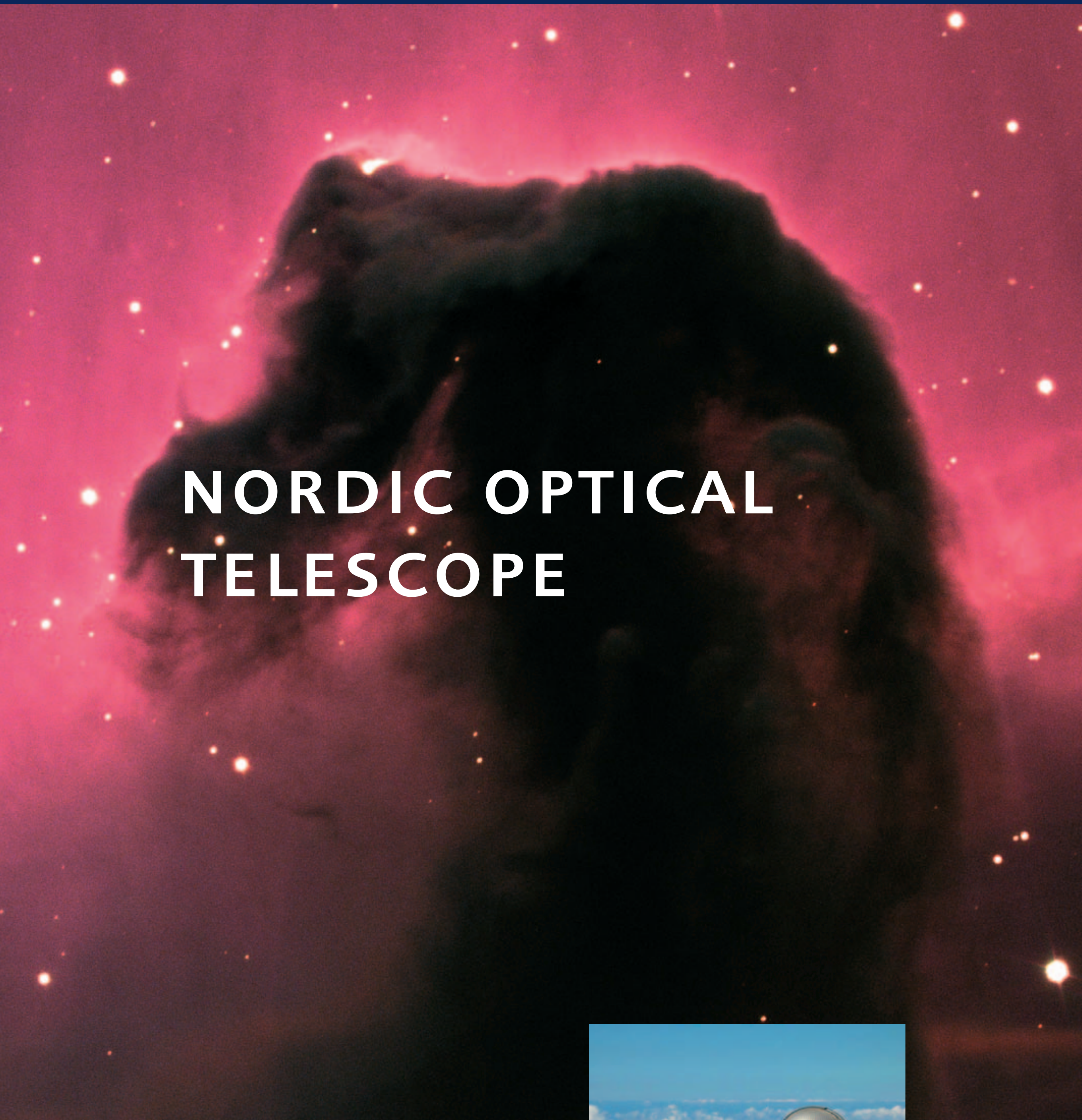
2004

ANNUAL REPORT

NORDIC OPTICAL TELESCOPE



The Horsehead Nebula in Orion.

NOT in summer, looking north.

Front cover: The Horsehead Nebula in Orion. Composite image in blue, yellow, and red light taken with ALFOSC.
Photo: M. Gålfalk, Stockholm University

NORDIC OPTICAL TELESCOPE

The Nordic Optical Telescope (NOT) is a modern, well-equipped 2.5-m telescope located at the Spanish Observatorio del Roque de los Muchachos on the island of La Palma, Canarias, Spain. It is operated for the benefit of Nordic astronomy by the Nordic Optical Telescope Scientific Association (NOTSA), established by the national Research Councils of Denmark, Finland, Norway, and Sweden, and the University of Iceland.

The governing body of NOTSA is the Council, which determines overall policies, approves the annual budgets and accounts, and appoints the Director and Astronomer-in-Charge. A **Scientific and Technical Committee** (STC) advises the Council on the performance and plans for the telescope and other scientific and technical policy matters.

An international **Observing Programmes Committee** (OPC) of independent, experienced scientists, appointed by the Council, performs peer review and scientific ranking of the observing proposals submitted. Each member has a substitute to broaden the scientific basis for the review, ensure that a full OPC can always meet, and resolve any potential conflicts of interest. Based on the ranking by the OPC, the Director prepares the actual observing schedule.

The **Director** has overall responsibility for the operations of the NOT, including staffing, financial matters, external relations, and long-term planning. The staff on La Palma is led by the **Astronomer-in-Charge**, who has authority to deal with all local and urgent matters related to the operation of NOT.

The composition of the Council and committees in 2004 is listed at the end of this report. Contact information to NOT itself is also provided there.

The Annual Reports for 2002-2004 are also available at:
http://www.not.iac.es/news/reports/

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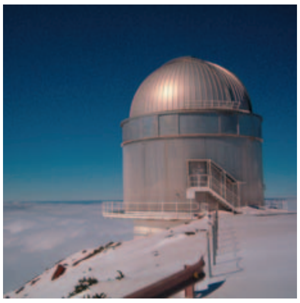

The ring nebula in Lyra.
Photo: W. Nowotny

Editor: Johannes Andersen
Layout: Anne Marie Brammer

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OUR STAFF

The NOT team mourns the loss of System Manager Markku Verkkoniemi, on October 19, 2004 (see next page). Amanda Kaas (now Djupvik) was on maternity leave June 2004 – June 2005. NOT students Silva and Arto Järvinen returned to Finland in the summer, to be replaced by Brian Krog, Denmark, Raine Karjalainen and Jyri Näränen, Finland, and Karl Torstensson, Sweden. Finally, Dr. Wang Xunhao returned to China, in October. The resulting NOT team in 2004 is presented below.

In accordance with the international agreements on the Canarian observatories, NOTSA also provided stipends for Spanish Ph.D. students Miguel de Val Borro at Stockholm University and Antonio López Merino, Copenhagen, in 2004.

Francisco Armas
Administrator

Thomas Augusteijn
Astronomer-in-Charge

Peter Brandt
Mechanic

Jacob W. Clasen
Software specialist

Graham Cox
Electronics engineer

Amanda Djupvik
Senior Staff Astronomer

Loida Fernández
Secretary

Eva Jurlander
Accountant

Raine Karjalainen
Ph.D. student

Brian Krog
Ph.D. student

Jyri Näränen
Ph.D. student

Carlos Pérez
Electronics technician

Saskia Prins
Data flow scientist

Tapio Pursimo
Staff astronomer

Eric Stempels
Instrument specialist

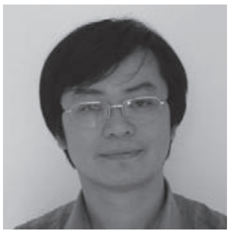
Peter M. Sørensen
Software specialist

Ingvar Svärdh
Software engineer

John Telting
Staff astronomer

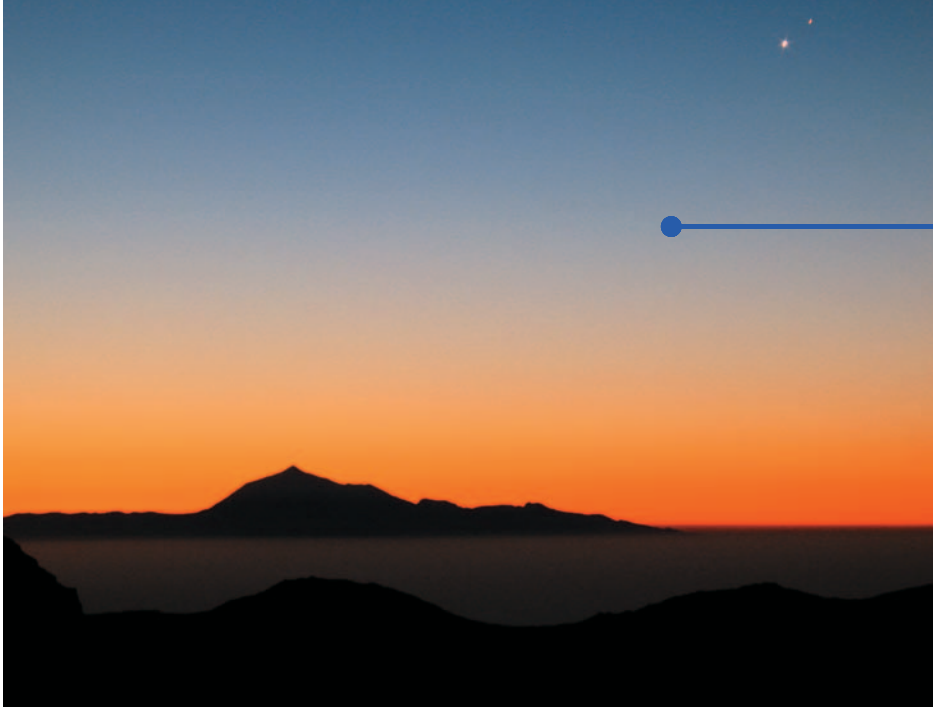
Karl Torstensson
Ph.D. student

Markku Verkkoniemi
System manager



Wang Xunhao
Visiting scientist

PREFACE



Dawn over Teide, with Venus and Mercury.

The Editor/Director.

2004 was a good, but also sad year at NOT. Much progress happened and takes up most of this report. But we on the staff are still recovering from the shock of losing our friend and colleague Markku Verkkoniemi in a road accident on October 19, at the age of only 42.

Markku was an expert on computers and software, a wonderful colleague and friend, a devoted husband and father, and a very careful driver. How his car could veer off the road on the way to the observatory and fall into one of the many deep ravines on La Palma remains a mystery despite very thorough investigations. No trace of any technical or medical problem has been found, nor any sign of any external cause for the accident. All that remains for us is to remember his excellent work, quiet humour, and keen interest in all aspects of life, and to send every good wish to his wife Cata and daughter Clara as they prepare to continue their lives without him. I thank all staff members and their families, who did all they could to soften the blow when it fell.

But life must go on, and the year began so well. Perhaps the most tangible improvement was the expansion and renovation of our Sea Level Office. The floor space almost doubled, and we now have proper air conditioning. Not only are working conditions for the staff now satisfactory, but we could also increase our NOT student team to four. This proved to be a great success as they now form a real team, exchanging professional and social experience between themselves and with the British and Italian students on La Palma (meet them in person on p. 20).

As regards our telescope, instrument, and services, 2004 saw steady progress and consolidation rather than major milestones. The payoffs will occur in terms of improved quality and efficiency of the observations from 2005, when we also expect new major instruments to enter service (see p. 4).

Activities within the OPTICON consortium ramped up quickly from January 1, 2004, although the I3 contract was formally signed in April and the first payments only arrived in October. In particular, the trans-national access programme was a success from day 1, and NOT saw strong demand from outside users from the start. Overall, the programme was so successful that we could easily spend all the funding in half of the five-year contract period. See more about OPTICON on p. 5.

In 2004, we also began to review the long-term scientific strategy for NOT, in the context of current developments in astronomy and in Europe. New large telescopes have entered the scene in force, and even larger ones are on the drawing board. Finland has joined ESO, and Spain is expected to follow shortly. Many new countries have joined the EU, and pan-European collaboration is rapidly expanding, encouraged by the EC. Thus, NOT is gradually turning into an instrument in the European orchestra and a gateway for Nordic astronomers to the international scene, rather than a standalone operation. In fact, NOT already fills this role quite successfully (see p. 22), and we look forward with confidence to developing it further and broaden its scope.

The following pages describe the main events and highlight a few of the many scientific results from NOT in 2004. I thank the contributors of the individual science reports, and apologise for any mistakes that may have occurred during the editing process. Unsigned text is by the Editor. The layout of the report is again due to Anne Marie Brammer; and Magnus Gålfalk, Stockholm University, contributed several beautiful images from NOT, including the cover photos photos (as in 2003) and the one above; I thank them both.

MAIN EVENTS

The activities at NOT in 2004 could fill a book; only the more salient developments can be summarised here. Up-to-date information is maintained at our newly redesigned web site, *http://www.not.iac.es*.

Staff

The Preface paid tribute to our late System Manager Markku Verkkoniemi; it is not repeated here, but cannot be forgotten. New safety measures are being implemented as a result of this accident. Amanda Kaas took maternity leave in June; we look forward to welcome her back in 2005 with her charming young daughter and her old family name, Djupvik. We are also glad to have Peter Brandt back in full swing after a long battle with a serious infection. NOT students Silva and Arto Järvinen returned to Finland, then joined the swelling Nordic ranks at the Astrophysical Institute in Potsdam. During the summer, they were replaced by Brian Krog, Denmark, Raine Karjalainen and Jyri Näränen, Finland, and Karl Torstensson, Sweden, whom you can meet on p. 20. Finally, Visiting Astronomer Wang Xunhao returned in October to Yunnan, China, leaving behind many friends and, we hope, the start of a fruitful collaboration between Nordic and Chinese astronomers.

Facilities

Over the summer and early autumn, the expansion of our Sea Level Office was finally completed. For the first time in years, the staff now works in uncrowded, properly ventilated offices, and a large room doubles as student office and coffee/meeting room. One office is sublet to the Mercator group, who already collaborates with some of our staff, but we still have a margin for accommodating a visitor or two. Having our own restrooms, kitchen, and storage space completes what is now a comfortable and efficient workplace. Our second serious bottleneck, the slow and unreliable network connection, will be attacked in 2005.

Services

The option of service observing, flexibly scheduled and executed by our staff, is becoming increasingly popular. At the end of the year, it was decided to supplement this by a "fast-track" proposal option where short projects, requiring only a few hours of observing time, are received on a running basis and, if approved, executed in service mode in a matter of weeks; this service starts in April 2005. A simple system of *Observing Blocks* has been implemented to ensure that the observations are just what the P.I. wanted. In parallel, our proposal processing system is being developed into an actual project management system, which delivers automatic e-mail receipt for submitted proposals, generates and maintains the on-line observing schedule, reminds observers of their impending observing run and the specified instrument set-up, tracks any problems during the run, and may eventually also link to publications from the project.

The Dumbbell Nebula. Photo: J. Näränen, K. Torstensson

Telescope and instrumentation

The telescope performed reliably throughout the year, again with negligible technical down time. This is in part due to the completion and replenishment of our inventory of spare parts, and to the programme of preventive maintenance now in place. The crucial cooling system, which maintains the telescope enclosure at night-time temperature during the day and removes excess heat from the electronics, began to show its age and needed a disproportionate effort in maintenance. Replacing it by a simpler and more energy efficient unit was approved and well under way by the end of the year. At the same time, the rotating seal at the centre of the building was modified to accommodate more signal cables and the fibre feed to FIES (see below).

Renewal of the **telescope control system (TCS)** to modern, maintainable standards is a major project that has been under way for some years. The development was finished in 2004, and the new TCS will be commissioned in 2005. A new, more sensitive guide camera was ordered; it will significantly increase the number of available guide stars. Design of the **sequencer script system** for integrated control of the telescope, instruments, and detectors made good progress, as did the implementation of uniform data file headers complying with modern standards.

The imager/spectrograph **ALFOSC** remains the main workhorse of NOT and worked reliably throughout the year. The filter wheel motions of the near-infrared camera/spectrograph **NOTCam** caused trouble again, but a focus pyramid was installed, the low-resolution spectroscopic mode of NOTCam was commissioned, and the focus mechanism was modified to allow use of the high-resolution camera also in high-resolution spectroscopic mode.

Progress on the fiber-coupled échelle spectrograph **FIES** was excruciatingly slow in 2004, due to administrative delays in obtaining the necessary building permit. It finally materialised at the turn of the year, enabling us to make new progress in spring 2005. Prototypes of the observing and pipeline data reduction software of FIES have already been completed and are being tested.

