judge, O. V. Khomenko, R. I. Kostik and N. G. Shchukina for comments. J. M. Krijger's research is funded by The Netherlands Organization for Scienti c Research (NWO). The TRACE sequences were taken as part of SOHO Joint Observing Program JOP72 proposed and led by P. G. Judge. J. M. Krijger and R. J. Rutten thank the Leids Kerkhoven Bosscha Fonds for travel support and the Lockheed-Martin Solar and Astrophysics Laboratory at Palo Alto, the High Altitude Observatory at Boulder, the Jurusan Astronomi and Bosscha Observatory of the Institute of Technology Bandung, and their colleagues at these institutions for hospitality. The Utrecht Naples collaboration is part of the European Solar Magnetometry Network supported by the European Commission under contract ERBFMRXCT980190. B. W. Lites acknowledges partial support from NASA Grant W-19.328. Careful reading by referee Dr. W. Curdt improved the paper.

Li, K. J., Schmieder, B., Malherbe, J.-M., Roudier, T., and Wiik, J.-E.: 1998, "Physical properties of the quiescent prominence of 5 June 1996, from Halpha observations", *Solar Phys.* **183**, 323–338
• *Schmieder, Malherbe: OP; Wiik: UiO*
• *Refereed journal; copy added to Year 1 report*
• *Objective (b)*

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: AIP Fellow*
• *Objective (d)*

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*
• *Objective (d)*

McIntosh, S. W., Bogdan, T. J., Cally, P. S., Carlsson, M., Hansteen, V. H., Judge, P. G., Lites, B. W., Peter, H., Rosenthal, C. S., and Tarbell, T. D.: 2001, "An Observational Manifestation of Magnetoatmospheric Waves in Internetwork Regions of the Chromosphere and Transition Region", *Astrophysical Journal Letters* **548**, L237–L241
• *Rosenthal (UiO Fellow), Carlsson, Hansteen: UiO*
• *Objective (b)*
• *Refereed journal*
• *Abstract:* We discuss an observational signature of magnetoatmospheric waves in the chromosphere and transition region away from network magnetic fields. We demonstrate that when the observed quantity, line or continuum emission, is formed under high-β; conditions, where β is the ratio of the plasma and magnetic pressures, we see fluctuations in intensity and line-of-sight (LOS) Doppler velocity consistent with the passage of the magnetoatmospheric waves. Conversely, if the observations form under low-β conditions, the intensity fluctuation is suppressed, but we retain the LOS Doppler velocity fluctuations. We speculate that mode conversion in the $\beta \sim 1$ region is responsible for this change in the observational manifestation of the magnetoatmospheric waves.

Mein, P., Schmieder, B., Malherbe, J.-M., Wiik, J. E., Engvold, O., Brekke, P., Zirker, J. B., Poland, A. I., Delaboudiniere, J. P., and Staiger, J.: 1998, "Velocity Fields of a Filament Region Observed with Ground-Based Telescopes and from SOHO", in *New Perspectives on Solar Prominences*, IAU Symp. 167, Astron. Soc. Pac. Conf. Ser. 150, 135
• *Mein, Schmieder, Malherbe, Delaboudiniere: OP; Wiik, Engvold, Brekke: UiO*
• *Objective (a)*

Muglach, B. F. K., Beaufort, T., Orlando, S., Martens, P., and Desteve, C.: 1998, "Coordinated Eclipse and SOHO Observations on 26 February 1998", in *A Cross-Roads for European Solar and Heliospheric Physics*, ESA SP-417, 337
• *Martens: ESA, Muglach: AIP Fellow*
• *Objective (a)*

Muglach, K.: 2002, "Dynamics of Active Regions Observed with TRACE", *Il Nuovo Cimento* , in press
• *Muglach: AIP Fellow*

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: AIP Fellow; Fleck: ESA*
• *Objective (b)*

Muglach, K., Fleck, B., Schühle, U., Stolpe, F., Foing, B. H., and Wilhelm, K.: 2000, "Dy-

namics of Chromospheric and Transition Region Lines Observed with SOHO/SUMER and the GCT/Tenerife", *Adv. Space Research* **25**, 1731–1734
• *Muglach: AIP Fellow; Fleck, Foing: ESA*
• *Refereed journal; copy added to Year 2 report*
• *Objective (a)*

Muglach, K. and O'Shea, E.: 2001, "Oscillations of Sunspot Umbrae Observed with TRACE and CDS", in *Workshop on MHD waves in Astrophysical Plasmas*, Proceedings of the INTAS Workshop on MHD waves in Astrophysical Plasmas, Universitat de les Illes Baleares, Palma De Mallorca, Spain, 155–158
• *Muglach: AIP Fellow, O'Shea: ESA Fellow*
• *Objectives (a), (b)*

