2008

NORDIC OPTICAL TELESCOPE

ANNUAL REPORT

Galaxy clusters acting as gravitational lenses.

Front cover: A mosaic of galaxy clusters showing strong gravitational lensing and giant arcs discovered with the NOT (see p. 5). Composite images in blue and red light from the NOT, Gemini, and Subaru telescopes. Photo: H. Dahle, Oslo.

NORDIC OPTICAL TELESCOPE

The Nordic Optical Telescope (NOT) is a modern 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 chief governing body of NOTSA is the Council, which sets overall policy, approves the annual budgets and accounts, and appoints the Director and Astronomer-in-Charge. A **Scientific and Technical Committee** (STC) advises the Council on scientific and technical policy.

An **Observing Programmes Committee** (OPC) of independent experts, appointed by the Council, performs peer review and scientific ranking of the observing proposals submitted. Based on the ranking by the OPC, the Director prepares the actual observing schedule.

The **Director** has overall responsibility for the operation of NOTSA, 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 matters related to the daily operation of NOT.

The members of the Council and committees and contact information to NOT are listed at the end of this report.

The NOT Annual Reports for 2002-2008 are available at:
http://www.not.iac.es/news/reports/

CONTENTS

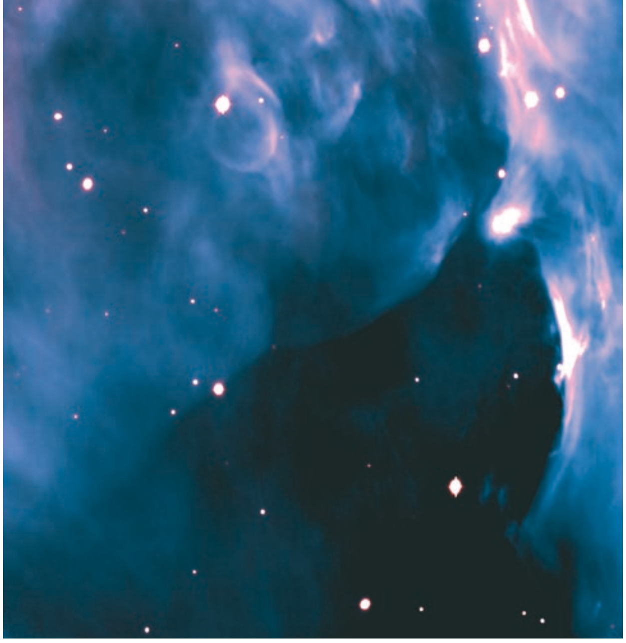
Editor: Johannes Andersen
Layout: Anne Marie Brammer

2

THE NOT TEAM

The NOT staff was strengthened in August, when former NOT student Raine Karjalainen took up a two-year post-doc position. Among our current students, Jarkko Niemelä (Helsinki) was succeeded by Zita Banhidi in June, while the others remained on board until the end of the year.

In accordance with the agreements with Spain, we also provided stipends for Spanish PhD students Laia Mencia Trinchant and Javier Blasco Herrera to obtain their degrees in Stockholm.



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PREFACE

It is a pleasure to introduce this report on a productive 2008 at the Nordic Optical Telescope. Steady progress has been made on several fronts of short- and long-term significance, and the crystal ball through which we try to peer into the future has become a bit less opaque. The following gives a brief overview of the main issues.

First, although I take pride in the accomplishments of the year, credit goes to the great team of people greeting you on the facing page. We were pleased to welcome our former student Raine Karjalainen back in mid-year in a postdoc position funded by NORDFORSK, and Zita Banhidi who replaced Jarkko Niemelä in the student group. The spirit in which Thomas Augusteijn runs his team is well illustrated by the above photo from the "family reunion" in July at Carlos Pérez' "summer palace"!

Preparing for the future remained my own first priority. As described earlier, our agreed long-term goal is to join a larger, coordinated and cost-effective European mid-size telescope facility. The task is to find out what it means in specific terms, what role the NOT should play, and how to make it happen under as-yet unknown rules. We pursue it along three main lines: Developing the infrastructure planning framework in European astronomy; developing our user base; and developing our own services. In parallel, NOTSA joined the worldwide IAU-UN *International Year of Astronomy 2009* as an official Associate.