Organisational matters

2004 also brought clarification of some long-standing ambiguities in the legal status of NOTSA and its staff, both in Sweden and on La Palma. In Sweden, only a formal update of the NOTSA Agreement from 1997 is needed; this is now under way. On La Palma, new Spanish contracts have been signed with all staff concerned as of January 1, 2005; this should settle all outstanding issues in a definitive manner. The financial implications are covered for 2005, but will require further work as regards the following years.

The OPTICON I3 project

Progress in the EC-funded *Infrastructure Co-ordination Network* OPTICON is described in earlier reports, and the 19.2 MEuro awarded in August 2003 to the OPTICON *Integrated Infrastructure Initiative (I3)* project under Framework Programme 6 was noted last year. Negotiation of the 500+-page contract lasted until April 2004, however, and the first payments arrived only in October(!). Yet, work began soon after January 1, 2004, the formal starting date of the contract, on the most of the activities of the project. In brief, they are:

1: The *Trans-National Access Programme,* which gives all European astronomers access to most European 2-4-m night-time telescopes and four solar telescopes (see the map) through the normal proposal and review procedures. Approved projects from outside the owner communities receive travel support, and a User Fee is paid to the telescope operator. The programme was an instant success – not least at NOT – and additional criteria had to be introduced to stretch the funding through the five years of the contract.

2: *Networking activities,* which promote contacts and coordination between European communities with common interests, e.g., the science case for a future European Large Telescope; UV astronomy; Virtual Observatories; optical-IR interferometry, and ground-space project coordination.

3: *Joint Research Activities,* which support the cooperated development of front-line technologies for European astronomy. Examples are next-generation adaptive optics; fast optical and infrared wavefront sensors; user-friendly interferometers; high-speed detector systems; and 'smart focal planes' for innovative use of large telescopes.

The success of OPTICON in promoting cooperation in European optical/IR astronomy, despite considerable initial scepticism, is truly impressive and inspires to proceed to the next higher level. NOTSA is enthusiastic and privileged to serve as a link between the Nordic communities and this exciting enterprise. For more information, see *http://www.astro-optocon.org* .

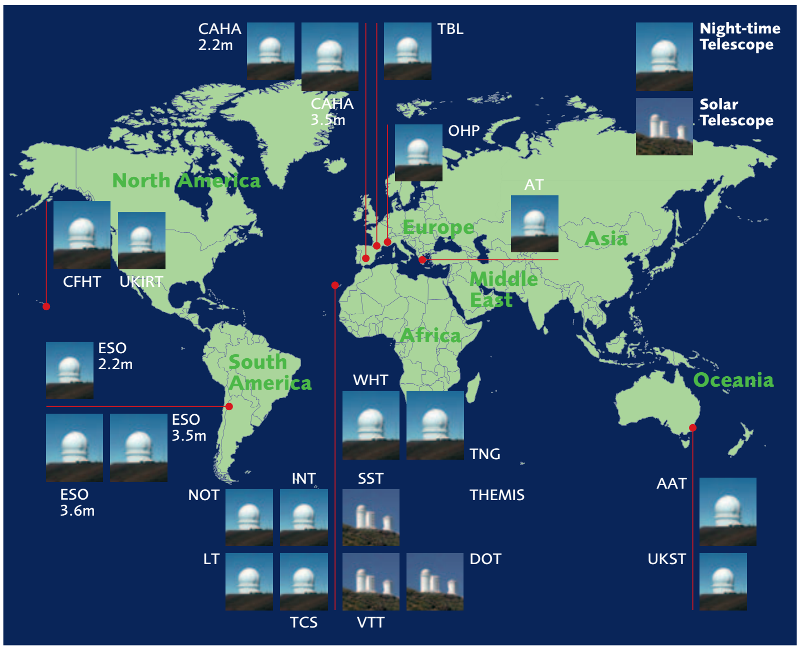
The long-term future

The international agreements that established the observatory on La Palma in 1979 expire in 2009. International and Nordic astronomy, and Europe itself, have changed beyond recognition during that time, and we must take stock of this when planning for the next quarter-century.

The ESO *Very Large Telescope* has made Europe a leader in ground-based astronomy. After Finland's entry in ESO, most NOT users now have access to superb 8-m telescopes with adaptive optics and instruments that are vastly beyond NOT's capabilities. New facilities in space and on the ground, such as ALMA, will soon appear to claim the attention of a roughly constant number of astronomers. Clearly, in the future the demand from our users will be for quality rather than quantity of access to telescopes such as NOT.

Nevertheless, the sky remains round, and also Europeans need to observe the northern hemisphere. We are led to consider a future in which NOT is integrated in a larger, scientifically more powerful and operationally more cost-effective northern facility with a broader European user base. The natural partners in such an enterprise are our British and Italian neighbours and friends on La Palma itself, where both telescopes, instruments, and staff can be readily shared if the will exists. A more specific plan for how this can be achieved was developed towards the end of the year and will be further discussed in 2005. Stay tuned!

The OPTICON Trans-National Telescope Network.



SCIENCE HIGHLIGHTS

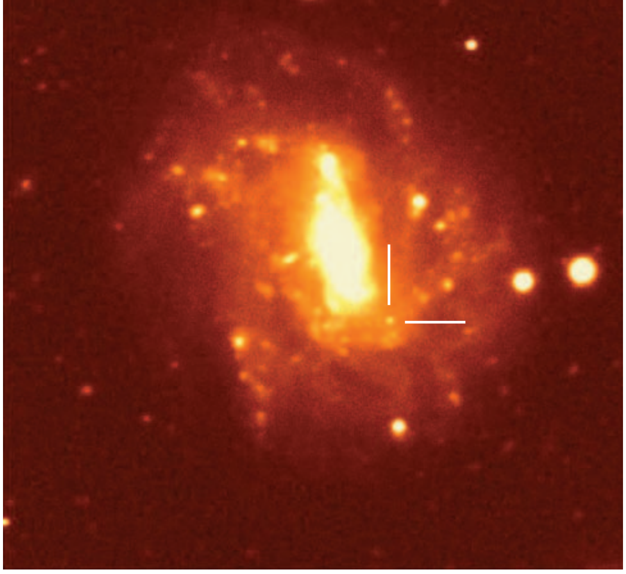


Fig. 1. SN 2003du in the galaxy UGC 9391, over a year after the explosion (see the report for 2003, p. 6).

A selection of scientific results from NOT in 2004 is described in the following. Texts were contributed by the author(s) listed under each, but have been edited to a roughly uniform format by the Editor. Publications in 2004 based on NOT data are listed separately on p. 29.

COSMOLOGY AND FORMATION AND EVOLUTION OF GALAXIES

Dark energy and dark matter appear to dominate the formation and evolution of the Universe; understanding their nature – so far a complete mystery – is a key goal of observational cosmology. Galaxies are the visible building blocks of the Universe and provide the tool – light – by which we study the rest, although they account for only 3-4% of the total. Thus, understanding how galaxies formed and evolved is a central field of modern astrophysics.

Using supernovae to understand the nature of the Universe

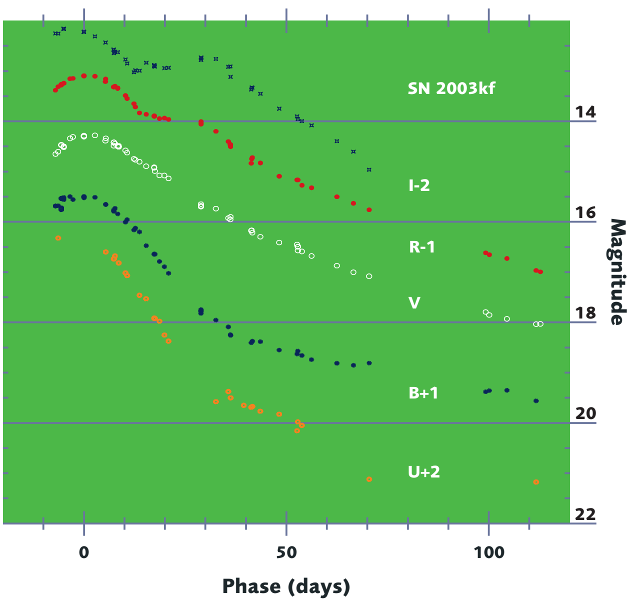
Just a few years ago, observational cosmology experienced a dramatic paradigm shift: Measurements of the brightness of very distant type Ia supernovae (SNe Ia for short) indicated that the expansion rate of the universe is increasing with time. This acceleration of the expansion of the universe requires the existence of a 'dark energy' component, corresponding to about 70% of the total mass of the universe, to overcome the gravitational self-attraction of matter. A leading contender is the vacuum energy density associated with Einstein's famous *cosmological constant* (Λ), but current particle physics theory overpredicts its magnitude by a phenomenal amount.

Understanding the nature of dark energy, and whether it is constant or evolving with time, is among the most fundamental questions in contemporary science. The resolution of this issue is likely to have an impact on whether and how General Relativity and Quantum Mechanics may be merged into one all-encompassing theory of Quantum Gravity.

The observational evidence for dark energy from SNe Ia is still relatively subtle: Very distant supernovae appear about 25% fainter than they would without it. Detailed knowledge of the nature of the supernovae is needed to interpret the measured brightness of these objects and derive their distances correctly. However, progress is slow, due to our limited knowledge of the physics of the explosions of SNe Ia. To remedy this handicap, a European network of leading theorists and observers (the European Supernova Collaboration, ESC) has set out on a careful, detailed study of SNe Ia in relatively nearby galaxies. NOT is one of the key telescopes in this campaign and has produced detailed multicolour images and spectra for over 15 months after the explosions of supernovae such as SN2003du and SN2003kf (see figures).

A breakthrough in our understanding of the physics of SNe Ia will require realistic models of the thermonuclear explosions and the emerging radiation. These must be combined with complete and detailed sets of observations of bright nearby SNe Ia in order to constrain the model parameters. Since 2002, the ESC has obtained high-quality optical and IR observations on about a dozen such SNe Ia. The analysis of these observations is under way in several groups. First results of modelling the spectra of SN 2002bo have already been published (Benetti et al. 2004); a complete analysis of the data by the novel *Abundance Tomography* technique is finished (Stehle et al. 2004, astro-ph/0409342), and a number of papers on the data and detailed modelling of other SNe are in preparation.

A. Goobar, Stockholm, and collaborators



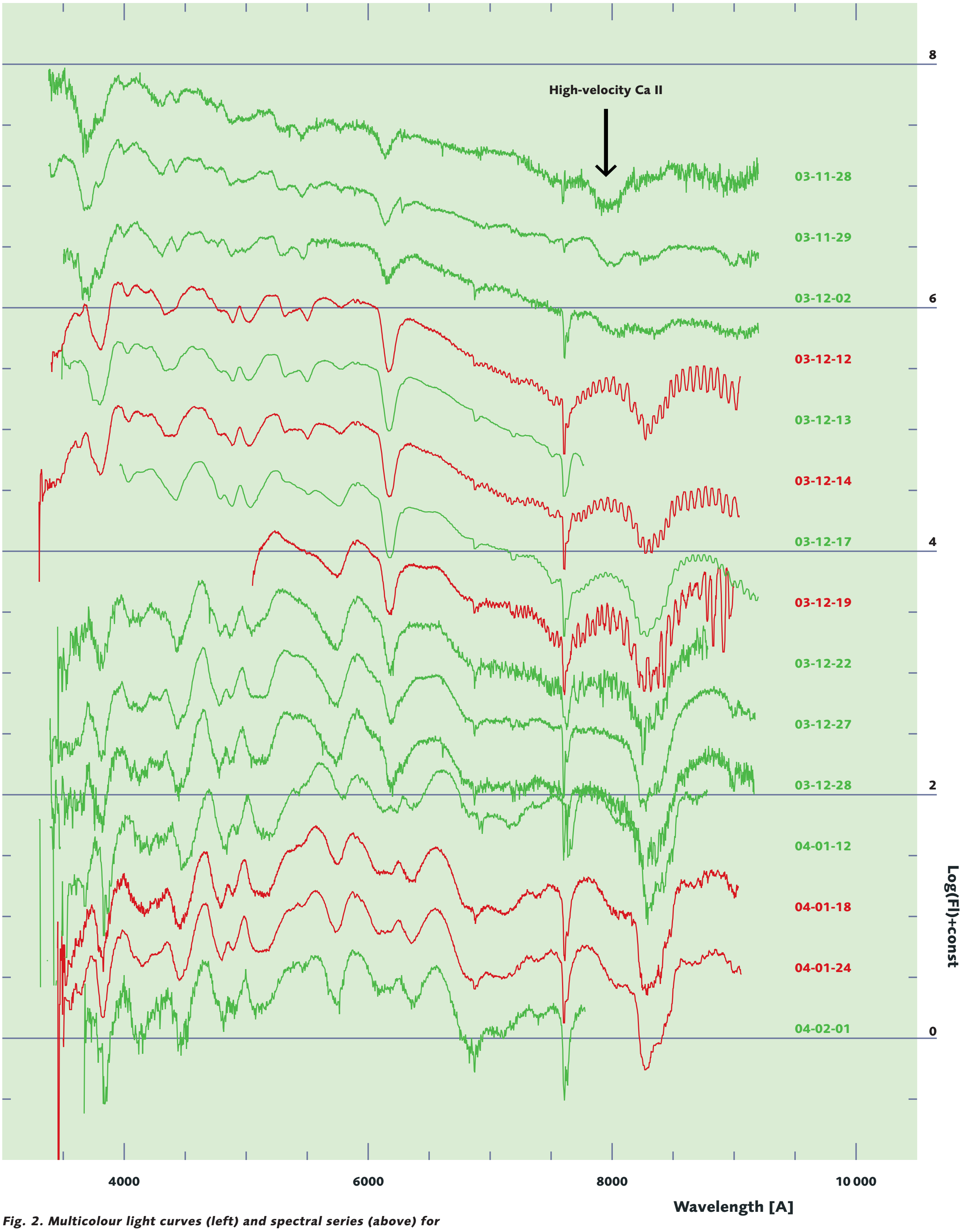


Fig. 2. Multicolour light curves (left) and spectral series (above) for the nearby SN Ia SN 2003kf. The spectra drawn in red are from NOT/ALFOSC. The spectra reveal the complex changes in physical conditions and chemical composition of the visible ejecta from the explosion. In particular, the newly-discovered high-velocity emission of ionized calcium in the pre-maximum spectra (top) gives new insight in the details of the explosion mechanism.

The NOT Gamma Ray Burst programme

Gamma Ray Bursts (GRBs) – bursts of energetic gamma rays from the universe, lasting from a second or less to a few minutes – remained a mystery for over thirty years. The first detection of an Optical Afterglow (OA) in 1997 finally proved that long-duration GRBs are of extragalactic origin. Further, the identification of a bright type Ic supernova with GRB 030329 provided a firm connection between long GRBs and the death of short-lived massive stars. In current understanding, the core collapse of a massive star is followed by a 'fireball', which sweeps through interstellar space with a range of densities and relativistic speeds, and the afterglow is fairly well understood as due to synchrotron emission from the shocked regions.

Due to their extreme intrinsic brightness, and because they are thus associated with ongoing star formation, long GRBs are emerging as an important new tracer of star formation and star-forming galaxies throughout most of the history of the visible universe: The ~40 known GRB redshifts range from $z \sim 0.1$ to the current record of $z = 4.5$.

Work at NOT has contributed significantly to the current understanding of GRBs. NOT joined right from the very first afterglow (GRB 970228) and has been used to discover and identify OAs since then. The success of NOT is due to its flexible and efficient operation, which enabled us to obtain high-quality data at very short notice, but above all to the excellent cooperation of the many visiting astronomers we had to interrupt with our requests; we thank them all most cordially. In all, our work at NOT has resulted in more than 30 refereed papers on OA discoveries, properties, and environments, and on GRB host galaxies and their local galactic neighbourhood (with about 1200 citations).

Competitive GRB observations are demanding and effort intensive, because the delay from satellite localisation to optical observation must be as short as at all possible. Even then, success is not ensured: In more than half the cases, no OA can be detected. While this can be frustrating, it is scientifically very interesting, because these "dark bursts" may give clues to the GRB/afterglow physics, the local GRB environment, or perhaps new GRB types at high redshift. So the potential scientific value of even a non-detection is still high. On the other hand, when an OA *is* identified, a good data set obtained early enough is immensely valuable, as it allows us to discern crucial details of the burst conditions and environment.