Muglach, K. and Schmidt, W.: 2001, "Height and Dynamics of the Solar Chromosphere at the Limb", *Astronomy & Astrophysics* **379**, 592–600
• *Muglach: AIP Fellow*
• *Objective (b)*
• *Refereed journal*
• *Abstract:* In this paper we present observations of He I 1083.0 nm, He D3 587.6 nm and Hbeta 486.1 nm taken at various positions at the solar limb. We determine and compare the emission of the lines in terms of line-parameters. The height of the chromosphere as seen in the helium lines varies in space and time and reaches values between 1100 and 1800 km above the continuum and is the same for both helium lines within the errors of the measurement. From a time-sequence of slit-spectra of about 23 min we study the oscillation signature of the chromosphere near the solar limb. We find velocity oscillations in He I 1083.0 nm that do not drop to zero near the limb as would be expected of vertically oriented oscillations, we even get horizontal oscillations in the off-limb emission data of both helium lines.
• *Acknowledgement:* The VTT is operated on the island Tenerife by the Kiepenheuer Institut für Sonnenphysik in the Spanish Observatorio del Teide of the Instituto de Astrofisica de Canarias. We would like to thank Louise Harra-Murnion for providing the Yohkoh SXT images. Yohkoh is a mission of the Institute of Space and Astronautical Science of Japan. This research was partially supported by the European Commission through the TMR programme (European Solar Magnetometry Network). We would like to thank H. Balthasar, H. Peter and J. Staude for comments on the manuscript.

Muglach, K. and Sütterlin, P.: 1998, "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: AIP Fellow; Sütterlin: UU Fellow*
• *Objective (a)*

Nordlund, Å., Dorch, B., and Stein, R.: 2000a, "Magnetoconvection and the solar dynamo", in *Cyclical evolution of solar magnetic fields: Advances in theory and observations*, IAU Colloquium 179 (Eds. P. Venkatakrishnan, O. Engvold and A.R. Choudhuri), Journal of Astrophysics and Astronomy 21, Indian Institute of Astrophysics,

Kodaikanal, India, 307–313
• *Dorch: KVA Fellow*
• *Objective (b), (f)*

Nordlund, Å., Dorch, S., and Stein, R.: 2000b, "Magnetoconvection and the Solar Dynamo", *Journal of Astrophysics and Astronomy* **21**, 307
• *Dorch: KVA Fellow*
• *Refereed journal*
• *Objectives (b), (f)*

O'Shea, E., Banerjee, D., Doyle, J. G., Fleck, B., and Murtagh, F.: 2001a, "Active Region Oscillations", *Astronomy & Astrophysics* **368**, 1095–1107
• *O'Shea (ESA Fellow), Fleck: ESA*
• *Objective (b)*
• *Refereed journal*
• *Abstract:* We report here on an investigation of high frequency oscillations in active regions, carried out using high cadence observations of O V 629 Å, Mg IX 368 Å and Fe XVI 325 Å, with the Coronal Diagnostic Spectrometer (cds) on soho. Using the techniques of wavelet analysis on various temporal series datasets, we find that certain oscillation frequencies are favoured for each line. We find furthermore that a ∼5 min oscillation signature is commonly present in all lines, suggesting a coupling of the photospheric driver with the transition region and coronal loop modes. We report on the tendency for higher frequency oscillations to be present at lower intensity values, suggesting that higher frequency oscillations occur in interloop regions or at loop boundaries, possibly as a result of some resonant absorption process. In addition, we find that the coronal lines of Fe XVI and Mg IX show more significant oscillations in the velocity than in the intensity, which suggests that in the velocity we measure additional non-compressive wave modes not visible in the intensity. As this effect is not seen in the transition region line of O V it would seem that these additional non-compressive modes are produced in and limited to the corona. We suggest that there are two main mechanisms responsible for the observed oscillations; either resonant Alfvén and/or fast kink waves or propagating slow magnetoacoustic waves, both present in coronal loops.
• *Acknowledgement:* Research at Armagh Observatory is grant-aided by the Dept. of Education for N. Ireland while partial support for software and hardware is provided by the STARLINK project which is funded by the UK PPARC. Information on the wavelet filtering program, MR/1, may be found at www.multiresolution.com. Wavelet software was provided by C. Torrence and G. Compo, and is available at URL: http://paos.colorado.edu/research/wavelets/. This work was supported by PPARC grant GR/K43315 plus a short-term fellowship to DB from Armagh Observatory. EOS and BF are members of the European Solar Magnetometry Network (www.astro.su.se/∼dorch/esmn/). We would like to thank the CDS team at Goddard Space Flight Center for their help in obtaining the present data. CDS is part of SOHO, the Solar and Heliospheric Observatory, which is a mission of international cooperation between ESA and NASA.

O'Shea, E., Banerjee, D., Doyle, J. G., Fleck, B., and Murtagh, F.: 2001b, "Active

Region Oscillations", in A. Wilson (Ed.), *Helio- and Asteroseismology at the Dawn of the Millenium*, Procs. SOHO 10/GONG 2000 Workshop, ESA SP-464, ESA Publ. Div., ESTEC, Noordwijk, 223–226
• *O'Shea (ESA Fellow) and Fleck: ESA*
• *Objective (b)*

O'Shea, E., Fleck, B., Muglach, K., and Sütterlin, P.: 2001, "Active Region Oscillations: Results from SOHO JOP 097", in *American Geophysical Union, Spring Meeting 2001, abstract #SH41A-02*, 41
• *O'Shea (ESA Fellow), Fleck: ESA; Muglach: AIP Fellow; Sütterlin: UU Fellow*
• *Objective (e)*