On the European scene, the publication of the ASTRONET *Infrastructure Roadmap* in 2008 was an historic event: Never before have European policy makers been presented with a comprehensive plan for *all* of astronomy in *all* of Europe, based on a common scientific vision and extensive community input. The Roadmap deals not only with the future mega-projects in ground- and space-based astronomy at all wavelengths, but also with the roles of existing facilities, theory, computing and archiving, and the crucial human resources – all within a plausible budget. Funding agencies in 26 countries with over 500 million inhabitants are now behind the Roadmap, which gives it credibility, but no guarantee of funding for the implementation phase. We are already moving into that phase, as ASTRONET has appointed a committee to review the future roles and organisation of all the European 2-4m telescopes by the end of 2009. We hope its report will enable us to progress towards our goal.

Meanwhile, we are broadening our user base in two directions. First, the NOT is becoming very attractive for European astronomers in general; indeed, a year ago, "foreign" proposals for observing time already outnumbered Nordic projects. The role of OPTICON in catalysing this development will probably prove more important in the long term than the cash refunds we receive. Second, we are developing a broad, coordinated set of educational services that is currently aimed at Nordic universities, but should be equally attractive throughout Europe.

Finally, we are developing our own capabilities. The telescope itself is fit for fight for another 20 years after a complete renewal of its basic infrastructure. We are now tuning our suite of instruments and our operations for maximum efficiency on the agreed priority science, transient and variable objects. Later chapters in this report give you more detail, but many of this year's science stories already show that our users are taking advantage of our increased flexibility, "fast-track" proposal option, and enhanced instrumentation.

But while we prepare for the future, our users keep the present busy and rewarding, and the following pages highlight some of the scientific projects recently carried out at the NOT. I thank the authors for sharing their stories with us, and hope that they will be pleased to see them in the attractive layout of Anne Marie Brammer.

Johannes Andersen

Johannes Andersen
Director & Editor

EVENTS IN 2008

The new control electronics for the building and telescope drives, dubbed "R2-D2" (the 'Star Wars' robot) and "Prof. AltAz" by our tireless staff.

A few main events in 2008 are summarised here. More detailed reports on instruments, education, observing time, and finances are given in later sections and at our web site.

Renewing the infrastructure

The NOT has been in continuous operation for twenty years, and some basic components were showing signs of wear and old age. Many spare parts are no longer available, and incomplete or missing documentation implied a risk of major breakdowns. Over the last five years we have gradually renewed the entire cooling system of the building, the control system of the telescope, and the drive electronics and motors for both. 2008 saw the arrival of the last units (see photo), and the telescope should now be fit for another 20 years. Moreover, the modern architecture and processor power of the new control systems create a basis for integrated user control of the entire facility.

ASTRONET and OPTICON

The ASTRONET project was initiated in 2005 by the major funding agencies for astronomy in Europe (see *www.astronet-eu.org*). Its goal is to establish a comprehensive planning and coordination process for all of European astronomy to promote its further competitive development – analogous to the US Decadal Surveys, but adapted to today's Europe. NOTSA is one of the participants.

As a first step, the ASTRONET *Science Vision* report (2007) charted the general course that our science should follow over the next 15-25 years. ~50 of the best scientists in Europe were assisted in its preparation by extensive input from the community. Based on the *Science Vision*, the ASTRONET *Infrastructure Roadmap* has now been completed in a similarly open process to describe the tools we need to reach those scientific goals.

Released in November 2008, the 180-page Roadmap presents a comprehensive, cost-effective plan for the – mostly national – investments that will be needed to keep Europe competitive at the forefront of astronomy. It describes not only the headline-grabbing mega-projects, but the entire food chain of astronomy from schoolchildren to space telescopes. Making the giant projects reality will take time, but ASTRONET has already now appointed a *European Telescope Strategy Review Committee* to take a fresh look at how Europe organises its 2-4m telescopes and, by the end of 2009, propose ways to do it better. We support this initiative vigorously.

2008 was the last year of the OPTICON EC contract under FP6. A four-year extension under FP7 has been approved, but with only half the current funding level. OPTICON will therefore focus on networking and support for the development of potential future technologies, but the *Trans-National Access Programme* will be reduced to ~2% of the total observing time. The plan, therefore, is to retain most of our European users for the next couple of years while developing new strategies for the longer term in cooperation with ASTRONET. 2009 and 2010 will be exciting years!

Nordic cooperation

The Report for 2007 described our strategy to forge closer ties within Nordic optical and mm astronomy to prepare for the time (soon!) when they will not be seen as separate disciplines. NORDFORSK awarded grants to NOTSA and Onsala Space Observatory, Sweden, to accelerate this development in education and research, and this was boosted in 2008 by grants to hold joint Nordic-Baltic optical/mm Research Training Courses in 2009 and 2010. The first of these will take place in Turku, Finland, in June 2009.