In 2004, the GRB program was activated only 5 times, leading to upper limits on three OAs and flux density measurements for another two. This slowdown is due to a temporary lack of satellites giving sufficiently precise positions of detected GRBs for optical study. But this is just the silence before a storm – to be provided by NASA's satellite Swift (Fig. 3). When fully operational in the spring of 2005, Swift is expected to provide ~100 accurate GRB positions per year, available in just minutes – potentially even while the burst is still ongoing.

Fig 3a: The Swift satellite, equipped with gamma-ray, X-ray, and optical cameras for immediate localisation of GRBs.

Fig 3b: The launch of Swift on November 20, 2004.

Swift will fundamentally change the optical study of GRBs – also at NOT. The first identification of OAs will be taken over by robotic telescopes, which respond rapidly and automatically to GRB alerts from Swift. With robotic telescopes performing the "routine" discovery work, we will use the

In order to alleviate these problems, we are collaborating with NOT to develop an on-site pipeline, primarily for imaging data, which will automatically reduce the data promptly after each exposure. Only the reduced image is then transferred, not all the raw data. When fully tested, the pipeline package will be available, and hopefully useful, for most NOT observers doing optical imaging.

J. Fynbo, Copenhagen, and collaborators

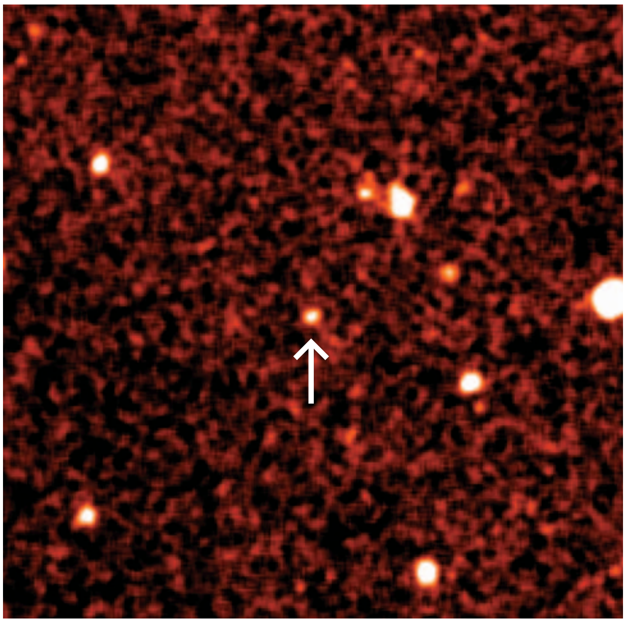


Fig. 4. K-band image from NOTCam of the Swift burst GRB 050124, 15 hr after the burst (field size 1'x1', E is up, N right). The afterglow is seen at K≈19, but due to a 24-hour delay in transmitting the data, the Keck telescope reported the discovery first, based on later images.

valuable follow-up time on NOT and other telescopes such as the VLT for spectroscopy and other detailed observations, and also to study exceptionally interesting cases in detail.

The flexible operation of NOT makes it well suited for such a role, but real-time access to data is required. The unreliable network connections to NOT have been a serious bottleneck so far. For example, NOT was first to see one of the first Swift detections (Fig. 4), but other telescopes beat us to the discovery because it took more than 24 hours to transfer the data!! Speed of access is crucial, not just to be first, but also to adapt the follow-up observations to circumstances in real time.

Ly-α emission from GRB host galaxies

The host galaxies of gamma-ray bursts (GRBs) tend to be compact, blue, and very faint; some are among the faintest objects ever detected. There is growing evidence that GRB host galaxies are also emitting in the Ly-α spectral line of hydrogen, at least at high redshift. Ly-α emitting galaxies are predominantly starburst galaxies of low metal abundance and little or no content of dust. Imaging of GRB host galaxies in Ly-α light can therefore provide information on their star-formation rates, dust content, and metallicity.

Using two special-purpose narrow-band filters centred on the Ly-α line at the appropriate redshift, we have used NOT to expand the modest sample of Ly-α data on GRB host galaxies by observing the hosts of GRB 021004 and GRB 030226, at redshifts 2.33 and 1.986, respectively.

Fig. 5 shows the observed Ly-α emission superimposed on an optical image of the host galaxy of GRB 021004, obtained

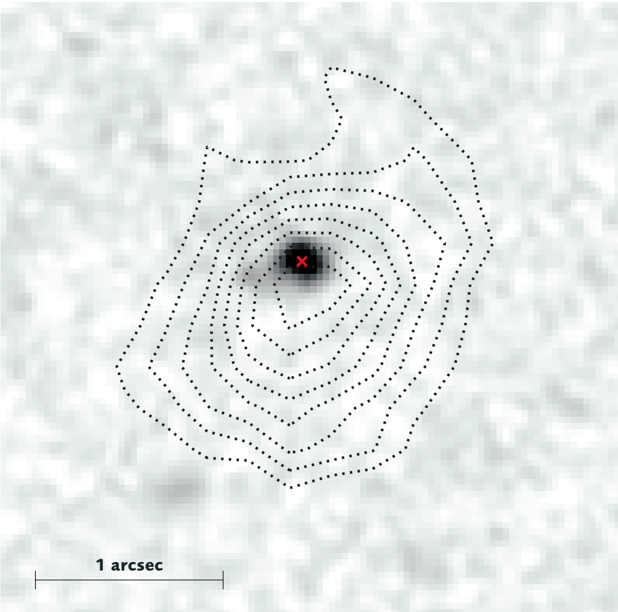


Fig. 5. Combined image of the host galaxy of GRB 021004 in continuum (stellar) light, from the Hubble Space Telescope, and in the light of the Ly-α emission line, from NOT (contours).

with the *Hubble Space Telescope* 239 days after the burst. The Ly-α image was made with NOT one year after the burst, with a total integration time of 5 hours in 0.9" seeing. The host is an extended, single-component object and strong Ly-α emitter, with the centre of the Ly-α emission very close to the centre of the host galaxy. The Ly-α emission is significantly more extended than the continuum emission. The other host galaxy, of GRB 030226, was not detected in Ly-α, even in a very deep image with about 20 hr exposure time. However, in both fields of view we detect several other galaxies with excess Ly-α emission, i.e. there are other star-forming galaxies in the close environment of the host galaxies.

From the Ly-α imaging the star formation rate, dust content, and metallicity of the host galaxies (or at least useful constraints on these quantities) can be obtained, providing information about the GRB progenitor stars and their environment. The results are consistent with the suggestion that stars exploding as GRBs are preferentially of "low" metallicity.

G. Björnsson, Reykjavik

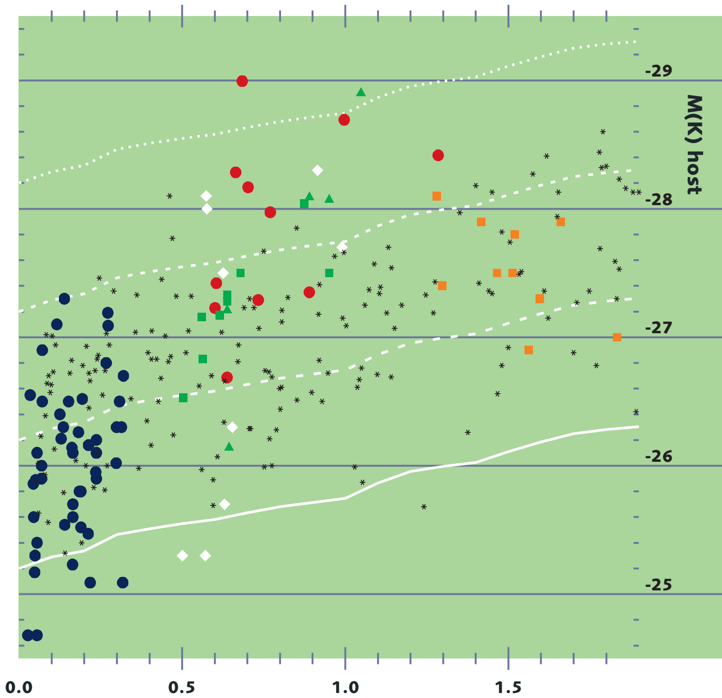
The luminous host galaxies of high-redshift BL Lac objects

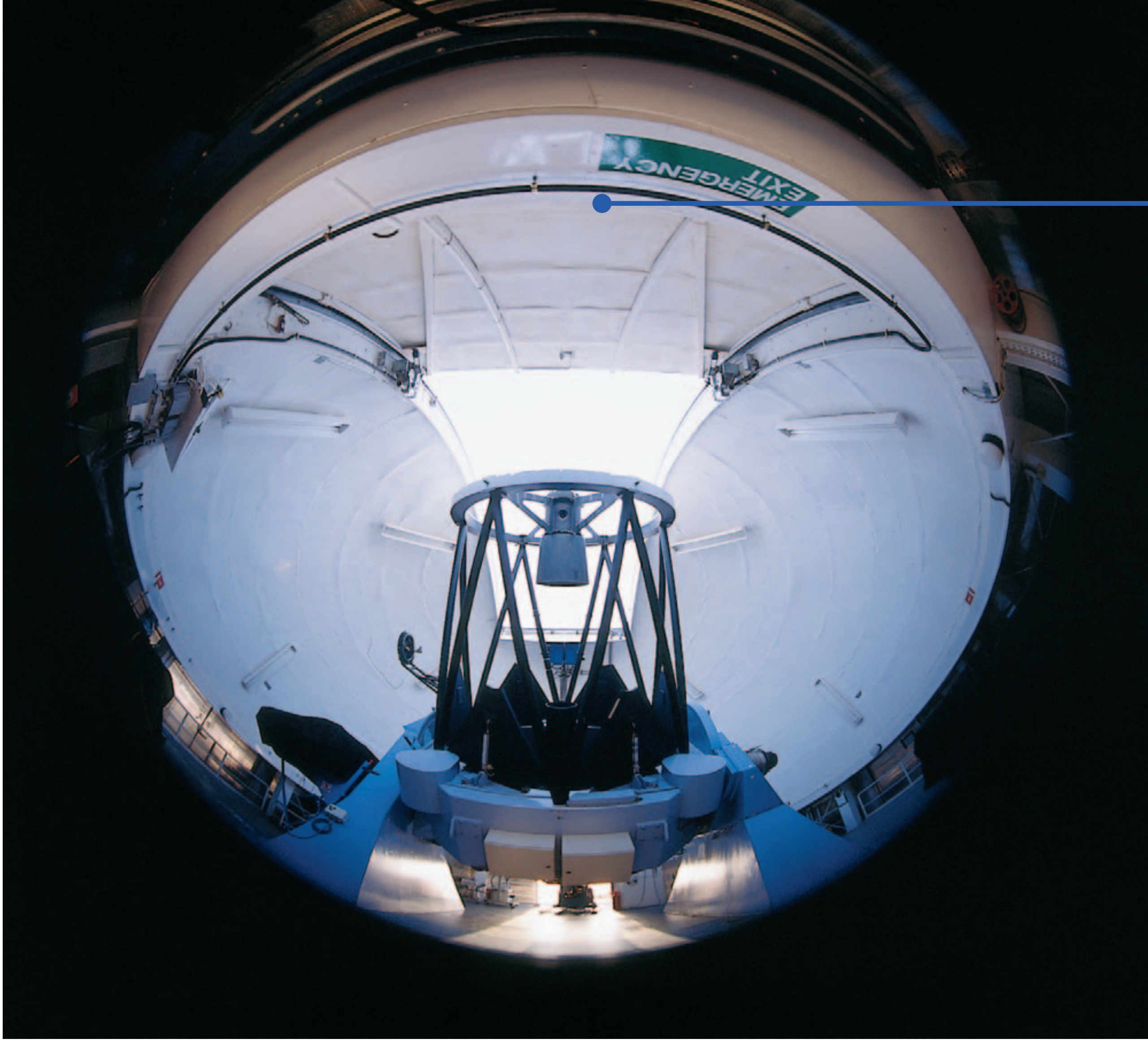
BL Lac objects are very active galactic nuclei (AGNs), in which a relativistic jet from the central black hole is presumed to be aimed directly at the observer, dominating the light of the galaxy and giving a featureless spectrum. BL Lacs have been observed to vary on several timescales and over a huge range in energy and wavelength, from radio waves to high-energy cosmic rays. Their relations with their host galaxies and to such similar AGN types as quasars are a subject of intense study.

The near-infrared K-band (2.2 μm) is the best region in which to study the host galaxies of BL Lacs, as the light of the dominant stellar population is at a maximum here, and dust obscuration is minimal. The first imaging study in the K-band of a sizeable sample of high-redshift BL Lac objects ($z > 0.5$) was performed with NOTCam to characterize the properties of their host galaxies and explore the evolution of BL Lac hosts. In 11 of the 13 BL Lacs observed, the host was detected and well represented by an elliptical galaxy.

The host galaxies of high-redshift BL Lacs are found to be large (average bulge scale length $R_{(e)}$ = 6.8 kpc), but of similar size to those hosting low-redshift BL Lacs, indicating that there is no evolution in the host galaxy size with time. The high-redshift host galaxies are very luminous (average $M(K)$ = -27.9), ~2.5 mag brighter than the typical galaxy luminosity, L^*, and ~1 mag more luminous than brightest cluster galaxies. They are also ~1 mag brighter than radio galaxies at similar redshift.

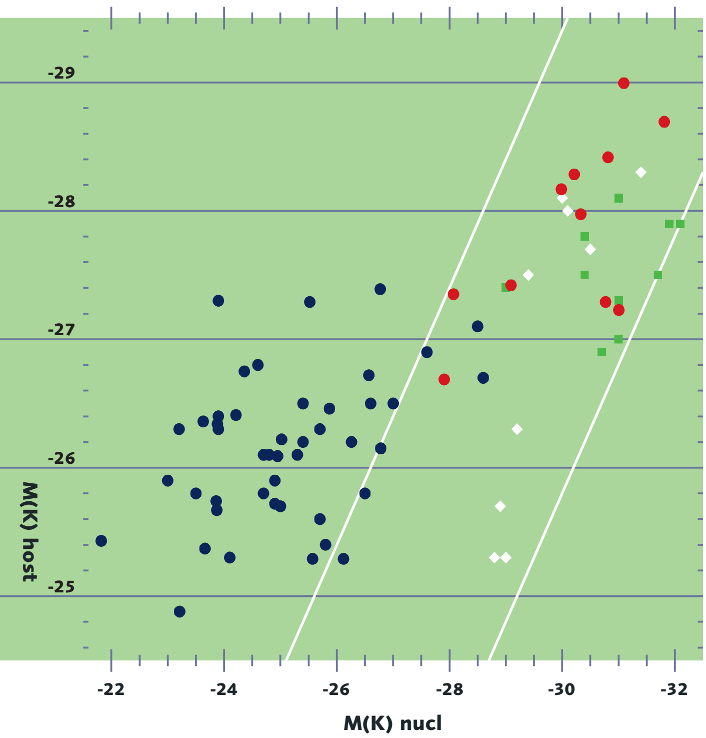
Fig. 6. Absolute K-band magnitude of AGN host galaxies vs. redshift, z. High-redshift BL Lacs are marked by red circles (this work), or green squares and triangles (others); low-redshift BL Lacs are shown as blue circles. White diamonds are flat-spectrum radio quasar hosts, orange squares are high-redshift quasar hosts, and the asterisks are radio galaxies. The solid line shows the passive evolution of an L* galaxy; the other lines the evolution of galaxies 1, 2, and 3 magnitudes brighter than L*.





A fisheye view of NOT. Photo: H. Karttunen

Fig. 7. K-band luminosity of AGN host galaxies vs. that of the nuclei (symbols as in Fig. 6). The solid lines correspond to constant ratios between host and nuclear emissions, spanning a factor of ~30 in that ratio.



On the one hand, these high luminosities agree with the few optical studies of high redshift-BL Lacs, and they are similar to those of high-redshift flat-spectrum radio quasars, consistent with these objects forming a common class of blazars. On the other hand, the average host luminosity is ~2 mag higher than that of low-redshift BL Lacs. This difference is not consistent with simple passive evolution of the host galaxies, and it suggests a significant contribution from recent star formation episodes. Spectroscopic studies and colour information of these host galaxies would help to elucidate this issue.

In high-redshift BL Lacs, the luminosities of the host galaxy and the nucleus appear to be fairly well correlated. This can occur at a fixed fraction of the Eddington luminosity (the limiting luminosity where photon pressure would tear the nucleus apart), as expected from the black hole mass – bulge luminosity relationship found in nearby spheroidal galaxies. No such correlation is seen for low-redshift BL Lacs. High redshift BL Lacs radiate with a wide range of power with respect to their Eddington luminosity, intermediate between the low levels observed in nearby BL Lacs and the higher levels occurring in luminous radio-loud quasars.