O'Shea, E., Muglach, K., and Fleck, B.: 2002a, "Oscillations above sunspots: Evidence for propagating waves?", *Astronomy & Astrophysics* **387**, 642–664
• *O'Shea (ESA Fellow) and Fleck: ESA, Muglach: AIP Fellow*
• *Refereed journal*
• *Abstract:* We present results of an analysis of time series data observed in sunspot umbral regions. The data were obtained in the context of the SOHO Joint Observing Program (JOP) 97 in September 2000. This JOP included the Coronal Diagnostic Spectrometer (CDS) and the Michelson Doppler Imaging (MDI) instrument, both part of SOHO, the TRACE satellite and various ground based observatories. The data was analysed by using both Fourier and wavelet time series analysis techniques. We find that oscillations are present in the umbra at all temperatures investigated, from the temperature minimum as measured by TRACE 1700 Å up to the upper corona as measured by CDS Fe xvi 335 Å (log T=6.4 K). Oscillations are found to be present with frequencies in the range of 5.4 mHz (185s) to 8.9 mHz (112s). Using the techniques of cross-spectral analysis time delays were found between low and high temperature emission suggesting the possibility of both upward and downward wave propagation. It is found that there is typically a good correlation between the oscillations measured at the different emission temperatures, once the time delays are taken into account. We find umbral oscillations both inside and outside of sunspot plume locations which indicates that umbral oscillations can be present irrespective of the presence of these sunspot plumes. We find that a number of oscillation frequencies can exist co-spatially and simultaneously i.e. for one pixel location three different frequencies at 5.40, 7.65 and 8.85 mHz were measured. We investigate the variation of the relative amplitudes of oscillation with temperature and find that there is a tendency for the amplitudes to reach a maximum at the temperature of O iii (and less typically O v and Mg ix) and then to decrease to reach a minimum at the temperature of Mgx (log T=6.0 K), before increasing again at the temperature of Fexvi. We discuss a number of possible theoretical scenarios that might explain these results. From a measurement of propagation speeds we suggest that the oscillations we observe are due to slow magnetoacoustic waves propagating up along the magnetic field lines.
• *Acknowledgement:* We would like to thank the TRACE instrument team and the CDS and MDI instrument teams at Goddard Space Flight Centre for their help in obtaining the data. CDS and MDI are part of SOHO, the Solar and Heliospheric Observatory, which is a project of international cooperation between ESA and NASA.

Original wavelet software was provided by C. Torrence and G. Compo, and is available at URL: http://paos.colorado.edu/research/wavelets/. This research was undertaken as part of the European Solar Magnetometry Network (ESMN) supported by the EU through the TMR programme (http://www.phys.uu.nl/∼rutten/tmr/). We wish to thank Dr. Dipankar Banerjee and Dr. David Berghmans for helpful discussions.

O'Shea, E., Muglach, K., and Fleck, B.: 2002b, "Sunspot Umbral Oscillations: Results from JOP097", in *12th Workshop on Cool Stars, Stellar Systems and the Sun*, , in press

- *Muglach: AIP, O'Shea, Fleck: ESA*
- *Muglach: ESMN YVR AIP, O'Shea: ESMN YVR ESA*

Rosenthal, C., Carlsson, M., Hansteen, V., McMurry, A., Bogdan, T., McIntosh, S., Nordlund, Å., Stein, R., and Dorch, B.: 2001, "Waves in the Magnetised Solar Atmosphere", in *Recent Insights into the Physics of the Sun and Heliosphere — Highlights from SoHO and Other Space Missions*, IAU Symp. 203 (Eds. P. Brekke, B. Fleck and Joe B. Gurman), ASP Conf. Series, San Francisco, California, 170–172

- *Rosenthal (UIO Fellow), Carlsson, Hansteen, McMurry: UiO; Dorch: KVA Fellow*
- *Objectives (a), (f)*

Rosenthal, C. S., Bogdan, T. J., Carlsson, M., Dorch, S. B. F., Hansteen, V., McIntosh, S. W., McMurry, A., Nordlund, ., and Stein, R. F.: 2002, "Waves in the Magnetized Solar Atmosphere I: Basic Processes and Internetwork Oscillations", *Astrophysical Journal* **564**, 508

- *Rosenthal: UiO Fellow; McIntosh: ESA Fellow; Dorch: KVA Fellow*,
- *Objective (c)*
- *Refereed journal*
- *Abstract:* We have modeled numerically the propagation of waves through magnetic structures in a stratified atmosphere. We first simulate the propagation of waves through a number of simple, exemplary field geometries in order to obtain a better insight into the effect of differing field structures on the wave speeds, amplitudes, polarizations, direction of propagation etc. with a view to understanding the wide variety of wave-like and oscillatory processes observed in the solar atmosphere. As a particular example, we then apply the method to oscillations in the chromospheric network and internetwork. We find that, in regions where the field is significantly inclined to the vertical, refraction by the rapidly increasing phase speed of the fast modes results in total internal reflection of the waves at a surface whose altitude is highly variable. We conjecture a relationship between this phenomenon and the observed spatio-temporal intermittancy of the oscillations. By contrast, in regions where the field is close to vertical the waves continue to propagate upward, channeled along the field lines but otherwise largely unaffected by the field.
- *Acknowledgements:* This research was partially supported by the European Commission through the TMR programme (European Solar Magnetometry Network, contract ERBFMRXCT980190) and by the Norwegian Research Council's grant 121076/420, "Modeling of Astrophysical Plasmas". We thank Phil Judge and Egil Leer for reading and commenting on an earlier draft of this paper.