Developing the NOT

Meanwhile, we are busy implementing the *Development Plan* for the scientific and educational services of NOT that was approved by the Council in 2007, based on the Nordic strategy agreed in 2006. We are already offering more scheduling flexibility and better facilities for both science and education (see p. 24), and the performance of our instruments (notably FIES – p. 20) is constantly being improved. More to follow in 2009!

J.A.

The core mission of NOT is to enable Nordic astronomers tto do science. The professional publications listed on p. 29 are the official record of our scientific output in 2008, but a few highlights are given below. Contributions have been edited to fit the available space, and for consistency of style.

COSMOLOGY AND FORMATION AND EVOLUTION OF GALAXIES

Standard cosmology says that the Universe is dominated by dark energy and dark matter of an unknown nature. Understanding these mysterious concepts and their role in shaping the visible Universe – the galaxies – is a central goal of observational cosmology. In turn, the first stars and galaxies set the Universe on its journey from primordial soup to today's world of galaxies, stars, planets, and life.

Weighing the dark matter in the Universe

The nature of dark matter is a key problem in modern cosmology – more than 80% of all matter around us is in an unknown form. Clues to the nature of dark matter may come from its distribution in massive objects. The phenomenon of "gravitational lensing" offers a direct way to probe this distribution: Very massive objects in the universe bend the rays of light from background sources along the same line of sight, and the distorted images can be used to infer the amount and distribution of total – mostly dark – matter in the lens.

Clusters of galaxies are the largest well-defined concentrations of dark (and luminous) matter. Massive clusters acting as gravitational lenses may produce strong, dramatic examples of such lensing – giant arcs sometimes observed around such clusters. The arcs are images of distant galaxies that have been strongly distorted by the massive gravitational lens. At larger projected radii from the center of mass, more subtle lensing effects are seen as systematic weak distortions of background galaxy images.

A combined analysis of the strong lensing effects seen near the cluster centers and the weak lensing detected at much larger radii allows us to accurately probe the dark matter distribution in the lensing cluster on a very wide range of scales. This can be compared to predictions from numerical simulations of the dark-matter distribution, which predict significant variations between clusters. A large, well-defined selection of cluster lenses is required to compare the simulated and observed distributions properly.

Fig. 1: Six strong cluster lenses, all recently discovered using NOT. Blue galaxies far behind the massive galaxy clusters are magnified and distorted into arcs by strong lensing effects (images from NOT, Gemini and Subaru).

The Sloan Digital Sky Survey (SDSS) is now providing large numbers of potential cluster lenses. So far, ~500 clusters have been imaged in good seeing conditions, resulting in the discovery of over 50 new lensing clusters. Most of the new clusters with giant arcs have been discovered using MOSCA at the NOT (see examples in Figs. 1 and 2), and spectroscopic redshift determination for these objects is under way at 8-10m telescopes. This has already led to the discovery of several very distant, highly magnified galaxies ($z > 5$).

Preliminary results from combined strong- and weak-lensing analyses of a small sample of clusters indicate that real dark matter is more centrally concentrated than expected from simulations. Potential, intriguing explanations include as-yet unexpected properties of dark matter and/or dark energy.

H. Dahle, N. E. Groeneboom, Ø. Rudjord, J. R. Kristiansen (Oslo); the SDSS Giant Arc Survey team

Fig. 2: The complex mass distribution of the galaxy cluster SDSS J1226+2152. Our MOSCA images first revealed one strong lens with a bright blue arc (centre), later a second cluster core and even stronger lens (lower left) and a third, smaller mass concentration (lower right). The blue shading shows the dark matter distribution as inferred from a weak gravitational-lensing analysis (NOT and Subaru images).

Galaxy clusters as giant gravitational lenses

Strong gravitational lenses (see above) may also produce multiple images of a single background object, typically a quasar. About 100 such cases are now known. In almost all cases, the objects acting as a gravitational lens and splitting the images are individual galaxies, and image separations are just a few arcseconds at most.

Only two recently-discovered multiply-imaged quasars have image separations larger than 10", and in both cases the lens is a galaxy cluster rather than a single galaxy. The largest-separation lensed quasar, SDSS J1029+2623 was discovered in 2006. The source is a distant quasar at redshift $z = 2.2$, which is split into three images by the lens, a foreground galaxy cluster at $z = 0.6$. The largest separation between the quasar images is 22.5". An unusually massive lens is required to produce such a large image separation, so finding a remote quasar precisely aligned with a sufficiently massive cluster of galaxies is an extremely rare event.