J. Kotilainen and T. Hyvönen, Turku; R. Falomo, Padova

HIGHLIGHTS

FORMATION, STRUCTURE, AND EVOLUTION OF STARS

Stars are born in dense interstellar clouds. They evolve quietly for most of their lives, but die in more or less violent ways and leave behind a black hole, a neutron star, or a white dwarf star. Theory successfully describes the main features of stellar evolution, but the processes are complex, especially the role of convection, magnetic fields, and stellar activity cycles. Moreover, stars in binary systems may interact and evolve into objects that are quite different from single stars. Some NOT projects in this field are described in the following.

The pulsating star that should not exist

Asteroseismology is a technique to investigate stellar interiors by analysing periodic light variations due to acoustic waves on the stellar surface. For high-gravity stars like white dwarf stars, we observe *gravity waves* or (*g*-mode pulsations), where gravity is the restoring force just like in ocean waves; in lower-gravity stars such as the Sun, different mechanisms are responsible.

A white dwarf has a simple structure: Nuclear reactions have stopped, the outer layers containing unburned hydrogen have been lost at the so called *planetary nebula* stage, and an almost naked stellar core of approximately 0.6 solar masses is left. White dwarfs contain heavy elements such as carbon and oxygen in their interiors, with thin layers of hydrogen and helium in their outer atmosphere. One of the great successes of asteroseismology is exactly to have been able to model slowly cooling white dwarf stars and determine their interior composition and the thickness of these layers.

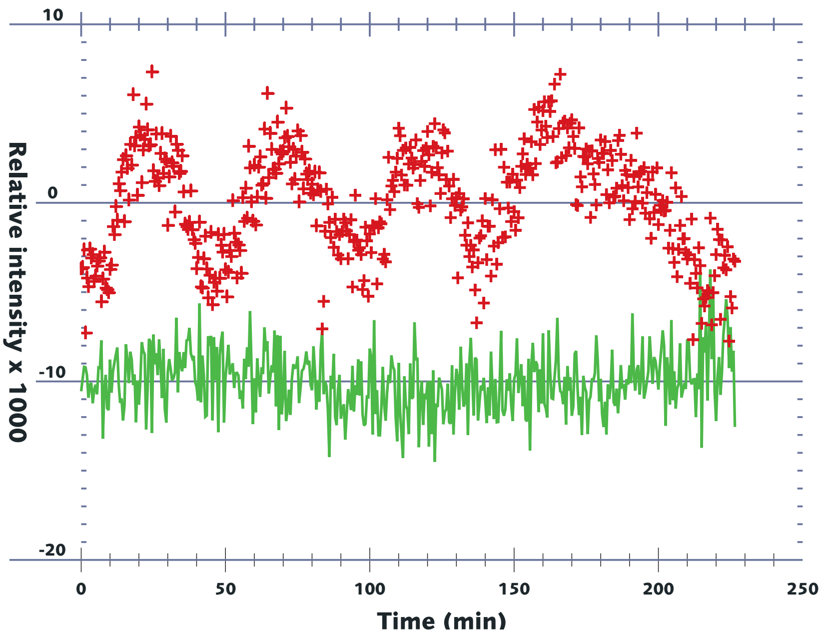


Fig. 8. Light curve of Abell 43 from July 27, 2004; for reference, the light curve of one of the comparison stars relative to the mean of them all is also shown (green line). The unit is 1000 x the relative light variation (i.e., the full range is +1/-2% of the average brightness).

However, some white dwarf stars are changing rapidly. They are hot (surface temperatures over 100,000 K), and some may still be losing their outer layers by a stellar wind. A particular interesting case is the star PG 1159-35, discovered to be variable in 1979. It has a rich spectrum of pulsations; until now 198 pulsation modes have been identified, allowing us to model the star in great detail. However, observed changes in the pulsation pattern point to rapid changes in the star. PG 1159 has a temperature of 140,000 K and a helium-rich atmosphere containing less than 3% hydrogen; presumably most of the hydrogen was lost in the planetary nebula stage.

A few years ago, a so-called ”hybrid PG 1159 star”, HS 2324+3944, was discovered. It contains 10% hydrogen and is losing mass via a wind. According to models this star should not be able to pulsate – yet it did! However, fine-tuning the composition of He, C, O, and other heavy elements showed that small variations could change the star from a non-pulsator to a pulsator. The unstable modes were predicted to have periods in the range 22-50 minutes.

In a program at NOT, we search for pulsating white dwarf within the fields of the French asteroseismology satellite COROT; these might disturb the observations of its solar-type main targets. None was found within the COROT fields themselves, but close to one field was a ”hybrid PG 1159 star” called Abell 43. The star is inside a nebula, which is fed by the strong stellar wind. Its temperature is 110,000 K and its hydrogen content 42% – far more than expected for a ”hybrid PG 1159” pulsator.

To our great surprise the star showed nice pulsations, with at least two periods of 43 and 50 minutes. As seen in the figure, after 3 short cycles one long cycle is observed – a clear sign of multiperiodicity. Note that the amplitude of the pulsations are quite small, only 0.5%, so this detection was clearly only possible due to the precision of the multi-window fast-photometry system with ALFOSC at NOT.

The fun about observing is to discover something unpredicted, and astronomy is full of such fun: Thanks to this discovery, astroseismologists have the challenge to model a star that was not supposed to pulsate at all! The observed periods strongly suggest that the variations cannot arise from motions in a binary system, but are due to non-radial *g*-mode pulsations. This raises puzzling questions regarding the excitation mechanism in this H rich, C and O-poor star, because the C and O abundances are too low to allow the instability to be triggered by the kappa-mechanism induced by the partial ionization of C and O, which has been invoked to explain the instability of the PG 1159 stars. While the theoreticians are pondering this mystery, the observers will be busy getting more information about this star.

G. Vauclair, Toulouse; J.-E. Solheim, Oslo; R.H. Østensen, ING

Stellar spot activity, differential rotation, and dynamos

Star spots are believed to be fundamentally the same phenomenon as sunspots, i.e. caused by magnetic activity. The stellar magnetic activity is explained by dynamo models. An important parameter in the models is the differential rotation, i.e. the fact that a late-type star with a convective envelope will not rotate as a rigid body. In a star with differential rotation, e.g. the Sun, the angular rotation velocity is a function of the latitude at the surface and also the depth in the convection layer.

Our programme *"Surface differential rotation of magnetically active single stars"* studies the spot activity of six stars by Doppler imaging, which utilizes the fact that a spot on the stellar surface will cause a moving distortion in the spectral line profiles. A series of high-resolution spectra then allows to reconstruct surface structures of stars, which are too small to be resolved directly. In our study, we use photospheric absorption lines in the wavelength range 6400-6450 Å, observed at NOT with the SOFIN spectrograph. In addition to studying the evolution of the spot pattern on the stars, we aim to determine the stellar differential rotation.

One way to estimate the surface differential rotation is to combine Doppler imaging with an analysis of long time series of photometry. The spot latitudes are obtained from Doppler images (see Fig. 9), and the angular velocity at the spot latitude is derived from the photometric rotation period. Differential rotation shows itself as a dependence of the photometric rotation period on spot latitude. Another way is to combine a long time series of Doppler images and study the longitudinal migration of spots at different latitudes. Finally, differential rotation will also influence the shape of the line profiles of rapidly rotating stars.

In our study we focus on the FK Comae-type stars, which are single, rapidly rotating, and magnetically very active stars. The results so far indicate surprising differences between apparently similar stars. In the case of HD 199178, the observations are best explained by anti-solar differential rotation, i.e. a rotation period *decreasing* with latitude (Fig. 10). The results for the prototype FK Comae star, FK Com itself, indicate a weaker and solar-type differential rotation.

T. Hackman, Helsinki; H. Korhonen, Potsdam

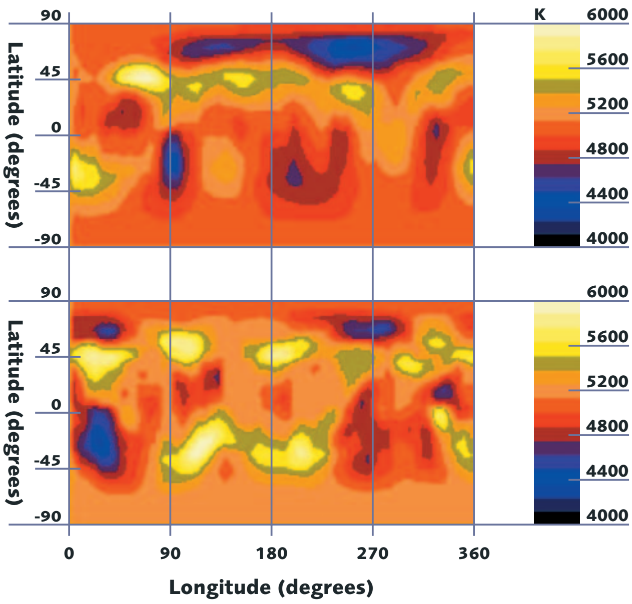


Fig. 9. Doppler images of FK Com at two epochs, in semi-Mercator projection. The colour coding shows the temperature distribution on the surface.

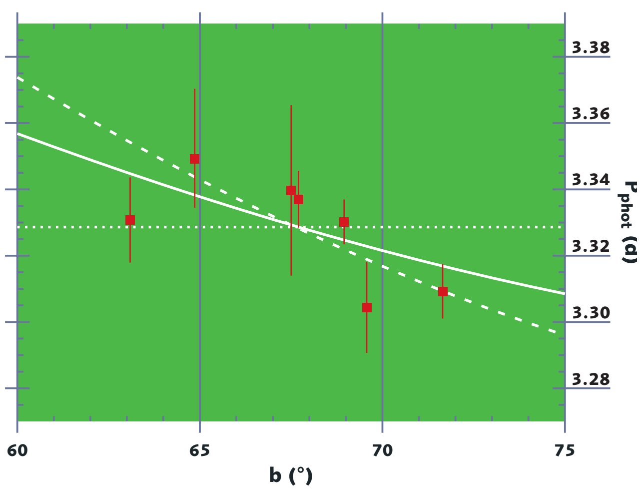


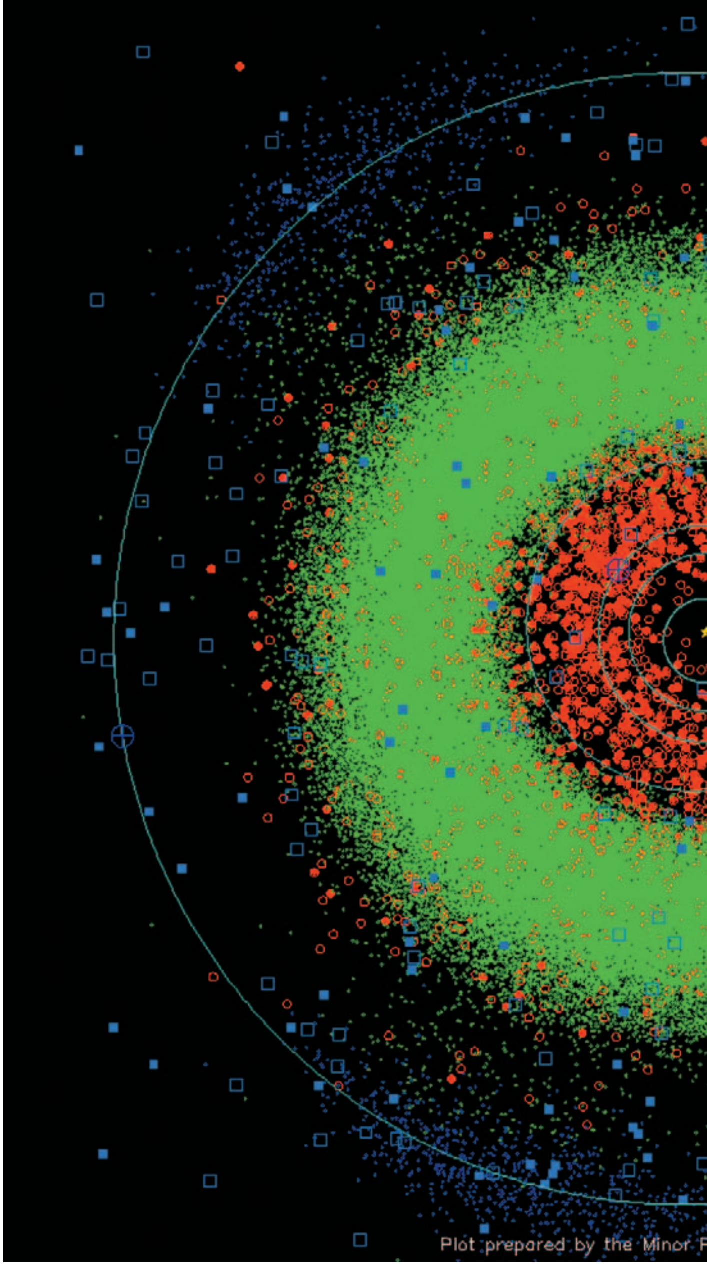
Fig. 10. Photometric rotation period P_{phot} vs. the latitude b of the main spot in HD 199178 during seven different seasons. The lines represent differential rotation curves as described by $P(b) = P_{eq} /(1-\alpha \sin^2 b)$ (the solar differential rotation formula) with α = -0.17 (dashed line, best fit to the spectral line profiles), α = -0.10 (solid line, least squares fit to the data in the figure), and α = 0 (dotted line, rigid body rotation).

SOLAR SYSTEM STUDIES

Despite the uniquely detailed data on Solar-System bodies that can be obtained directly by space missions, ground-based observations remain important. NOT has a special advantage here in being able to observe very close to the horizon at dusk and dawn, when objects inside the orbit of the Earth become visible for a short time. In earlier years we highlighted studies of the major planets; here we report on ongoing work on a special class of minor planets, the Near Earth Objects (NEOs), which impact on Earth at long intervals and thereby are of more than just academic interest.

Mineralogy of Near Earth Asteroids

Asteroids are *minor planets* orbiting the Sun, too small to retain an atmosphere. Most asteroids are located between the orbits of Mars and Jupiter (2.0-3.3 AU), in a region called the *Main Belt* (shown as green dots in Fig. 11). There are also asteroids whose orbits cross the orbit of Mars (Mars Crossers), and asteroids captured near the Lagrangian points of the orbit of Jupiter (*Trojans,* blue circles in Fig. 11). Finally, the Near-Earth Objects (NEOs; red circles in Fig. 11) have orbits with perihelion distances less than 1.3 AU and include both asteroids and dead or dormant comets.