Rosenthal, C. S., Bogdan, T. J., Carlsson, M., Hansteen, V., McIntosh, S., Nordlund, Å., and Stein, R. F.: 2000, "Wave Propagation in the Magnetised Solar Atmosphere", in *IAU Symposium*, Vol. 203,
- *Rosenthal (UiO Fellow), Carlsson, Hansteen: UIO; McIntosh: ESA*
- *Objectives (b), (f)*

Rosenthal, C. S. and Julien, K. A.: 2000, "Numerical Modeling of the Absorption and Scattering of Acoustic Radiation by Sunspots", *The Astrophysical Journal* **532**, 1230–1239
- *Rosenthal: UiO Fellow*
- *Objective (f2)*
- *Refereed journal*
- *Abstract:* We present numerical calculations of the scattering of acoustic-gravity waves by a model sunspot consisting of an inhomogeneous, vertically magnetized region embedded in a polytropically stratified layer. The calculations show the transformation of incoming f-mode and p-mode power into downward-propagating, slow magnetoacoustic waves resulting in substantial absorption of incident f-modes and first-order p-modes and indicating that the slow-mode transformation model is a viable explanation for the observed absorption. In addition to absorption, we find large scattering phase shifts for the f-modes. Phase shifts are small for all p-modes. Coupling between modes of different radial order is generally small. The remaining differences between our results and the observations may constitute evidence that, if the mode transformation picture is correct, real sunspots must deviate significantly from the simple unidirectional field geometry we use here. In particular, we suggest that a sunspot consisting of a bundle of fibrils, in each of which the magnetic flux density increases rapidly with depth, would reproduce more closely the measured strong absorption and scattering of p-modes.
- *Acknowledgement:* C. S. R. acknowledges support from SOI/MDI NASA grant NAG 5-3077 and from the European Commission Training and Mobility of Researchers Programme through the establishment of the European Solar Magnetometry Network (contract FMRX-CT98-0190 DG12MIHT).

Rouppe van der Voort, L. and Krijger, J.: , in press, "Observations of umbral flashes", in *The future of Cool–Star Astrophysics, Proceedings of the 12th Cambridge Workshop on Cool Stars, Stellar Systems and the Sun*, ASP conference series,
- *Rouppe van der Voort: KVA; Krijger: UU*
- *Objective (a)*

Rutten, R. J., Hammerschlag, R. H., Bettonvil, F. M., and Suetterlin, P.: 2000, "Dutch Open Telescope: Status and Prospects", in *AAS/Solar Physics Division Meeting*, Vol. 32, 02107
- *Sütterlin: UU Fellow*
- *Objective (d)*

Rutten, R. J., Hammerschlag, R. H., Sütterlin, P., and Bettonvil, F. C. M.: 2001, "Proxy Magnetometry with the Dutch Open Telescope", in *ASP Conf. Ser. 236: Advanced Solar Polarimetry – Theory, Observation, and Instrumentation*, 25

• *Sütterlin: UU Fellow*
• *Objective (e)*

Rutten, R. J., Hammerschlag, R. H., Sütterlin, P., Bettonvil, F. C. M., and van der Zalm, E. B. J.: 2001, "Solar magnetometry with the Dutch Open Telescope", in A. Wilson (Ed.), *The Solar Cycle and Terrestrial Climate*, Procs. 1st Solar & Space Weather Euroconference, ESA Special Publication SP-463, Estec, Noordwijk, 611–616
• *Sütterlin: UU Fellow*
• *Objective (d)*

Rutten, R. J., Kiselman, D., Rouppe van der Voort, L., and Plez, B.: 2001, "Proxy Magnetometry of the Photosphere: Why are G-Band Bright Points so Bright?", in *ASP Conf. Ser. 236: Advanced Solar Polarimetry – Theory, Observation, and Instrumentation*, 445
• *Rutten: UU; Kiselman, Rouppe van der Voort: KVA*
• *Objectives (a), (d)*

Sütterlin, P.: 2001, "The size of penumbral fine structure", *Astronomy & Astrophysics* **374**, L21–L24
• *Sütterlin: UU Fellow*
• *Objectives (a), (d)*
• *Refereed journal*
• *Abstract:* I present power spectra of penumbral and granular intensity variations from a speckle-restored G-band image sequence of sunspot NOAA 9407 taken on April 1, 2001 with the Dutch Open Telescope on La Palma. I compare spatial power spectra of the sunspot penumbra with spatial power spectra from granulation with and without filigree. Relative to the granular power distribution, the penumbral power spectrum is enhanced over a wide range in spatial frequency peaking at 0.35 arcsec. For smaller scales, the penumbral power distribution closely resembles that of the granular intensity variations. In contrast, the power spectrum of granulation with filigree exhibits increased power down to the resolution limit of 0.22 arcsec, indicating the presence of unresolved magnetic elements.
• *Acknowledgement:* This research is funded by the European Solar Magnetometry Network (ESMN) under EC-TMR contract ERBFMRXCT98019. The DOT project is funded by Utrecht University, the Netherlands Graduate School for Astronomy NOVA and the Netherlands Organization for Scientific Research NWO. The new DOT data acquisition system was built by the Instrumentele Groep Fysica IGF at Utrecht. R.H. Hammerschlag and F.C.M. Bettonvil assisted in the observing. I acknowledge helpful comments from R.J. Rutten and the referee.