We have used MOSCA observations at NOT to further characterize this lens, using both strong and weak lensing measurements to constrain the total mass and mass distribution in the cluster. Our deep images (Fig. 3) reveal several blue background galaxies that are stretched into giant arcs by the gravitational lens effect. A model of the central mass distribution in the lensing cluster has been constructed from these strongly lensed objects.

A weak-lensing analysis of the background galaxies in a wider field can be used to determine the distribution of total (i.e. dark and luminous) matter in the entire cluster. A meaningful weak-lensing analysis of a cluster at $z = 0.6$ normally requires a larger telescope than NOT, because the images must be very deep to reveal a sufficient number of lensed galaxies far beyond the cluster. However, MOSCA images obtained in excellent seeing conditions (0.5-0.6") enabled us to make a firm detection of the weak gravitational signal of the cluster lens. This confirms the centre position and ellipticity of the mass distribution as derived from the strong-lens model. We find that the lensing cluster is one of the most massive galaxy clusters known at $z = 0.6$. In the future, a larger sample of similar, widely separated lensed quasars may place strong constraints on the cosmological model.

H. Dahle, B.E. Berntsen, Oslo

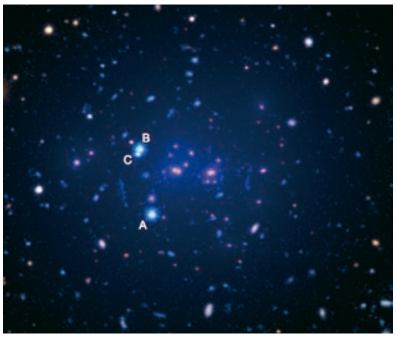


Fig. 3. Composite (blue and red) colour image of the gravitationally lensed quasar SDSS J1029+2623; the three images of the quasar are labelled A, B and C. The images of several faint blue galaxies are stretched into narrow arcs by the gravitational lens. The reddish objects inside the galaxy cluster are massive elliptical galaxies, which together form the gravitational lens. The diffuse blue light shows the overall mass distribution in the cluster, inferred from a strong-lensing analysis of system.

Gamma-ray burst redshifts from the NOT

Gammy-ray bursts (GRBs) are among the most violent phenomena in the Universe. When optical afterglows were initially discovered in 1997, the first priority was to determine their distances and, when these were found to be vast, the explosion mechanism and the nature of the progenitors. The long-duration bursts are now known to arise in the explosion of very massive stars, while the origin of the short GRBs is less clear.

During the last decade, tremendous progress has been made. One of the most interesting aspects of GRB research is that, in fact, it sheds new light on a very broad range of astrophysics: The reionization epoch in the early Universe; star formation, stellar evolution, and the formation of compact objects; interstellar gas, heavy-element enrichment, dust, and light extinction; and low-luminosity galaxies and chemical evolution at high redshift.

Determining distances for a large, representative sample of GRBs remains fundamental to all these studies. The *Swift* satellite (see the Annual Report for 2004) combines high sensitivity with prompt reporting and accurate X-ray and optical positions of new GRBs, essential for ground-based spectroscopy to become possible. Our aim is to determine redshifts for a complete sample of GRBs, using mainly the ESO Very Large Telescope (VLT) and the NOT. With the typical rapid decline of GRB afterglows, being early on the target can often far outweigh the size advantage of the larger telescope.

In order to maximise our success rate, we select a subset of the *Swift* GRB detections with favourable conditions for ground-based follow-up observations, without biasing the sample towards optically bright afterglows. Of course, this reduces the sample size (from 370 to 168), but the redshift completeness increases greatly: 88 out of 168 now have reported redshifts. A plot of the afterglow magnitude as a function of the time after the GRB when the redshift was obtained (Fig. 4) shows that most are then already fainter than $R = 20$, the practical limit for spectroscopy with 2-4-m telescopes. Hence, 8-10-m telescopes are needed to secure most *Swift* GRB redshifts.

However, NOT retains an important role in GRB redshift determinations: In 2008 we managed to secure redshifts for 4 GRBs with NOT – by far the largest number from any 2-4-m class telescope, and the result of its flexible operation and wide range of instrumentation. This has been essential for our project and will hopefully remain so indefinitely!