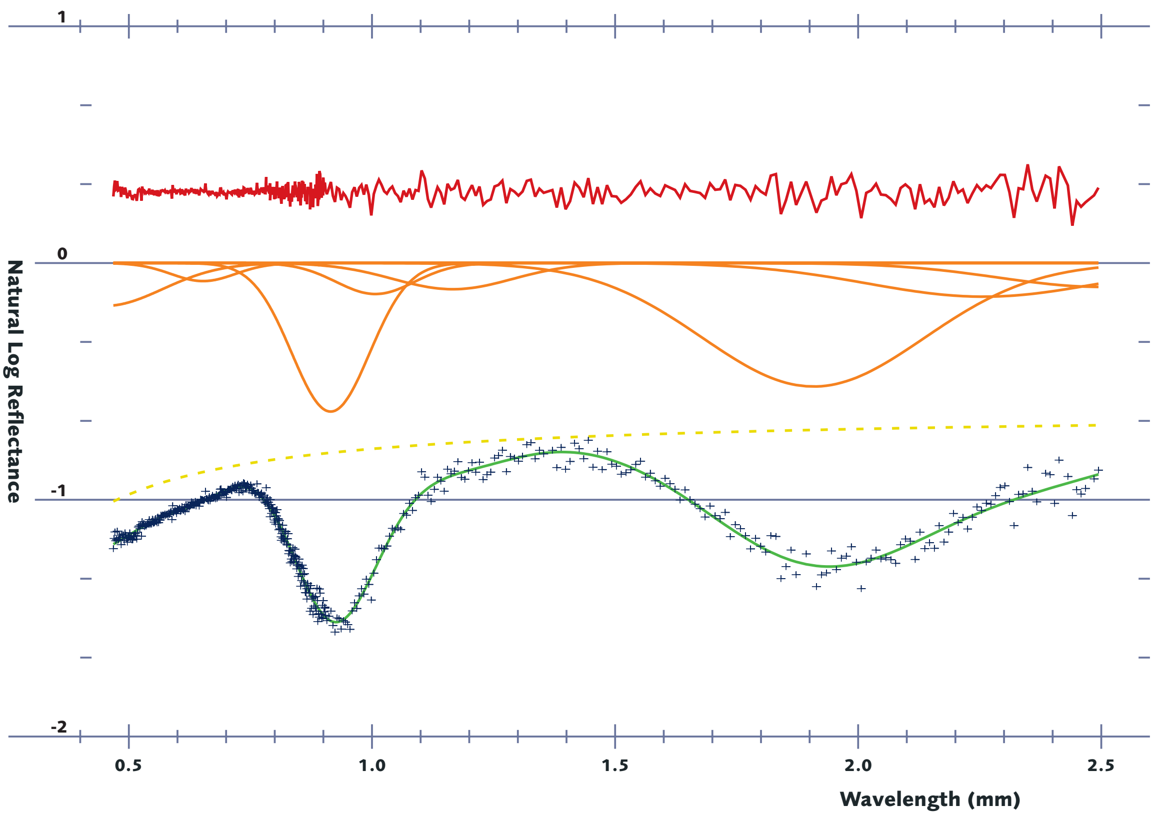
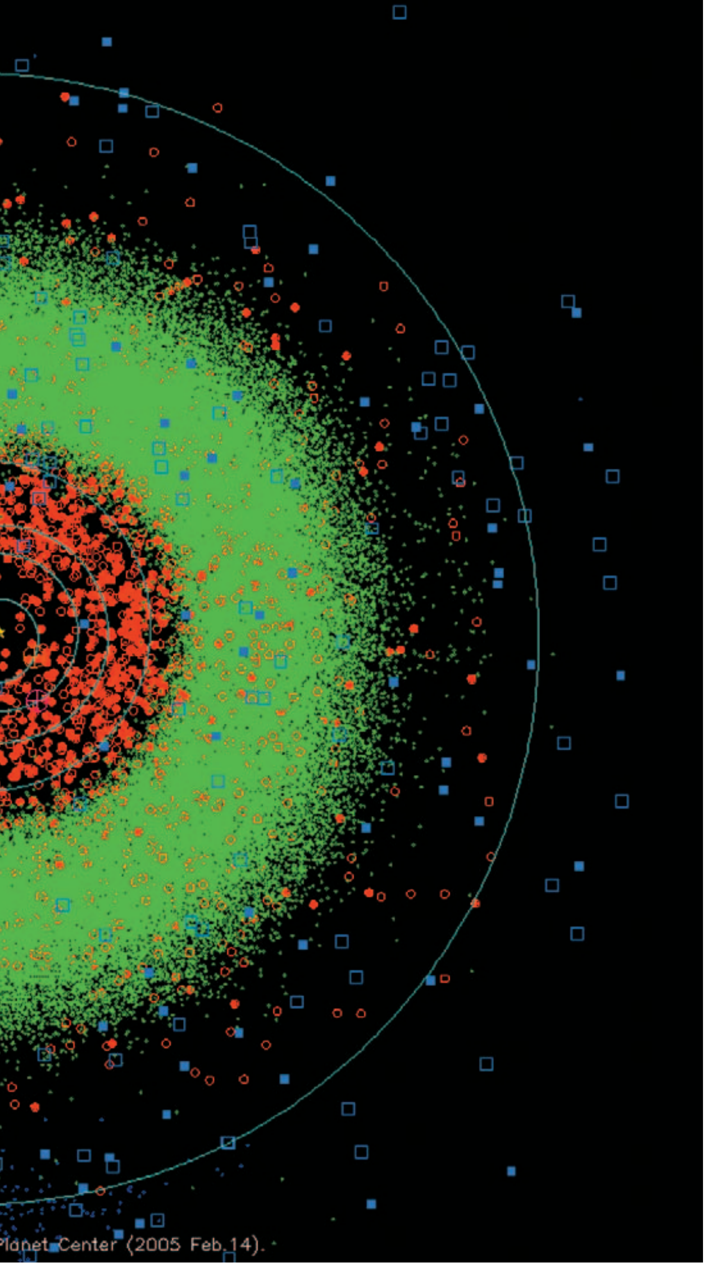


Fig. 11. Current positions of major and minor planets in the inner region of the solar system. The orbits of the major planets are shown as light blue circles, Main Belt asteroids as green dots, while the "clouds" of dark blue dots along Jupiter's orbit are the Trojans. NEOs are shown as red dots, numbered periodic comets as light blue squares, and other comets as unfilled light blue squares.

Fig. 12 (left). Deconvolution analysis of the visible and near-infrared spectrum of the NEO 2000 XH44. Individual absorption bands associated with the presence of different silicates (above) are combined as shown to reproduce the observed spectrum of the object (below, crosses).



A fundamental observable characteristic of an asteroid is its *colour*. Incident sunlight is both scattered and absorbed by mineral grains on an asteroid's surface, and depending on the optical properties of these grains, the light that is reflected to Earth varies with wavelength. Thus, reflectance spectroscopy is a basic tool to determine the mineralogical composition of asteroid surfaces.

Near-Earth asteroids are believed to be the parent bodies of most meteorites that arrive on Earth. Mineralogical analysis of their reflectance spectra provides a spatial context for the detailed meteoritic data, potentially establishing the relationships between individual asteroids and particular meteorite types. Furthermore, asteroids survive from the early Solar System and thus provide information on its initial conditions as well as the processes operating since then. Therefore, identifying the compositional and mineralogical properties of a large sample of these objects will ultimately lead to a better understanding of the physical and chemical evolution of the Solar System. However, although more than 60,000 asteroids have well-established orbits, less than 10% of those have had their compositional properties determined.

Current asteroid studies include dynamical calculations to understand the source(s) and mechanism(s) of the resupply of the NEO population, geological issues related to the original composition of the asteroidal parent bodies, and the chemical and thermal processes that altered and modified the original planetesimals. In this context, ground-based reflectance spectroscopy plays a crucial role in the mineralogical characterization of the asteroid population. The low-resolution spectroscopic configuration of ALFOSC is especially efficient in providing high-quality optical spectra of these objects. Together with near-infrared data, optical spectra of Near-Earth asteroids provide valuable data that can be analysed with the latest deconvolution methods to extract mineralogical information on their surfaces (see Fig. 12). The good performance of the telescope and instrument allowed us to obtain optical spectra for more than 65 NEOs over the last 3 years.

J. de León, J. Licandro, M. Serra-Ricart, IAC

Physical and orbital characterization of Potentially Hazardous Asteroids

Near-Earth Objects (NEOs) are the special subgroup of the minor bodies (asteroid or comets) in the Solar System whose orbits approach the Earth very closely, posing the risk of an actual impact on our planet at some time in the future. No object known today is currently on a collision course with Earth, but the class of potentially hazardous objects (PHOs) have orbits that might, in a few tens of years, be perturbed sufficiently to make a collision possible.

Unlike most other natural disasters, the asteroid impact hazard is in principle both predictable and avoidable. However, were an impact to be predicted, we would need thorough knowledge of the physical and dynamical properties of the object in order to initiate any mitigation measures. In pursuit of this goal, a group of Nordic asteroid and comet researchers called the Nordic NEON (Near-Earth Object Network) started an observing program in 2004 with the aim to characterise the physical and orbital properties of a sample of NEOs. The size, shape, surface properties, and spin vector of individual NEOs can be derived from light curves obtained at several observing and illumination geometries. Improved orbit calculations and impact risk assessments are based on precise position measurements from the photometry frames and from separate observations.

Light curves already exist for some 35 PHOs, but for most of them only an approximate period is known, and the properties of well over 500 PHOs are totally unknown. An approximate period can be derived from just a few nights of observations, and we have already estimated periods for 5 previously unobserved PHOs. On the other hand, determining the shape and rotational pole of an object requires far more detailed data, and it takes a few years to obtain such solutions for the previously unobserved targets. So far, we have obtained improved spin and shape solutions for 4 targets (see Fig. 13).

Positions are determined both for NEOs which have not been not observed lately, and for newly discovered objects; in both cases the orbits are uncertain and the objects may be lost. Through December 2004, we have recovered three 'lost' NEOs and determined improved orbits for 35 objects. One of the targets was the PHO 2004 AS1; the dramatic discovery night prediction implied a possible immediate Earth impact (within 48 hours!), but this was quickly ruled out by the new observations.

K. Muinonen, J. Virtanen, J. Torppa, T. Laakso, M. Granvik, Helsinki; J. Näränen, NOT; K. Aksnes, T. Grav, Z.J. Dai, Oslo; G. Hahn, Berlin; C.-I. Lagerkvist, H. Rickman, Uppsala; R. Michelsen, Copenhagen

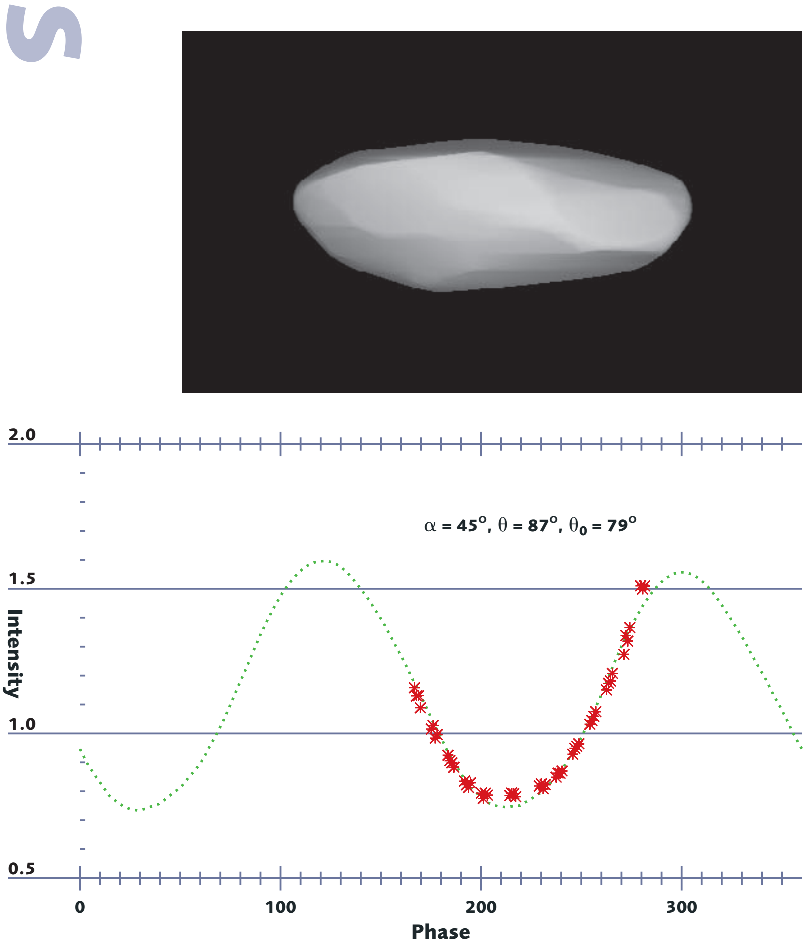


Figure 13. Partial light curve of the PHO (1685) Toro obtained at NOT, and prediction (dashed line) from a physical model of its shape (top) and spin, derived from all light curves from 1972 to 2004.

PROGRESS IN INSTRUMENTATION

Keeping the instrumentation at NOT competitive is a key item in our long-term planning. As major upgrades of our instrumentation imply major investments, it is important to review the potential of any instrument upgrades before undertaking such investments. In early 2004, we commissioned a design study for a new, more powerful and versatile instrument adapter for NOT from Copenhagen University; no decision to proceed is imminent, but it helped us to clarify focus our options and focus our thinking. Meanwhile, a number of upgrades of immediate benefit have been completed, such as archiving data on DVDs in a much more compact format than RD-ROMs.

Spectroscopic capabilities at NOT

The spectroscopic capabilities of the astronomical instruments of NOT are of great interest to the Nordic astronomical community: Half of the observing proposals for semesters 29 and 30 in 2004 applied for time to do spectroscopy. Currently, the spectroscopic instrumentation available at NOT comprises ALFOSC (low-resolution optical; on loan from Instituto de Astrofísica de Andalucía, Granada, Spain), NOTCam (low-resolution near-IR), and SOFIN (high-resolution échelle, optical). The fibre-fed high-resolution optical échelle spectrograph FIES should become available during 2005. We give here a concise review of recent developments as well as some of our plans and thoughts as regards future enhancements (see also Fig. 14). A more detailed report can be found at *http://www.not.iac.es/instruments/development/JHTspecUpgrades.pdf* .

ALFOSC: A new blue grism, #16, (R=900 for a 1" slit) has recently filled a gap that existed in the range of resolutions offered by the grism suite of ALFOSC in the blue. The grism was tailored to study velocity shifts in the Balmer lines of blue stars, but has proven useful for other research fields as well. A new Volume Phase Holographic (VPH) grism will be installed in the summer of 2005; it covers a wavelength range of about 400 Å around H-**α**. The expected total system efficiency is ~29%, about 5 times that of the ALFOSC échelle mode; thus, NOT+ALFOSC will detect as many photons from a given source as many larger telescopes, e.g., the WHT+ISIS. Further VPH grisms for ALFOSC are being considered. See *http://www.not.iac.es/instruments/alfosc/*

NOTCam: The échelle grism (R~2000 with the Wide Field camera) has already been used by visiting astronomers in the K band. It will become more useful in the other bands when a calibration unit is installed on the telescope in the spring of 2005, providing Ar and Xe lamps for wavelength

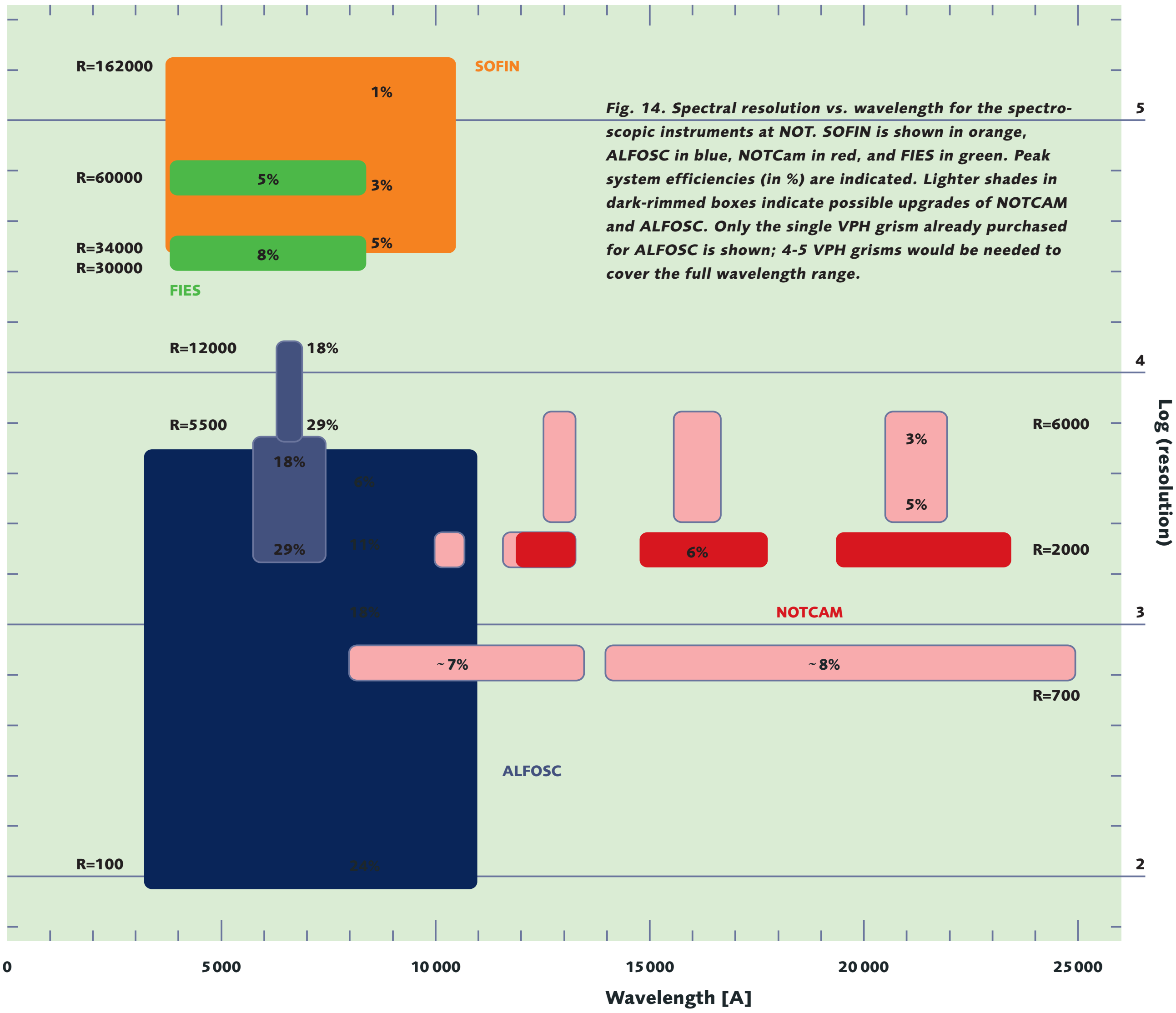


Fig. 14. Spectral resolution vs. wavelength for the spectroscopic instruments at NOT. SOFIN is shown in orange, ALFOSC in blue, NOTCam in red, and FIES in green. Peak system efficiencies (in %) are indicated. Lighter shades in dark-rimmed boxes indicate possible upgrades of NOTCAM and ALFOSC. Only the single VPH grism already purchased for ALFOSC is shown; 4-5 VPH grisms would be needed to cover the full wavelength range.

calibration and a halogen lamp for flatfielding. NOTCam has also recently been upgraded so that the grism can be used with the High Resolution Camera, giving a resolution of R~5500 in the J, H, and K bands; this combination will be commissioned in early 2005. NOTCam could be further upgraded to offer a low-resolution spectroscopic (R~700) mode, e.g. for studies of NIR spectral energy distributions, which could sample the Z+J or H+K bands. Redwards of 9000 Å, this mode of NOTCam would be preferable to ALFOSC, in terms of both efficiency and fringe amplitude. See *http://www.not.iac.es/instruments/notcam/spectroscopy/* .