Sütterlin, P., Rutten, R. J., and Skomorovsky, V. I.: 2001, "Ba II 4554 Å speckle imaging as solar Doppler diagnostic", *Astronomy & Astrophysics* **378**, 251–256
• *Sütterlin: UU Fellow*
• *Objective (d)*
• *Refereed journal*
• *Abstract:* We present observations testing the Dopplergram capability of a narrow-band (80 mÅ) Lyot filter imaging the solar surface in the wings of the Ba II 4554

Å resonance line in combination with speckle reconstruction to obtain high angular resolution. The Ba II 4554 Å line is found to be an excellent tool for high-resolution Doppler mapping thanks to opacity insensitivity to temperature variations and line-width insensitivity to thermal broadening. The resulting Dopplergrams show concentrated downflows of 1.2-2.2 km;s-1 in intergranular lanes that probably mark magnetic fluxtubes. Two-wavelength profile sampling is found to suffice for high-resolution Dopplergram construction. The filter will be installed as part of a multi-wavelength speckle imaging system on the new Dutch Open Telescope.
• *Acknowledgement:* We are indebted to A. Ludmany for the initial suggestion to try the Irkutsk filter at La Palma, to G.B. Scharmer for allocating SVST telescope time in ESMN context, and to F.C.M. Bettonvil, R.H. Hammerschlag and G.N. Domishev for assistance with the observations. The SVST is operated by the Royal Swedish Academy of Sciences at the Spanish Observatorio del Roque de los Muchachos of the Instituto de Astrofísica de Canarias. P. Sütterlin's research is funded by the European Solar Magnetometry Network (ESMN) under EC–TMR contract ERBFMRXCT98019. Improvement of the barium filter was funded by the Russian Foundation for Basic Researches (grant 00-02-16068-a). The travel of V.I. Skomorovsky and G.N. Domishev to La Palma was funded by SOZOU, NOVA and LKBF. DOT research is funded by NWO, NOVA and Utrecht University.

Sütterlin, P. and Wiehr, E.: 2000, "Applying speckle masking to spectra", *Solar Physics* **194**, 35–42
• *Sütterlin: UU Fellow*
• *Objective (d)*
• *Refereed journal*

Schmidt, W., Muglach, K., and Knölker, M.: 2000, "Free-fall Downflow Observed in He I 1083.0 nm and Hβ", *Astrophysical Journal* **544**, 567–571
• *Muglach: AIP Fellow*
• *Objective (b)*
• *Refereed journal*
• *Abstract:* In a short time-sequence of simultaneously observed slit spectra of He I 1083.0 nm and H beta we find the signature of material flowing toward the solar surface with up to 42 km/s, in addition to material which is almost at rest. The constant acceleration of the moving material is about 200 m/s. These multiple velocities occur in a small region of about 5 arcs in a plage region. We observe a highly dynamical phenomenon which lasts a few minutes. The duration and constant acceleration suggest free fall of matter unobstructed by magnetic structures or along vertical field lines.

Schmieder, B., Aulanier, G., Delannee, C., van Driel-Gesztelyi, L., Simnett, G., and Wiik, J. E.: 2000a, "The relationship between CMEs and prominence eruption from SOHO and Tenerife observations", in *IAU Symposium*, Vol. 203,
• *Wiik: UIO; Schmieder, Aulanier: OP*
• *Objective (b)*

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*
• *Objective (b)*

Schmieder, B., Deng, Y., Mandrini, C. H., Rudawy, P., Nitta, N., Mason, H., Fletcher, L., Martens, P., and Brynildsen, N.: 2000b, “Dynamics in Restructuring Active Regions Observed During Soho/Yohkoh/Gbo Campaigns”, *Advances in Space Research* **25**, 1879–1882
• *Schmieder: OP, Brynildsen: UIO*
• *Refereed journal*
• *Objectives (a), (b)*

Schmieder, B., Engvold, O., Wiik, J. E., and Deluca, E.: 1999b, “Fine Structures and Dynamics of a Filament in EUV lines: SOHO/CDS and SUMER, TRACE”, in J.-C. Vial and B. Kaldeich-Schümann (Eds.), *8th SOHO Workshop: Plasma Dynamics and Diagnostics in the Solar Transition Region and Corona*, Vol. 8, ESA Special Publications 446, 599
• *Engvold, Wiik: UIO; Schmieder: OP*
• *Objective (a)*