P. Jakobsson, Reykjavík, and collaborators

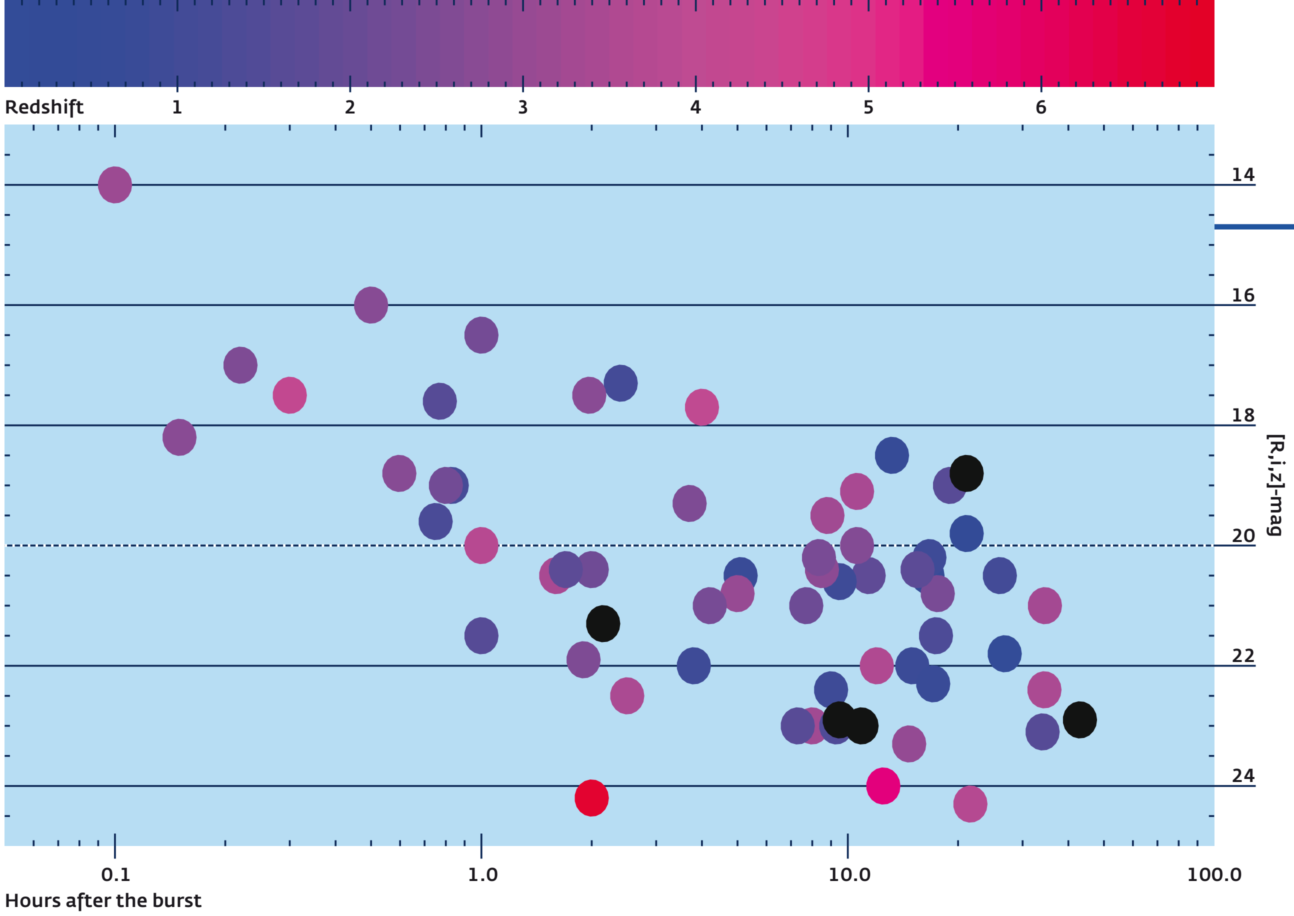


Fig. 4. Red/infrared magnitudes of GRB afterglows when the spectroscopic redshifts were obtained. The measured redshifts are colour coded (see the scale at the top). The dashed line at R = 20 marks the limit for 2-4-m telescopes to detect absorption lines, so quick action is essential.