SOFIN: The recent addition of new optical coatings, a Loral CCD detector, and a new cross-disperser has increased the efficiency of SOFIN very considerably. Dr. I. Ilyin (now Potsdam) continues to develop and provide support for SOFIN; the current development aims to enhance the polarimetric capabilities of the instrument. See *http://www.not.iac.es/instruments/sofin/* .

FIES: FIES is a fibre-fed, standby spectrograph for high-resolution échelle spectroscopy in the range 3800-8400 Å with high stability. It is being completed in collaboration between NOT and Dr. S. Frandsen (Aarhus Univ.). A new CCD detector has been installed, and with the building permit now in place, FIES will soon be moved to a separate building outside the telescope to ensure a stable environment. The optics will be recoated and a new fibre unit installed, all contributing to improved instrument performance. The fibre input end will be mounted permanently in the telescope adapter, enabling FIES to be used in flexible scheduling at all times. A pipe-line reduction package for FIES is being developed. For the current status, see *http://www.not.iac.es/instruments/fies/* .

J. Telting, NOT

Progress in "Lucky Imaging"

The spatial resolution of ground-based optical images is limited by the smearing effects of atmospheric turbulence. A number of techniques are being developed to reduce this blurring. ”Lucky Imaging” offers a particularly flexible, yet simple solution: Amongst the rapid fluctuations of the atmosphere, moments of relatively stable air appear for a few tens of milliseconds. Taking images with ”LuckyCam” at high frame rates and with no penalty in readout noise allows us to follow rapid seeing variations and select the moments with the very best images; effectively, we are then integrating only during periods of truly superb seeing.

The size and image quality of NOT make it an ideal telescope for this technique, and an extensive test programme in 2000 – 2004 has demonstrated LuckyCam’s ability to achieve very competitive resolution enhancement in the I band, in all kinds of seeing. In good seeing, LuckyCam can correct the images to a resolution close to the diffraction limit of NOT over a much wider field of view than standard adaptive optics, using reference stars as faint as I=16.5 and thereby achieving essentially complete sky coverage. Even under poor seeing conditions (1-2”), image resolution can be improved by as much as a factor of three.

Fig. 15. A composite image of the 1% best frames of the binary ζ Bootis, with separation of 0.8". Note the clear appearance of diffraction rings around both components.

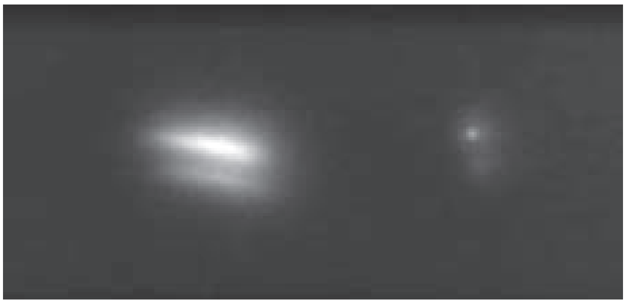


Figure 16. Simultaneous high-resolution images (right) and spectra (left) of the pre-main-sequence binary WSB20 (separation 1.0"), taken in 1.1" seeing. The slope of the spectra is due to the atmospheric dispersion.

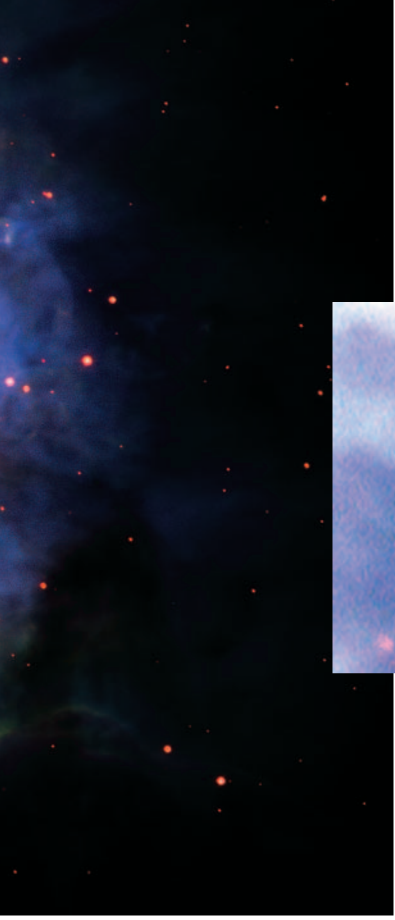
Of course, selecting only the very best frames implies a loss of light, and one must choose a compromise between signal and resolution. Using 30% of the frames improves the resolution by at least a factor of two to three, but by selecting only the 1% very best images in good (0.5”-0.75”) seeing, one can reach the diffraction limit of NOT at about 0.1” (see Fig. 15).

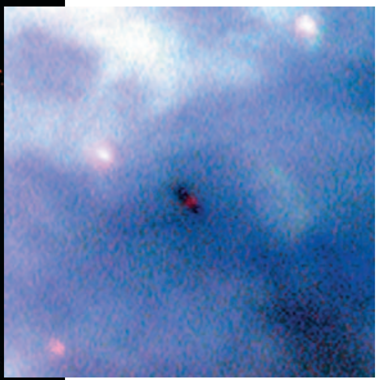
In 2004 we added a capability to obtain grism spectroscopy simultaneously with the high-resolution imaging. As an example, we obtained the first well-separated spectra of two very close binary components (Fig. 16). This opens the way to new and exciting applications of LuckyCam, also in extragalactic astronomy, and the technique is being further developed. A longer-term goal is to make the system more user-friendly, and hopefully also permanently available at NOT.

N. Law, C.D. Mackay, Cambridge UK

Correcting the field distortion of NOTCam

The optics in NOTCam must be able to focus the entrance pupil (essentially the primary mirror of NOT) on a cold mask to remove any background radiation, then refocus the image formed by the telescope onto the same detector at two very different image scales – all over a wavelength range of more than a factor two. As a consequence, the cameras employ quite complicated optics producing significant geometric distortions. In the process of preparing a deep NOTCam image of the dark globule B335 to search for embedded Herbig-Haro objects, it was found that the quality of composite images taken with the wide-field camera was in fact severely limited by these distortions.





The Orion Nebula in blue/red/infrared light, emphasising both the hot high-mass and dust-obscured low-mass stars. The insert shows a proto-planetary dust disk, reddening the central star and silhouetted against the bright nebula. Photo: M. Gålfalk

A model of the distortion was constructed, using stars with known coordinates from the 2MASS catalogue. A frame taken in excellent seeing was divided into overlapping circular sectors, each with enough stars to fit a polynomial to the displacements in the radial direction. For each pixel, a spline curve of displacements was fitted (i.e., a million curves!) and used to calculate the image distortion in the radial direction. The distortion model can be downloaded from *http://www.astro.su.se/~magnusg/NOTCam_dist* .

The distortion was found to be negligible around the image centre, but very significant close to the frame corners. For projects where the whole field is used, and especially when frames with large offsets are combined, correcting the frames for distortion is very important for the resulting image quality as well as for obtaining accurate photometry and source positions. The model reveals that, at worst, the distortion in NOTCam shifts corner positions by as much as 20 pixels, i.e. 4.6”(!); it is also not quite symmetric.

To illustrate the improvement, Fig. 17 shows an image composed of 15 dithered Ks exposures of B335 in 0.48” seeing, before and after correction for distortion. Only a corner of the image is shown in order to highlight the improvement. Fig. 18 shows the same two images superimposed, emphasizing how large this effect is. Not correcting for the distortion clearly ruins an otherwise excellent image; sources that appeared extended (e.g. potential Herbig-Haro objects – the whole point of the project!) are clearly stellar after the correction. Similarly, any shift-and-add or shift-and-filter operations on the images should only be performed after correction for the distortion.

M. Gålfalk, Stockholm

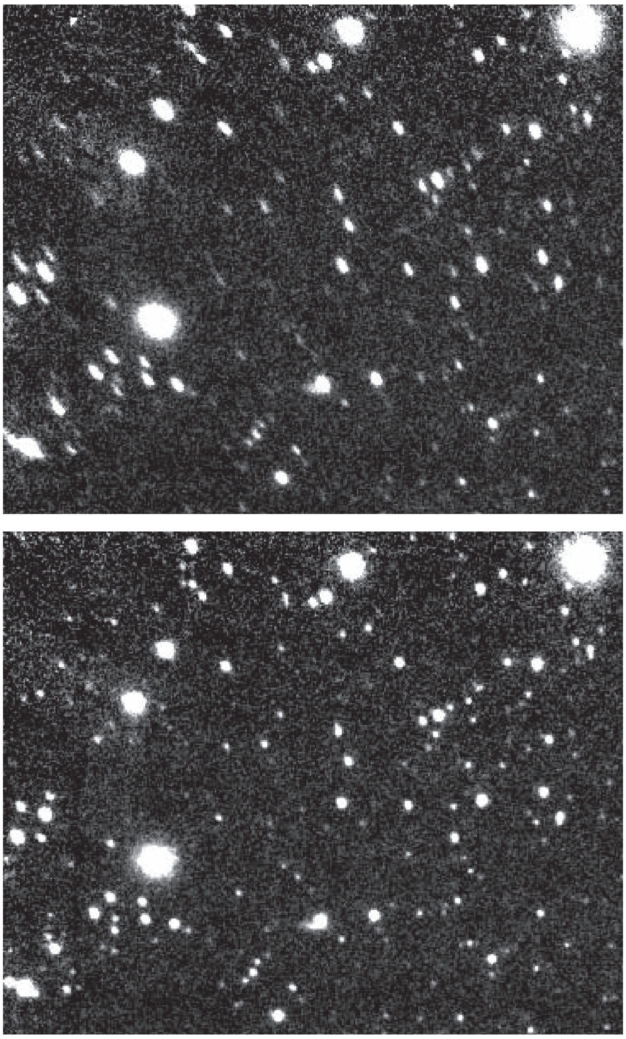


Fig. 17. One corner of a Ks image with NOTCam of the dark globule B335, before (left) and after (right) distortion correction. The final images are combined from exposures in 15 dithering positions (5x3 grid), with 10" offsets. The seeing is 0.48".

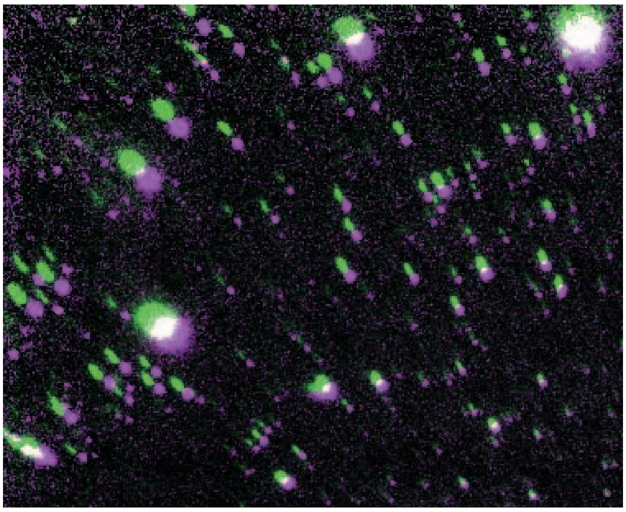


Fig. 18. The two images in Fig. 17 superimposed (corrected image in red, uncorrected in green).

Heidi Korhonen

Part of NOT's mission is to give young astronomers the experience of front-line observational astronomy and living abroad, then see them off to careers elsewhere. We have asked former NOT student Heidi Korhonen (AIP, Potsdam), former support astronomer Andreas Jaunsen (Paranal Observatory, Chile, but heading back to Norway), and former Astronomer-in-Charge Hugo Schwarz (Cerro Tololo Inter-American Observatory, Chile) about their experience from NOT.

Heidi, you were a NOT student on La Palma in 1998-1999. What attracted you to NOT?

Just after my Masters degree in 1997 I went to observe at NOT for 10 nights. I liked it a lot! Observing was fun, and even the sleepless nights and almost sleepless days didn't bother me. After my observing run I thought that it would be great to work in an observatory, but most likely I would never have the opportunity. A couple of months later I saw the NOT studentships announced. At that point I did not yet have funding for my Ph.D. studies, so I thought it was an excellent opportunity for me and applied immediately. The rest is history, as they say.

What did you like the most while you were here?

I liked almost everything, but especially the support duties at the mountain. I enjoyed meeting the visiting astronomers and getting to know them and their science. After a while at NOT, I knew most Nordic observational astronomers. It often felt like I was going up to the mountain to meet friends, not just to work.

– and what were the greatest challenges?

In the beginning, everything was also a challenge! When I came to NOT I knew almost nothing about observations. During the first months I had to learn a lot about the telescope operations, different instruments and about everything that can go wrong. Fortunately I learned relatively quickly what to do, and I could always call someone else if I was in doubt. I made some stupid mistakes during my first support nights alone, but I don't think I caused too much lost observing time. At least I hope I didn't! (smiles)

Looking back, what do you consider the most valuable result of your time at NOT?

For me there were several valuable results. First of all, I learned a lot about astronomical observations, telescope operations, and instruments. Second, I got to know a great many Nordic astronomers. Nowadays, almost wherever I go, to different institutes and to conferences, I meet people whom I first met at NOT. It is a very nice feeling. And third, on a much more personal level, I found my husband at NOT.

When you applied for your next job, was the NOT experience an asset? If yes, how?

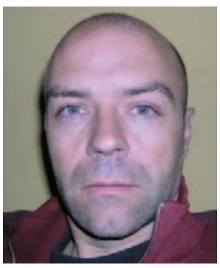
In July 1999 I went back to Finland. As usual in Finland, at that point I had no fellowship to fund the rest of my Ph.D. studies. But in January 1998 I got a full scholarship for the rest of my Ph.D. In all of Finland there are only 6 such positions in astronomy, and I managed to get one! I believe that my time at NOT was a big factor in my favour in competing for that scholarship. When I got my current Postdoc position at the Astrophysical Institute Potsdam, I believe the main factor was the science I had been doing, but I think it also helped that I had worked in an observatory; it shows that you have other skills than just those you get in university. I think my experience from NOT will also be very valuable when I apply for jobs in the future.

– and will you still come back to observe?

Since I left NOT I have been back twice, both times for a one-week observing run in November. During those runs, we spent most of the time sitting in the Residencia and watching clouds, snow, and rain... But when we could observe, we got some very nice spectra. So yes, I have been back, and I certainly plan to come back to NOT as often as I can.

Andreas, you were a support astronomer at NOT in 1995-1996. What attracted you to come?

I learned about NOT when I was an undergraduate student in 1990-91. Already at that time I was fascinated by the idea of living and working in an exotic environment such as La Palma. Later, I travelled to NOT on several occasions to observe and immediately found it very exciting – so I had my mind set on moving to La Palma as soon as I could. The motivation was mostly professional, however, i.e. to learn more about the instruments, observing strategies, and partially also to observe (in unused technical time).