Schmieder, B., Kotrc, P., Heinzel, P., Kucera, A., and Andretta, V.: 1999c, “Diagnostics constraints on prominence parameters from SOHO and grounbased 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*
• *Objective (b)*

Schmieder, B., van Driel-Gesztelyi, L., Delannée, C., Simnett, G. M., and Wiik, J. E.: 2001, “The Relationship between CMEs and Prominence Eruptions”, in *IAU Symposium*, Vol. 203, 310
• *Wiik: UIO; Schmieder: OP*
• *Objective (a), (b)*

Settele, A., Sigwarth, M., and Muglach, K.: 2002, “Temporal and spatial variations of the magnetic field vector in sunspots”, *Astronomy & Astrophysics* , in press
• *Settele: ESA Fellow, Muglach: AIP Fellow*
• *Objective (a)*
• *Refereed journal*
• *Abstract:* In order to look for magnetic field vector oscillations in sunspots we used data measured with the Advanced Stokes Polarimeter at the Dunn Solar Telescope. We analyzed two time series of 65 and 110 minutes which were taken by scanning repeatedly a 6.24 x 75$''$ field of view, while obtaining the full Stokes vector in the lines FeI 630.15 nm and 630.25 nm. An inversion was carried out and Fast-Fourier Transform (FFT) analysis were used to find oscillatory phenomena. We discuss possible unwanted effects which lead to apparent magnetic field oscillations and find an aver-

age amplitude of (B, ψ) 5.8 G/0.23° rms by excluding these effects, which also means that only 6% and 22% of the two sunspot umbrae respectively remained for analysis. If we smooth the power spectra over 2×2 pixels, all significant power disappears.
• *Acknowledgement:* The observations and main parts of the data reduction were done during a 3 month stay of AS at Sunspot, Sacramento Peak, NM, USA. It was financed by the NSO via AURA. This research is part of the European Solar Magnetomety Network (ESMN) supported by the EU through the TMR programme and used facilities of the ESA and AIP in this context.

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 ESMN–COMPAQ industrial connection*
• *Objective (d)*

Sobotka, M. and Sütterlin, P.: 2001, "Fine structure in sunspots. IV. Penumbral grains in speckle reconstructed images", *Astronomy & Astrophysics* **380**, 714–718
• *Sütterlin: UU Fellow*
• *Objectives (a), (d)*
• *Refereed journal*
• *Abstract:* The properties of penumbral grains (PGs) in a large regular sunspot are studied from a 70 min sequence of G-band images acquired on 20 September 1999 at the Dutch Open Telescope, La Palma. The frames were processed using the speckle masking algorithm, resulting in an almost diffraction-limited time series (30 s cadence), basically free of atmospheric distortions. Applying feature tracking to a movie of 140 frames yields proper motions, intensities, and lifetimes for a set of 1058 PGs with lifetimes longer than 10 min. About 54% of the PGs move toward the umbra and 46% toward the photosphere. The inward-moving PGs are located mostly in the inner penumbra (up to 0.6 of the distance from the umbra to the photosphere). Their average lifetime and median speed are 50 min and 0.52 km s-1. Most of the outward-moving PGs are observed in the outer penumbra and their average lifetime and median speed are 31 min and 0.75 km s-1. These measurements confirm the previous results published by Sobotka et al. (1999a).
• *Acknowledgement:* The work of M. Sobotka was accomplished under Grant A 3003903 by the Grant Agency of the Academy of Sciences of the Czech Republic (ASCR) and under the Key Project K 2043105 of the ASCR. P. Sütterlin is funded by the European Solar Magnetometry Network (ESMN) under EC-TMR contract ERBFMRXCT98019. The DOT project is funded by Utrecht University, the Netherlands Graduate School for Astronomy NOVA and the Netherlands Organization for Scientific Research NWO.

Straus, T., Deubner, F.-L., Fleck, B., Marmolino, C., Severino, G., and Tarbell, T.: 1998a, "Phase spectra seen from space", in F.-L. Deubner, J. Christensen-Dalsgaard, and D. Kurtz (Eds.), *New Eyes to See inside the Sun and Stars*, IAU Symp. 185, Kluwer,

Dordrecht, 455
• *Straus, Severino: OAC; Fleck: ESA*
• *Objective (b)*

Straus, T., Fleck, B., Severino, G., Deubner, F., Marmolino, C., and Tarbell, T.: 1998b, "k-ω Phase Spectra Obtained from Space", in *A Crossroads for European Solar and Heliospheric Physics*, ESA SP-417, 293
• *Straus, Severino: OAC; Fleck: ESA*
• *Objective (b)*

Straus, T., Severino, G., Deubner, F.-L., Fleck, B., Jefferies, S. M., and Tarbell, T.: 1999, "Observational constraints on models of the solar background spectrum", *Astrophys. J.* **516**, 939–945
• *Straus, Severino: OAC; Fleck: ESA*
• *Refereed journal; copy added to Year 1 report*
• *Objective (c)*