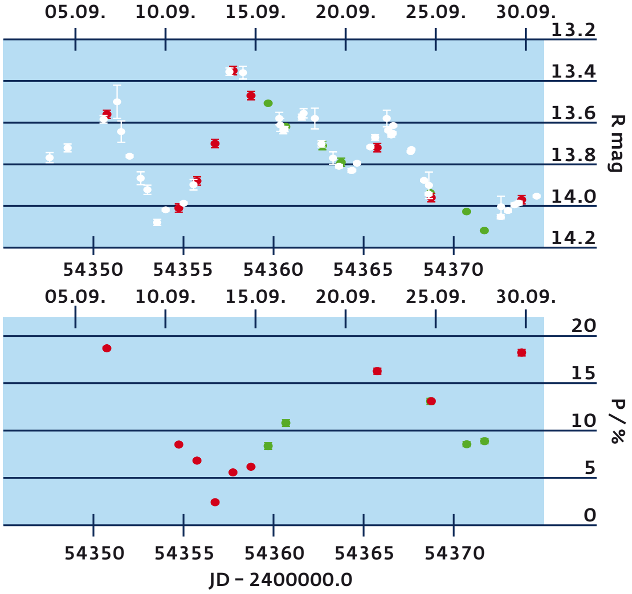
A black hole binary in a quasar

Most galaxies – including our own Milky Way – are thought to harbour a central, massive black hole. Present-day galaxies are believed to form by gradual mergers of smaller galaxies over cosmic time, building up the central black hole to supermassive size. And quasars are seen when such a supermassive black hole accretes material from its host galaxy and emits powerful jets in our direction. The details of these processes are the subject of intense study.

The quasar OJ287 is exceptional by showing quasiperiodic optical outbursts every ~12 years over the past 115 years. This was first recognized in 1982 by A. Sillanpää, who predicted another outburst in 1983 and observed it to arrive on schedule. This led to a gradually improving series of binary black hole models, with H. Lehto as one of the prime architects. By 2007, four more outbursts had been observed to occur as predicted, within an accuracy of three weeks. This was enough information for M. Valtonen to make a very detailed prediction of the 2007 outburst, using an elaborate general relativistic orbit calculation by S. Mikkola. September 13, 2007, was the most likely date. However, OJ287 had a conjunction with the Sun only a month earlier, and it only began to become observable in the morning twilight in the second week of September.

Enter the NOT. One of its special capabilities is pointing very close to the horizon, enabling us to see OJ287 in early September, and we were granted generous observing time. Unlike the "normal", fainter outbursts of OJ287, which are highly polarized (up to 40%), the type of outburst we were expecting emits unpolarized light, and NOT can make polarization measurements as well. The main NOT observer was staff astronomer T. Pursimo, and as Fig. 5 shows, these observations were indeed crucial in dating the unpolarized outburst peak among the data from many observers from Japan to Britain and Spain. The outburst began on September 12, within a day from the predicted time and well within the error margin of the orbit solution – remarkably close considering that the (redshifted) basic orbital period is 12 years.

Fig. 5. Measurements of optical flux and polarization of OJ287 in September 2007. Red and green points: NOT and Calar Alto observations (figure: K. Nilsson).



Why did this result merit publication in *Nature* (p. 31)? More importantly than just verifying that binary black holes exist, as they should on theoretical grounds, this binary system is in fact highly relativistic (see Fig. 6). For the first time, we can probe the exact details of gravitational acceleration in very strong fields and prove that the central body is indeed a black hole, not just "something heavy". Subsequent work has shown that when the 2007 outburst and two others are included in a new orbit solution, even the quadrupole acceleration and the spin of the primary black hole can be determined. So make sure that your telescope can go close to the horizon!

M. Valtonen, A. Sillanpää, K. Nilsson, Turku; and collaborators

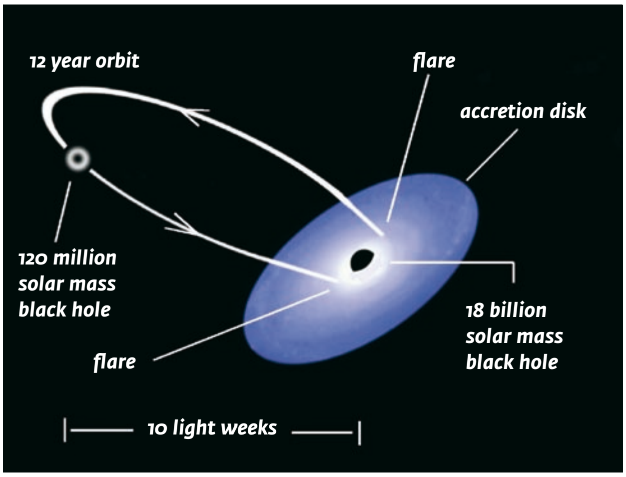


Fig. 6. A model of the binary black hole system in OJ287 (figure: G. Poyner).

A highly obscured supernova in a luminous infrared galaxy

Early in the history of the Universe (seen at high redshift today), most massive stars formed in luminous infrared galaxies (LIRGs) and ended their lives quickly as core-collapse supernovae (CCSNe). Thus, LIRGs should exhibit CCSN rates a couple of orders of magnitude greater than ordinary field galaxies. Most of these supernovae are likely to be heavily obscured by dust in the nuclear starburst environment. However, the extinction is strongly reduced in the near-IR, making searches for such SNe feasible.