Andreas Jaunsen

What did you like the most about being at NOT while you were here?

Many things. I enjoyed solving problems with the instruments, telescope or software, helping visitors to get started with their run, and the laid-back atmosphere of La Palma. But, most of all I think I enjoyed meeting all the people who came to NOT from various places, and working with the cheerful NOT staff!

– and what were the greatest challenges?
To remain calm and focused in stressful situations when I was practically alone with the responsibility of preparing upcoming runs, or when problems occurred and had to be fixed at short notice.

Looking back, what do you consider the most valuable result of your time at NOT?
Hands-on experience with instruments and the telescope, and practical experience with observing.

When you applied for your next job, was the NOT experience an asset? If yes, how?
I think my experience from NOT was part of the reason why I was chosen for the ESO fellowship program in 2000. At that time, they offered me a position at La Silla (instead of Paranal) because of my previous working experience at the NOT; La Silla operations are still more hands-on, as opposed to the more structured way of operating Paranal Observatory. In the end, however, I chose to go to Paranal because of its obvious advantages of being ESO's newest and the world's largest observatory. Although the job is very different from what I did at NOT, the experience I got there helped me to adapt quickly.

– and will you still come back to observe?
Of course. I hope to start new programs with the NOT in the near future and hope then to come back to visit!

Hugo, you came from ESO, La Silla, as NOT's first Astronomer-in-Charge 1995-2000. What attracted you to the job?
Oh, there were several reasons. A major one was that I knew NOT was a telescope that had much promise and should function well, but didn't; and I liked the challenge of being involved from the beginning in making such a major change. Being in charge of a group would also be a step up from my previous position. And I also wanted to move closer to Europe again.

What did you then like the most about the job once you came?
Building up the staff almost from scratch and creating a small, close-knit team in which I could make a real contribution and a visible difference, and seeing the improvements in operation. My ideas and suggestions did no longer just drown in a big machinery, but were discussed and taken seriously; sometimes they might be wrong, but then we would know just why. We also began to analyse the troubles in a systematic fashion, sort them out by importance, and solve them in that order – and downtime went from 12-15% to effectively zero. Being part of this – and a significant part – that was a great feeling! I could use my brain and experience to the fullest, and left NOT as a much better astronomer.

– and what were the greatest challenges?
Essentially two: (i) Turning a dysfunctional, understaffed telescope with a reputation for producing little science, and then of poor quality, into a buzzing and successful operation was a major effort, even with the experience I had from La Silla. (ii) Hiring a good staff, keeping things going, and maintaining good, lasting relations both with them, on the one hand – also when problems occurred! – and with a Director at a distance, on the other, was an unfamiliar task and a real challenge. And we never had quite the money we needed!

What do you consider the greatest achievements during your term?
Building a group that felt like a team, working together, taking decisions together, and making things actually happen. NOT went from failure to success during that period! And we got the service building extended into something that is actually useful, the Sea Level Office that allows the group to work so much more efficiently, and many other things.

When you decided to move on, was your experience from NOT an asset in applying for other positions?
Oh yes, absolutely!! I am now second in command on a much larger and more advanced new telescope at a first-rank international observatory, and have been a serious contender for even more prestigious positions. The management experience I got at NOT, and the perspective of seeing the full scope of a telescope operation, not just bits and pieces, were absolutely essential for the continuation of my career.

– and you still come back to NOT to observe?
Yes, I still have more good scientific ideas than I can get time for at my own observatory (laughs). But then I still feel that I know ALFOSC so well that I can do things with it that I cannot do anywhere else. And along came this great project for which TurPol seemed ideal, so no, you aren't finished with me yet!

Hugo Schwarz

STUDENTS @ NOT

NOTSA offers research studentships for astronomy and engineering students – currently the four of us, who come from three different countries, Denmark, Finland, and Sweden. We would like here to first describe the programme in general terms, then give our personal views after a good half year's experience of La Palma – an island that is quite different from back home.

NOT students are normally enrolled in M.Sc. or Ph.D. programmes at Nordic universities and work on their thesis about 75% of their time at NOT. A stipend from NOTSA covers our living expenses; in return, we spend ~25% of our time working on tasks for NOT, such as support to visiting astronomers or technical and astronomical tasks assigned by the staff. Most of the work is carried out in the NOT sea-level office (SLO) in Santa Cruz de La Palma. NOT students may live, at reasonable rates, in the two NOT apartments in Santa Cruz, each housing two students.

NOT is a very nice telescope on which to learn observational astronomy: Big enough that first-class science can be done, but not too big for students to be allowed and encouraged to participate in most aspects of the work – something that large telescopes cannot offer. The working atmosphere at NOT is very informal and encourages students to work independently. Thus, we gather a lot of experience and ability to work on other telescopes as well, which will be invaluable in our later research careers. Another benefit is getting familiar with Spanish culture and way of life, as many of the world's foremost observatories are located in Spanish-speaking countries; NOT offers 20 hours of Spanish lessons, adapted to the level of the individual student.

On average, we spend about 3 nights per month at the telescope, supporting visiting observers or doing service or technical observations. On a typical support night you drive up to the telescope just after lunch, which takes about one hour. Once at the telescope, the requested instrument set-up must be done, a few filters changed, or perhaps a couple of grisms and slits installed. In the afternoon the observer shows up, and you start introducing him/her to the telescope. The amount of instruction and night support needed varies greatly, as some observers are already veterans at NOT and others have almost no previous experience.

After dinner at the Residencia, you hurry up to the telescope to be ready to start the observations at sunset. Most of the time you spend about half of the first night helping the observers to start up and get familiar with the telescope; when they feel comfortable operating the telescope themselves, you can retire to the Residencia to sleep. On rare occasions something goes wrong at the telescope, and the

The spiral galaxy Messier 77. Photo: J. Näränen, R. Karjalainen

Left to right: NOT students Kalle Torstensson, Brian Krog, Raine Karjalainen, and Jyri Näranen.

The globular cluster Messier 3 in blue/red/infrared light, highlighting both the hot and cool evolved stars. Photo: M. Gålfalk

observers call you up. It is then your job to help them solve whatever problem they might have. In the morning you go back up, archive the data collected during the night, and check if any problems occurred that require action, after which you go down to Santa Cruz and the office again. Most of us participate in one or more observing programmes, thus increasing our total experience.

But work is not all: La Palma is a subtropical island on the western edge of the Canary Islands archipelago. The east coast is fairly humid, but the west coast is drier and easily accessible by car. The islanders call it La Isla Bonita (the beautiful island) or La Isla Verde (the green island), and it is one of the best hiking places in Europe. Well-marked trails take you through very diverse landscapes, from the southern volcanoes to subtropical rainforests at Los Tilos, not to forget the interior of the caldera, which is a realm of its own. But in addition to walks, La Palma offers all kinds of outdoor sports, such as year-round motorbiking, football, diving, and swimming.

Phil. Lic. Raine Karjalainen, Oulu, Finland: The opportunity to do observational astronomy was excellent for a guy who was used to sitting in front of the computer: My Master's and Licentiate thesis were on N-body simulations of the dynamics and photometry of planetary rings. But knowing how to use computers is still an advantage, as the romantic idea of looking at stars through the telescope is quite out of date. The NOT studentship is a very good way of getting your feet wet in making observations, even with little or no previous observing experience.

Brian Krog, B.Sc., Århus, Denmark: Before coming to La Palma, I got a B.Sc. degree in mathematics and physics at the University of Aarhus, after which I continued my studies in the field of astronomy. I am currently writing my M.Sc. thesis on Lyman-α Emitting Galaxy-building Objects (LEGOs) in the southern GOODS field.

Working at the NOT is a great working experience, and it gives a unique insight into the operations of a telescope. Apart from the opportunity to get a very intimate knowledge of making observations, it is also allows you to learn about instrumentation, data handling, and of course astronomy. I was lucky enough to get five nights at the telescope in December, using the instrument I know best; but then luck ran out and we had just about the worst weather of 2004. In fact, we could hardly get to the telescope – or anywhere else for that matter!

Moving from very flat Denmark to the steepest island in the world, and to another latitude and culture, is quite a change. The many scenic points on La Palma are all worth a visit, and living on the island also gives you an insight into Spanish culture and language. – And the restaurants and bars of La Palma are good places for absorbing both Spanish culture and beverages at a very reasonable price!

Jyri Näränen, M.Sc., Helsinki, Finland: I arrived on La Palma in May 2004. After graduating as an M.Sc. in astronomy from the University of Helsinki, it was clear to me that I wanted to do my Ph.D. work in observational astronomy. So applying for a NOT studentship was a natural decision. During my time at NOT I have participated in several projects, but the one that I'm most closely linked to is the Nordic Near Earth Object Network, in which I am a co-I. In this project, we study both the orbits of near-earth asteroids from new positional data, and their shapes and spin vectors from light curves – see p. 15-16.

I have really enjoyed working at the NOT as well as living in La Palma. On the one hand, I have learned great deal about observational astronomy and I'm still learning all the time. On the other hand, I am a keen motorbiker, and it's been fantastic to continue driving throughout the fall and winter. In Finland the season stops by end of September! I've also done some diving here; La Palma is also very beautiful underwater, and the visibility under the surface is much better than in the Baltic.

Even though I'm from Finland, I experienced the worst snowstorm of my life here in La Palma, in January 2005. I was up, supposedly observing for three nights, but during the second night it started hailing, and eventually I was stuck in the Residencia for 5 days. It was one of my most interesting experiences on La Palma this far: How many can boast of having created a snow man in the Canary Islands?? The storm highlighted the contrast between winter and summer conditions – and a nice reminder of the realities of observational astronomy!

Kalle Torstensson, M.Sc., Onsala, Sweden: I was the last of the students to arrive this year, and coming to La Palma in early September was a great way to prolong a much-too-short Nordic summer. I finished my master's thesis at Onsala Space Observatory in the spring of 2004, and with a background in radio astronomy, the studentship at La Palma gave me a perfect opportunity to expand into optical/IR astronomy. I am mainly working on AGN and starburst galaxies, and in particular with LINERs.

Observing with NOT can be quite exciting: I had six nights in February, but the weather was abysmal, and we spent a few days cleaning snow and ice from the dome without ever opening it. The last morning, as we were about to go down to Santa Cruz, we discovered that a lighting had struck the observatory. So we ended up spending the whole day bringing computers, telephones, and everything else back up. By then, the next snow storm had started, and we had to spend another night at the Residencia...

This year we are four NOT students, who usually go out with the four ING students. Living on La Palma makes you realize that it is a small, fairly remote island. Not that I don't like it – I enjoy it immensely – but there are certain things you don't find here, such as many night clubs (there is one!), fast food chains (McDonald's, Burger King), etc. On the other hand, where else can you escape from these things? Another treat is the locals, who are very hospitable and friendly and teach you Spanish with a nice Canarian (Palmeran) accent: "Hola guapa, soy soltero..."

By Raine Karjalainen,
Brian Krog,
Jyri Näränen, and
Kalle Torstensson

General

Providing observing time is the *raison d'être* of NOT. The competition is fierce, and it is essential that the allocation of observing time be done in a competent, impartial, and transparent manner. Accordingly, observing proposals are peer reviewed for scientific merit and ranked by an *Observing Programmes Committee (OPC)* of five respected Nordic scientists, appointed by the Council and independent of the NOT management (see p. 33).

Proposals are invited in May and November for the semesters beginning the following October 1 and April 1. The *Call for Proposals* is announced widely, and all necessary forms and information are available on the web *(http://www.not.iac.es/observing/proposals/)*. Based on the ranking by the OPC, the Director drafts a schedule, taking into account such practical constraints as object visibility and phases of the Moon. The OPC reviews the draft again before it is finalised and posted at our web site, and applicants are notified of the outcome. The agreements establishing the observatory specify that 20% of the time is reserved for Spanish astronomers, and 5% for international projects.

To promote competition and high scientific standards, external proposals are welcomed and reviewed on an equal footing with Nordic proposals. European astronomers with approved projects at NOT and several other European 2-4-m class telescopes may, in addition, be eligible for financial support from the EU under the OPTICON trans-national access programme (see *http://www.otri.iac.es/opticon/* for details).

The spiral galaxy NGC 7217. Photo: Näränen, K. Torstensson

Observing time in 2004

Observing statistics are compiled by allocation period, and this report covers the period April 1, 2004, to April 1, 2005. The *"pressure factor"* (nights requested/nights available) remained high at 2.0. In total, 316 nights were used for scientific observations (i.e., excluding technical time). Subtracting also Spanish and international time, 258 nights were allocated to scientific projects ranked by the OPC, plus the training course organised by Stockholm University (see the Report for 2003). Of these, 44 nights or 17% went to non-Nordic ("foreign") projects and 20 nights or 8% to projects by NOT staff; the remaining 194 nights were distributed as follows: Denmark 56 (29%), Finland 54 (28%), Iceland 0, Norway 30 (15%), and Sweden 55 (28%). Note that some "foreign" projects have Nordic P.I.s in long-term positions abroad.

The use of different instruments is also of interest. In 2004, instrument use was as follows: ALFOSC 207 nights (66%), NOTCam 47 (15%); SOFIN 40 (13%), MOSCA 8 (3%), Stancam 3 (1%), and visitor instruments 11 (3%). Fluctuations from semester to semester, and from year to year, are quite large.

Service observing, scheduled flexibly and executed by NOT staff, is offered if the scientific returns of a project may be enhanced significantly. This option is becoming increasingly popular, in particular for such unpredictable *Targets of Opportunity* as supernovae and gamma-ray bursts (see. p. 6-9), and service observations were conducted during 48 nights in 2004 (19% of the Nordic time). A simple *Observing Block* system ensures the safe and complete transfer of information from the P.I. to the observer and back.

Long-term trends in time allocation

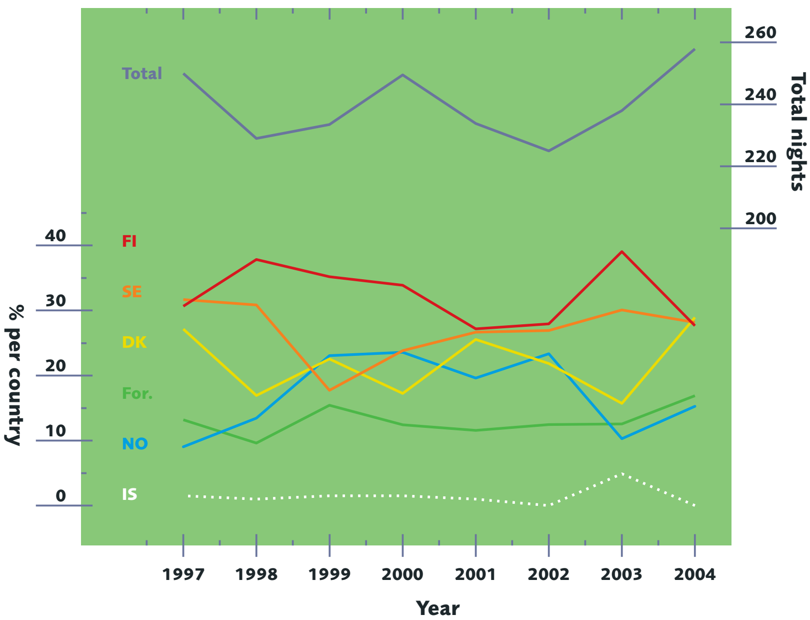
For planning purposes, it is important to distinguish long-term trends in the demand for observing time from short-term fluctuations caused by the changing interests of small, but active research groups – sometimes driven by instrument availability. Several persistent trends can be distinguished, and are being acted upon:

First, the demand for **service observing** continues to increase. As it has been found to require ~30% more staff effort than classical visitor mode, the priority given to it must be carefully weighed against the cost. However, the success of this service has been such that it has been decided to enhance it from April 2005 by a "fast-track" proposal mode, offered for a fixed set of instrument configurations: Short projects can be submitted at any time, reviewed quickly and, if approved, executed within a month or so after submission (weather permitting!). This is expected to be useful for pilot projects in preparation for larger projects, snapshot projects, and cases where a few hours will allow

to complete a project interrupted by clouds or by an urgent *Target-of-Opportunity* observation. For details, see our web site.

Flexibility of the instrumentation is also needed to schedule observations in a scientifically optimum manner. The fibre-fed spectrograph FIES will allow us to offer high-resolution spectroscopy as well as direct imaging at very short notice, without time-consuming instrument changes. However, further considerable upgrade of the standby instrumentation at NOT will require investments of manpower and money that may be difficult to justify, given the compromises in performance that will be necessary. Accordingly, we are beginning to explore the possibility of a closer alliance with our British and Italian neighbours and friends, allowing us to offer more powerful scientific capabilities through an exchange of time rather than of instruments. Implementing such a system will take a few years – but so do instrumentation projects, from concept through funding to construction and commissioning.