Sütterlin, P., Hammerschlag, R. H., Bettonvil, F. C. M., Rutten, R. J., Skomorovsky, V. I., and Domyshev, G. N.: 2001, "A Multi-Channel Speckle Imaging System for the DOT", in M. Sigwarth (Ed.), *Advanced Solar Polarimetry – Theory, Observation, and Instrumentation*, Procs. 20th NSO/SP Summer Workshop, Astron. Soc. Pacific Conf. Series, Vol. 236, 431–438
• *Sütterlin: UU Fellow*
• *Objective (d)*

Sütterlin, P., Wiehr, E., and Stellmacher, G.: 1999, "Continuum photometry of solar white-light faculae", *Solar Physics* **189**, 57–68
• *Sütterlin: UU Fellow*
• *Objective (d)*
• *Refereed journal*

Trujillo Bueno, J., Degl'Innocenti, E. L., Collados, M., Merenda, L., and Sainz, R. M.: 2002, "Selective Absorption Processes as the Origin of Puzzling Spectral Line Polarization from the Sun", *Nature* **415**, 403–406
• *Merenda: IAC Fellow*
• *Objective (d)*
• *Refereed journal*
• *Abstract:* Magnetic fields play a key role in most astrophysical systems, from the Sun to active galactic nuclei. They can be studied through their effects on atomic energy levels, which produce polarized spectral lines. In particular, anisotropic radiation pumping processes (which send electrons to higher atomic levels) induce population imbalances that are modified by weak magnetic fields. Here we report peculiarly polarized light in the He I 10,830-Å multiplet observed in a coronal filament located at the centre of the solar disk. We show that the polarized light arises from selective absorption from the ground level of the triplet system of helium, and that it implies the presence of magnetic fields of the order of a few gauss that are highly inclined with respect to the solar radius vector. This disproves the common belief that popula-

tion imbalances in long-lived atomic levels are insignificant in the presence of inclined fields with strengths in the gauss range, and opens up a new diagnostic window for the investigation of solar magnetic fields.
• *Acknowledgement:* We thank R. Casini and J. O. Stenflo for discussions on quantum electrodynamics and for helping with the presentation of the Letter. The German Vacuum Tower Telescope is operated by the Kiepenheuer Institut at the Observatorio del Teide of the Instituto de Astrofísica de Canarias (IAC). The Tenerife Infrared Polarimeter (TIP) has been developed by the IAC. We also acknowledge the support of the European Solar Magnetometry Network and of the Spanish Plan Nacional de Astronomía y Astrofísica.

Tziotziou, K., Heinzel, P., Mein, P., and Mein, N.: 2000, "Study of chromospheric CaII cloud-like features", in *The Solar Cycle and Terrestrial Climate*, Procs. of 1st Solar & Space Weather Euroconference, ESA SP–463, ESA Publ. Div., ESTEC, Noordwijk, 443–446
• *Tziotziou: OP Fellow*
• *Objective (f)*

Tziotziou, K., Heinzel, P., Mein, P., and Mein, N.: 2001a, "Non-LTE inversion of chromospheric CaII cloud-like features", *Astronomy & Astrophysics* **366**, 686–698
• *Tziotziou: OP Fellow*
• *Objectives (a), (f)*
• *Refereed journal*
• *Abstract:* A chromospheric cloud like feature observed in the 8542 Å CaII line is studied by a two step inversion procedure which provides estimates of its temperature, electronic density, microturbulence, geometrical thickness and bulk velocity. The first step involves the computation of a large grid of models by a multi-level non-LTE transfer code which gives the CaII line depth-dependent mean intensity inside an isolated, isothermal cloud lying above the chromosphere. The second step involves the inversion of the observed profiles with the grid of computed synthetic CaII profiles. A searching and matching χ^2 algorithm is implemented followed by an interpolation algorithm which permits a more accurate determination of the parameters on which the profiles depend. The five grid parameters are reduced to four by defining the emission measure from the geometrical thickness and electronic density. We show that this inversion procedure gives accurate results for some of our inversion parameters when dealing with solar filaments and is complementary to a previous study of the same object in the Hα line. The main advantages, problems and future extension of the inversion approach are also discussed.
• *Acknowledgement:* MSDP observations were obtained in the framework of the International Observing Time offered by the CCI of the Canarian Observatories and supported by the European Commission through the Access to Large-Scale Facility "Activity of the Human Capital and Mobility Program". The Vakuum-Turm-Teleskop (VTT) is operated on the island of Tenerife by the Kiepenheuer-Institut für Sonnenphysik at the Spanish Observatorio del Teide of the Instituto de Astrofísica de Canarias. PH was supported by the CNRS and by the project K1-003-601 of the Academy of Sciences of the Czech Republic. This research is part of the European

Solar Magnetometry Network supported by the EC through the TMR programme. The authors are grateful to the referee, Dr. J. Bruls for his comments and suggestions.

Tziotziou, K., Mein, N., Mein, P., and Heinzel, P.: 2002a, "Theoretical Hydrogen population relations for horizontal cloud-like structures", in *SOLSPA 2001*, Procs. of the 2nd Solar Cycle and Space Weather Euroconference, ESA SP–477, ESA Publ. Div., ESTEC, Noordwijk, 183–186
- *Tziotziou: OP Fellow*
- *Objective (f)*
- *Acknowledgement:* This research is part of the European Solar Magnetometry Network supported by the EC through the TMR programme.