Fig. 7. Composite JHKs colour image of SN 2008cs (marked) as observed with NOTCam. Note the reddish colour of the supernova.

While searching for highly-obscured SNe in the nuclear regions of LIRGs, using the Gemini-North telescope with laser guide star adaptive optics in the K band (2 μm), we discovered the highly-obscured SN 2008cs located in the LIRG IRAS 17138-1017, at a distance of 75 Mpc. Radio observations at 22.4 GHz with the Very Large Array a month later indicated vigorous interaction of the SN ejecta with the circumstellar medium and confirmed its core-collapse nature. We then used NOTCam and NIRI at Gemini for near-IR photometric follow-up of the supernova. These observations are also consistent with SN 2008cs being a core-collapse event, and we derived a line-of-sight host galaxy extinction of about 16 magnitudes in the *V*-band its *JHK* colours and light curve. We believe this the highest extinction yet measured for a SN.

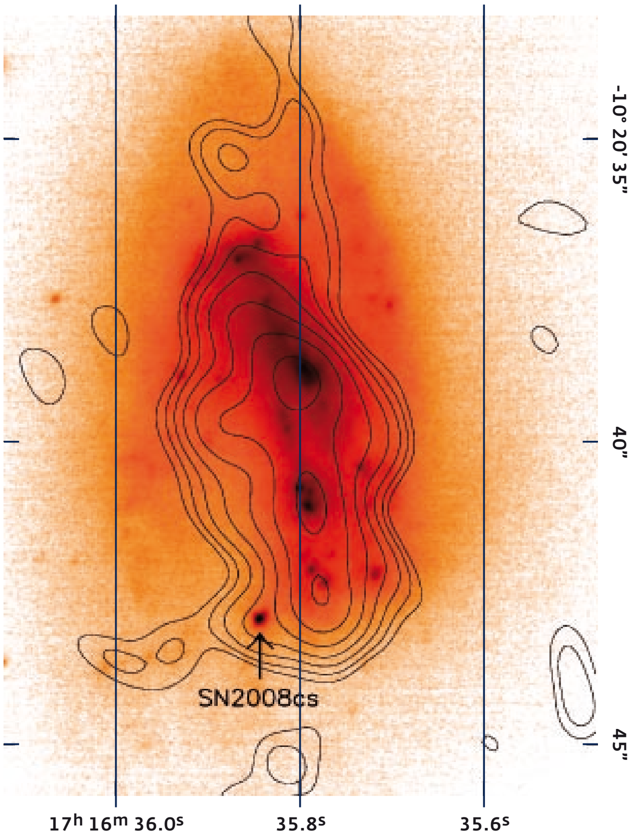


Fig. 8. Adaptive-optics image in the K-band from NIRI at Gemini. The VLA radio contours are overlaid.

Direct studies of such highly extinguished SNe in starburst galaxies and LIRGs may have an important impact on the statistics when estimating complete CCSN rates, both locally and at high redshift. The current discovery rate of SNe is significantly lower than the actual rate of such events as expected from the infrared luminosity of these types of galaxy, and dust extinction seems to be an important factor.

E. Kankare, S. Mattila, Turku; S. Ryder, Sydney; M. Pérez-Torres, Granada; and colleagues

Understanding the physics of Type Ia supernovae

Supernovae Type Ia are currently the best-known cosmological distance estimators and are used to measure the cosmological parameters. They also feature prominently in future experiments to unveil the nature of the Dark Energy. However, our understanding of the physics of SN Ia explosions is still insufficient, raising concerns that subtle systematic effects may affect the cosmological conclusions.

A long-term goal of our SN Ia observing program at NOT (see Annual Reports 2004 and 2007) is to better understand the physics of SNe Ia through detailed modelling of our data. Observations at NOT continued during 2008 on the