Annual number of nights allocated by NOT, and the Nordic and "foreign" (For.) shares of the time.



Outside interest in NOT, as measured by approved "foreign" projects, has long remained at a level of 10-12% of the observing time, but jumped to 17% in 2004. This is undoubtedly due, at least in part, to the OPTICON *Trans-national Access Programme* (see. p. 5), which encourages proposals from non-Nordic astronomers. Indeed, NOT was the most successful telescope in the entire OPTICON network in terms of the number of projects, teams, and observers supported under the programme. While this obviously reduces the Nordic observing time at NOT itself, the OPTICON programme similarly opens access for Nordic astronomers to a wide range of European state-of-the-art night-time and Solar telescopes all over the world. Moreover, the User Fees received from OPTICON allow us to hire extra staff and thus compensate the Nordic community in quality of service for the loss in quantity of access at NOT.

The **national distribution of observing time** is not a pure question of scientific ranking, but cannot be ignored, given that the Danish, Finnish, Icelandic, Norwegian, and Swedish Associates share the operating costs of NOT in the proportions 20:30:1:20:30%, respectively. Common sense advises that, in the long run, each community should get approximately the fraction of time its Associate pays for.

Classifying projects by the nationality of the P.I., the figure shows the total number of nights allocated annually by NOTSA as well as the national shares of the Nordic observing time and of "foreign" projects, for the years for which adequate statistics exist. Averaged over the last five years, the Nordic time has been distributed with 22.6% to Danish projects, 30.4% to Finland, 1.4% to Iceland, 17.2% to Norway, and 28.5% to Sweden. Staff and "foreign" time account for 6% and 14% of the total allocated to all projects. Within the considerable fluctuations seen from year to year, there appear to be no major anomalies, but the evolution will be kept under close scrutiny.

FINANCIAL MATTERS

General

NOTSA is a non-profit organisation. Its income, contributed almost 100% by the Associates, is devoted entirely to the operation and development of NOT according to the policies set by the Council. Budgets and accounts are submitted annually to the Council for approval. The Director is then responsible for operating NOT within the approved budgets and in compliance with *Financial Rules* defined by the Council, which also appoints the auditors for four years at a time. In 2003-2005, NOTSA's accounts are audited by *Audiator OY* of Finland.

A mid-term financial strategy was approved by the Council in 2002, by which a programme to upgrade our facilities and services to users would be conducted in 2003-2005, hiring additional staff for the task. The budgets for the years 2003-2005 therefore operate with negative results until end-of-year reserves return to normal operating levels.

Accounts for 2004

NOTSA's accounts for 2004 are summarised in the table (next page) and compared with the approved budget for 2004 as well as the final accounts for 2003. Note that the 2004 accounts were not yet audited at the time of writing, so minor adjustments between headings may occur in the final version. The content of each budget heading is explained below.

Budget headings

Directorate covers directorate staff and operations, committee travel, financial charges, stipends to Spanish Ph.D. students at Nordic universities, OPTICON meeting travel, and the Annual Report.

La Palma staff includes staff, students, and visitors on La Palma, including health insurance, training courses etc.

La Palma infrastructure includes the NOT facilities on the mountain and at sea level; electricity, water, and cleaning; computer networks; and cars and other transportation.

La Palma operations cover staff accommodation and meals at the observatory; communications and shipping; and telescope, laboratory, and office equipment and consumables, etc.

Telescope and instrument operation and maintenance comprises operation, repair, and upgrade of telescope and instruments, cryogenics, electronics, optics, and data acquisition and archiving equipment.

Development projects indicate investment in major new facilities or instrumentation as approved by the Council on a case-by-case basis (primarily FIES).

Contributions are shared among the Associates as follows: Denmark 19.8%, Finland 29.7%, Iceland 1%, Norway 19.8%, and Sweden 29.7%.

Other income derives from bank interest, refunds from the OPTICON EU contracts, and sale of souvenirs.

Financial developments in 2004

As shown by the table above, the actual cost of the directorate, facilities, and operations in 2004 corresponded quite well to the budget. Staff costs increased relative to 2003 because new staff was hired, but remained well within budget. The expansion and air conditioning of the sea-level office in Santa Cruz was completed and paid in 2004 within the budget foreseen. *Telescope operations* went up relative to 2003, primarily due to the telescope cooling system repair, which was approved by the Council in mid-year, but only halfway finished by the end of the year; total expenses remained within the budget as approved in late 2003.

The budget for *Instrument operation and maintenance* included substantial funding for new detectors and filters for the wide-field camera FRED, none of which became ripe for implementation in 2004. 50 kEuro for renewal of the detector controller systems were foreseen under *Telescope development projects*, but progress at Copenhagen University was delayed, and our funds remained unspent. *Special development projects* denotes the high-resolution spectrograph FIES. Amazingly, just getting a building design and construction permit took all of 2004(!); the permit was finally issued in January 2005, but little money could be spent in 2004.

Overall, the deficit in 2004 as recorded in the accounts was only half of the amount budgeted. However, as explained above, most of the apparent savings on upgrade and development projects correspond to expenses deferred until 2005; given the known commitments and progress on these projects, we are confident that they will be completed (and the corresponding funds spent) in 2005.

Accordingly, a very substantial deficit is foreseen for 2005, partly because of the completion of the development projects referred to above, partly due to the implications of the new staff contracts. Given the healthy reserves at the end of 2004, cash flow problems are not expected in 2005, but additional funding will be needed from 2006 to maintain and develop our services as described in this report. Discussions with the Associates are under way at the time of this writing, with a result expected during 2005.

ACCOUNTS

BUDGET HEADING	Expenses 2004 Euro	Budget 2004 kEuro	Expenses 2003 kEuro
Directorate	193 215	230	205
La Palma staff	791 804	835	668
La Palma infrastructure	158 855	155	124
La Palma operations	113 233	105	99
Telescope operation and maintenance	86 413	85	38
Instrument operation and maintenance	46 470	115	54
Telescope development projects	19 023	95	14
Special development projects	3 195	50	31
Total expenses	**1 412 208**	**1 670**	**1 233**
Contributions	1 207 400	1 207	1 184
Other income	31 794	118	46
Total income	**1 239 194**	**1 325**	**1 230**
Result of the year	**-173 013**	**-345**	**-3**
Reserves at beginning of the year	867 737	770	871
Reserves at end of the year	744 724	425	868

The spiral galaxy Messier 102. Photo: J. Näränen, R. Karjalainen

The first observer battling his way towards NOT after the snowstorm in February 2005. Photo: J.-E. Solheim

Publications measure the productivity of observers rather than of telescopes; yet they are one of the standard measures of the scientific output of an observatory such as NOT. Accordingly, users are requested to report all refereed papers based on NOT data to the data base maintained at our web site. Papers published in 2004 are listed below; if they have more than 12 authors, six names and the total number are given.

International refereed journals:

Aerts, C., De Cat, P., Handler, G., Heiter, U., Balona, L.A., Krzesinski, J. et al. (25 authors including J. Telting, NOT): *"Asteroseismology of the β Cephei star ν Eridani II. Spectroscopic observations and pulsational frequency analysis"*, 2004, MNRAS **347**, 463

Arribas, S., Bushouse, H., Lucas, R.A., Colina, L., Borne, Kirk D.: *"Optical imaging of very luminous infrared galaxy systems: Photometric properties and late evolution"*, 2004, AJ, **127**, 2522

Ausseloos, M., Scuflaire, R., Thoul, A., Aerts, C.: *"Asteroseismology of the β Cephei star ν Eridani: massive exploration of standard and non-standard stellar models to fit the oscillation data"*, 2004, MNRAS **355**, 352

Benetti, S., Meikle, P., Stehle, M., Altavilla, G., Desidera, S., Folatelli, G. et al. (18 authors): *"Supernova 2002bo: Inadequacy of the single parameter description"*, 2004, MNRAS **348**, 261

Blanc, G., Afonso, C., Alard, C., Albert, J.N., Aldering, G., Amadon, A. et al. (59 authors, including J. Andersen, NOT): *"Type Ia supernova rate at a redshift of approx 0.1"*, 2004, A&A **423**, 881

Cid Fernandes, R., González Delgado, R.M., Schmitt, H., Storchi-Bergmann, T., Martins, L.P., Pérez, E., Heckman, T., Leitherer, C., Schaerer, D.: *"The stellar populations of low-luminosity active galactic nuclei. I. Ground-based observations"*, 2004, ApJ **605**, 105

Clem, J.L., VandenBerg, D.A., Grundahl, F., Bell, R.A.: *"Empirically constrained color-temperature relations. II. uvby"*, 2004, AJ **127**, 1227

Dahlén, T., Fransson, C., Östlin, G., Näslund, M.: *"The galaxy population of intermediate-redshift clusters"*, 2004, MNRAS, **350**, 253

Esteban, C., López-Martín, L., López-Sánchez, Á.R., Cedrés, B., García-Rojas, J.: *"IRAS 04000+5052: A not so compact, not so metal-poor H II region"*, 2004, PASP **116**, 723

Gålfalk, M., Olofsson, G., Kaas, A.A., Olofsson, S., Bontemps, S., Nordh, L. et al. (20 authors): *"ISOCAM observations of the L1551 star formation region"*, 2004, A&A **420**, 945

Garavini, G., Folatelli, G., Goobar, A., Nobili, S., Aldering, G., Amadon, A. et al. (58 authors): *"Spectroscopic observations and analysis of the peculiar SN 1999aa"*, 2004, AJ **128**, 387

González Delgado, R.M., Cid Fernandes, R., Pérez, E., Martins, L.P., Storchi-Bergmann, T., Schmitt, H., Heckman, T., Leitherer, C.: *"The stellar populations of low-luminosity active galactic nuclei. II. Space Telescope Imaging Spectrograph observations"*, 2004, ApJ **605**, 127

Gutiérrez C.M., López-Corredoira M.: *"QSO+Galaxy association and discrepant redshifts in NEQ3"*, 2004, ApJ, 605, L5

Hakala, P., Ramsay, G., Byckling, K.: *"Monitoring the spin up in RX J0806+15 2004"*, MNRAS **353**, 453

Heber, U., Drechsel, H., Østensen, R.H., Karl, C., Napiwotzki, R., Altmann, M., Cordes, O., Solheim, J.-E., Voss, B., Köster, D., Folkes, S.: *"HS 2333+3927: A new sdB+dM binary with a large reflection effect"*, 2004, A&A **420**, 251

Heidt, J., Tröller, M., Nilsson, K., Jäger, K., Takalo, L. O., Rekola, R., Sillanpää, A.: *"Evolution of BL Lacertae host galaxies"*, 2004, A&A **418**, 813

Hunt, L. K., Pierini, D., Giovanardi, C.: *"Near-infrared observations of galaxies in Pisces-Perseus. V. On the origin of bulges"*, 2004, A&A **414**, 905

Jakobsson, P., Hjorth, J., Ramírez-Ruiz, E., Kouveliotou, C., Pedersen, K., Fynbo, J.P.U. et al. (15 authors): *"Small-scale variations in the radiating surface of the GRB011211 jet"*, 2004, New Astronomy, **9**, 435

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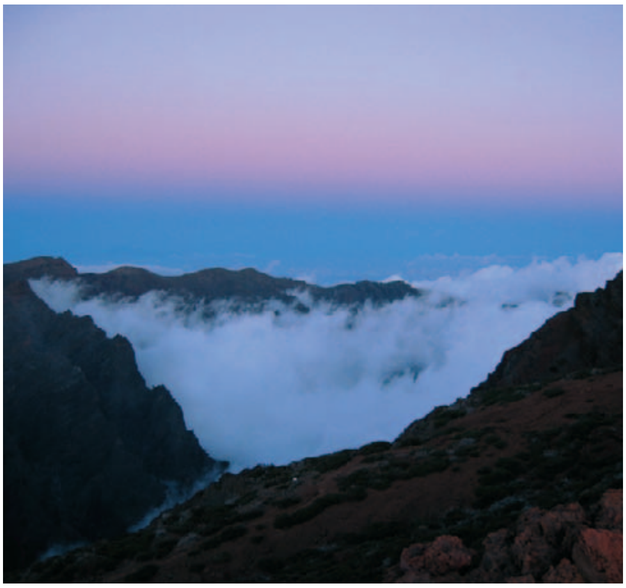

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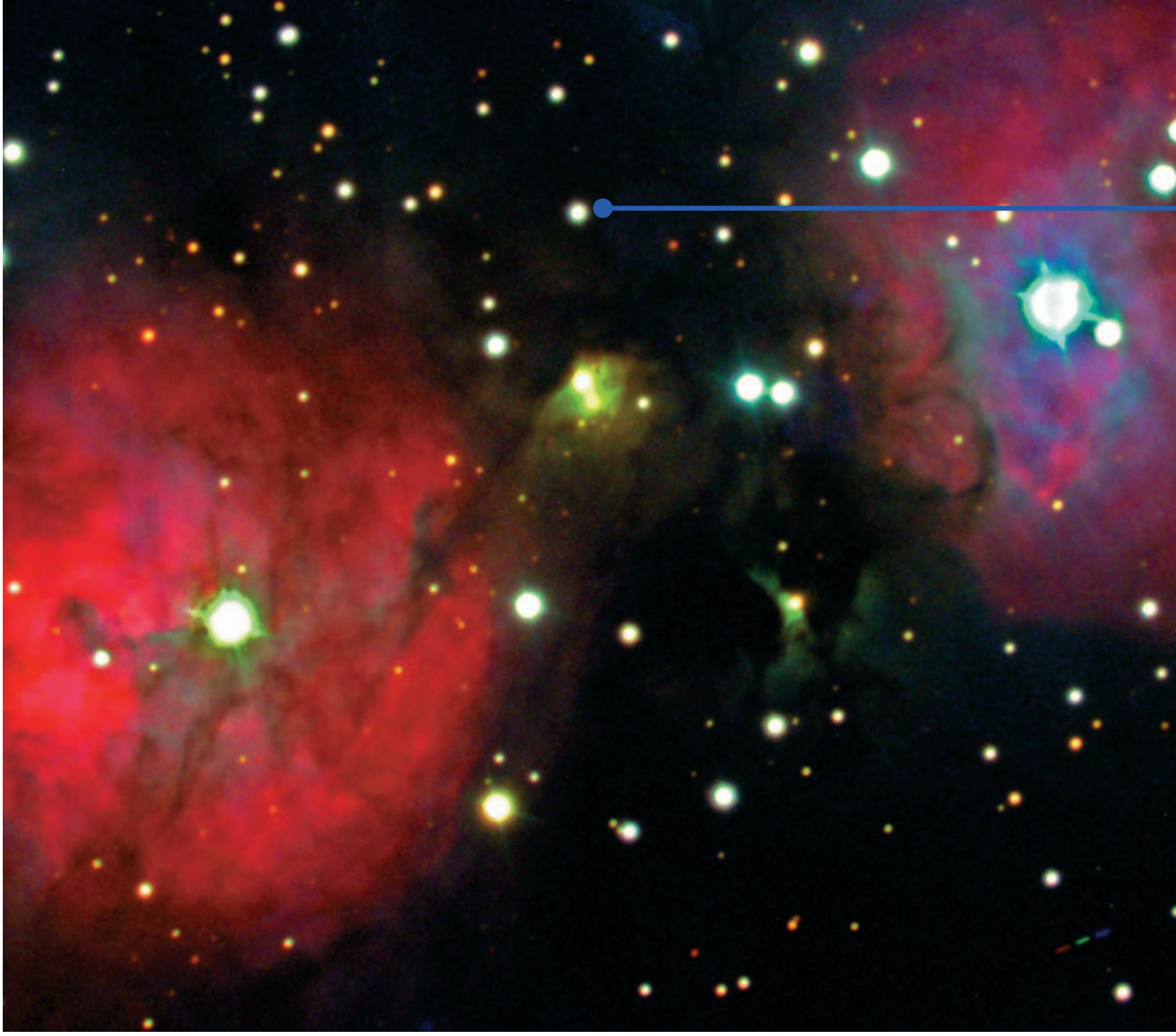

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Back cover: The northern spiral galaxy Messier 51. ALFOSC images in blue, yellow, and red light have been combined to highlight the bright, young blue stars on the outside of the spiral arms, and the older, yellow stars inside. Photo: M. Gålfalk, Stockholm University.

2004

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The spiral Galaxy Messier 51.

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