Tziotziou, K., Mein, P., Tsiropoula, G., and Eibe, M. T.: 2001b, "2D Spectroscopy and science with THEMIS", in *Procs. of the 5th Hellenic Astronomical conference*, e-publication, preprint at http://astrophysics.physics.uoc.gr/conf/
- *Tziotziou: OP Fellow*
- *Objective (a),(b),(f)*
- *Acknowledgement:* THEMIS is a French-Italian telescope operated on the island of Tenerife by CNRS-CNR in the Spanish Observatorio del Teide of the Instituto de Astrofísica de Canarias. This research is part of "Programme d'Actions Intégrées Franco-helleniques PLATON 2001" and the European Solar Magnetometry Network supported by the EC through the TMR programme.

Tziotziou, K., Tsiropoula, G., and Mein, P.: 2002b, "Ca II 8542 Å sunspot oscillations observed with THEMIS", *Astronomy & Astrophysics* **381**, 279–289
- *Tziotziou: OP Fellow*
- *Objectives (a),(b)*
- *Refereed journal*
- *Abstract:* Oscillations in the umbra and the penumbra of an isolated sunspot located near the solar disk centre were investigated. The observations were obtained with the Multichannel Subtractive Double Pass (MSDP) spectrograph operating in the Ca II 8542 Å line and installed at the focus of THEMIS (Tenerife). From the MSDP data, two-dimensional intensity and Doppler shift images were computed at different wavelengths within the line. Intensity and Doppler shift oscillations in the umbra and the penumbra of the sunspot showing up as umbral flashes and penumbral waves were analyzed using a 23 min time series with a cadence of 46 s. The Ca II umbral flash intensity profile shows an emission core in its blue wing. We investigate the relation between umbral flashes and running penumbral waves by a power spectrum analysis which shows a 6 mHz frequency for the standing umbral oscillations (flashes) which are observed only on the upper half part of the umbra. The running penumbral waves propagate with an average phase velocity of 16 km s^{-}1 and their frequency is constant in the penumbra and equal to 3 mHz. Although the time slice images suggest that umbral flashes and running penumbral waves are probably due to the same resonator, the power analysis shows no direct relationship between the two phenomena.
- *Acknowledgement:* We would like to thank all the THEMIS team and especially C. Briand for the efficient help during the observing campaign. This research is part of "Programme d'Actions Intégrées Franco-helleniques PLATON 2001" and the Eu-

ropean Solar Magnetometry Network supported by the EC through the TMR programme.

Vogt, E. and Hénoux, J.-C.: 1999, "Observations of linear polarization in the Hα line during two solar flares", *Astron. Astrophys.* **349**, 283–294
- *Vogt: OAC Fellow; Hénoux: OP*
- *Refereed journal; copy added to Year 2 report*
- *Objective (a)*

Vogt, E., Hénoux, J.-C., and Sahal-Bréchot, S.: 1999, "Impact polarization of the Hα line during solar flares", in K. Nagendra and J. Stenflo (Eds.), *Solar Polarization*, Kluwer Academic Publishers, 431–442
- *Vogt: OAC Fellow; Hénoux, Sahal-Bréchot: OP*
- *Objective (b)*

Vogt, E., Sahal-Bréchot, S., and Bommier, V.: 2001, "Polarization of the hydrogen Hα line in solar flares. Contribution of the local polarized radiation field and effect of the spectral index of the proton energy distribution", *Astronomy & Astrophysics* **374**, 1127–1134
- *Vogt: OAC Fellow; Sahal-Bréchot, Bommier: OP*
- *Objective (b)*
- *Refereed journal*
- *Abstract:* Linear polarization of the hydrogen Halpha line was observed during solar flares. The polarization vector is directed towards disk center and its degree is of the order of 5%. The best explanation for this polarization is anisotropic collisional excitation of the n = 3 level of hydrogen by vertical beams of protons with an energy greater than a few keV. However, previous calculations gave an expected polarization degree of 2.5% or less, a factor of two below the observations. In this paper, the theoretical model for the formation of the line polarization has been refined, including the effect of polarization in the local radiation field that is created by hydrogen proton anisotropic excitation. We have also increased the spectral index of the proton energy distribution from 4 to 5, giving more weight to the low energy protons which are the most efficient for impact polarization, without ionizing the atmosphere too much. It is found that the inclusion of the polarization of the local radiation field does not increase the Halpha polarization very significantly; however, going from a spectral index of 4 to 5 results in an expected polarization degree of 4.5%, compatible with the observations.
- *Acknowledgement:* Part of this work was done in the frame of the European Solar Magnetometry Network (ESMN) which is funded by the European Commission through a TMR grant.

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*
- *Refereed journal; copy added to Year 2 report*
- *Objective (b)*

Williams, D., Phillips, K., Rudawy, P., Mathioudakis, M., Gallagher, P., O'Shea, E., Keenan, F., Read, P., and Rompolt, B.: 2001, "High-frequency oscillations in a solar active region coronal loop", *Monthly Notices of Royal Astron. Soc.* **326**, 428–436

- *O'Shea: ESA Fellow*
- *Refereed journal*
- *Objective (a)*