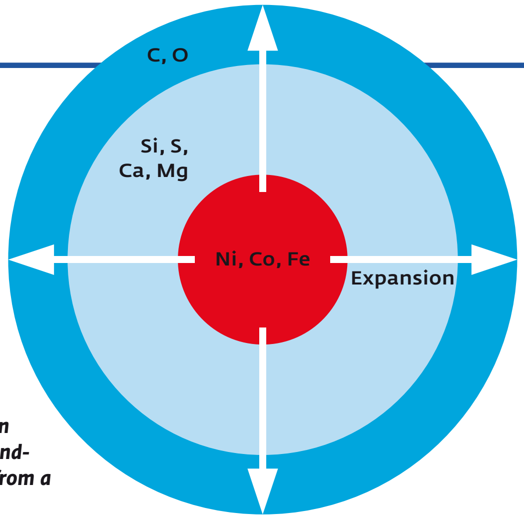
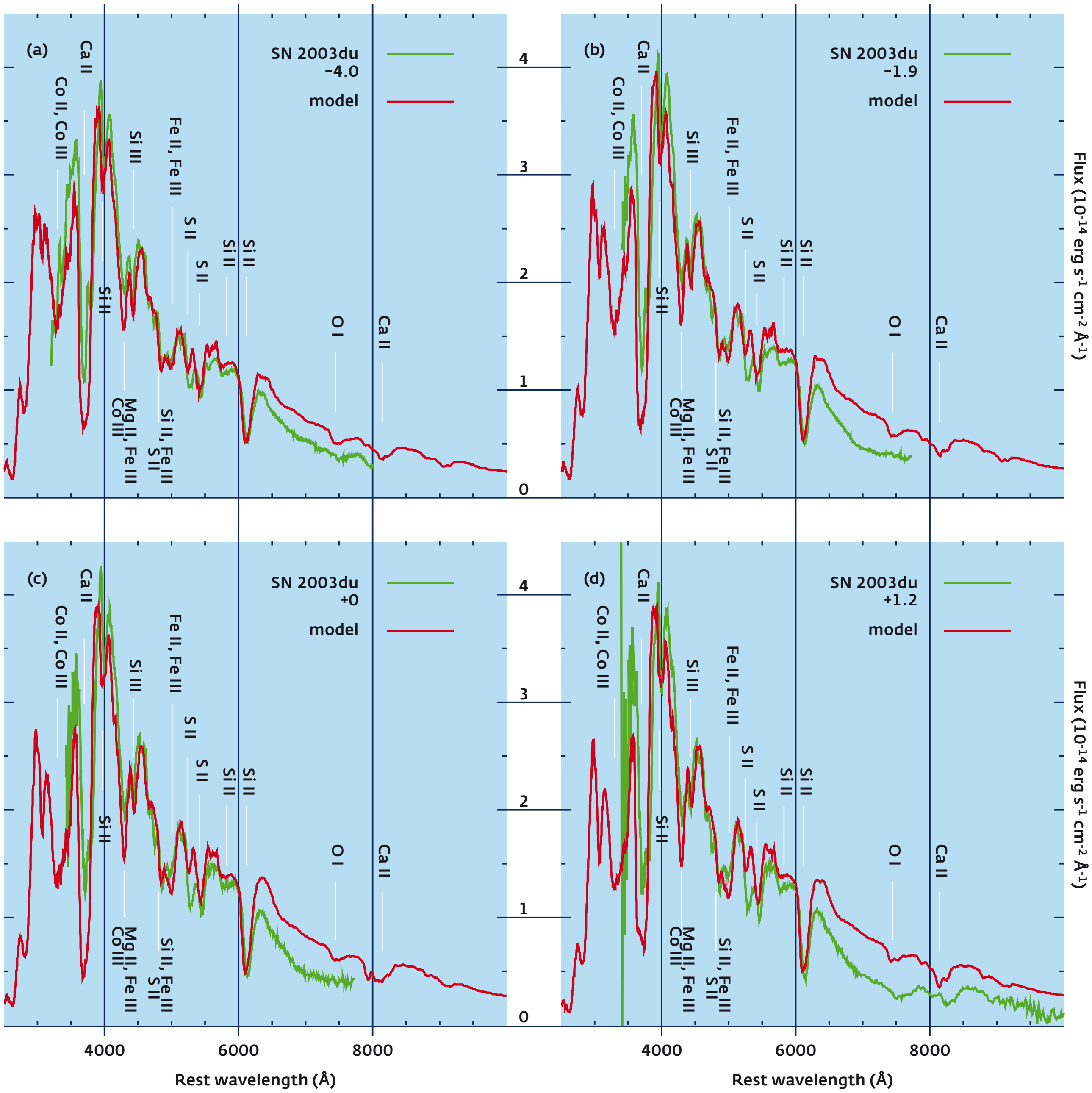


Fig. 9. A sketch of the layered chemical composition of the expanding ejecta from a SN Ia.

Fig. 10. Observed spectra of SN 2003du around maximum light (black lines with the date before/after maximum given at the top of each figure), compared with the model spectra (red lines).



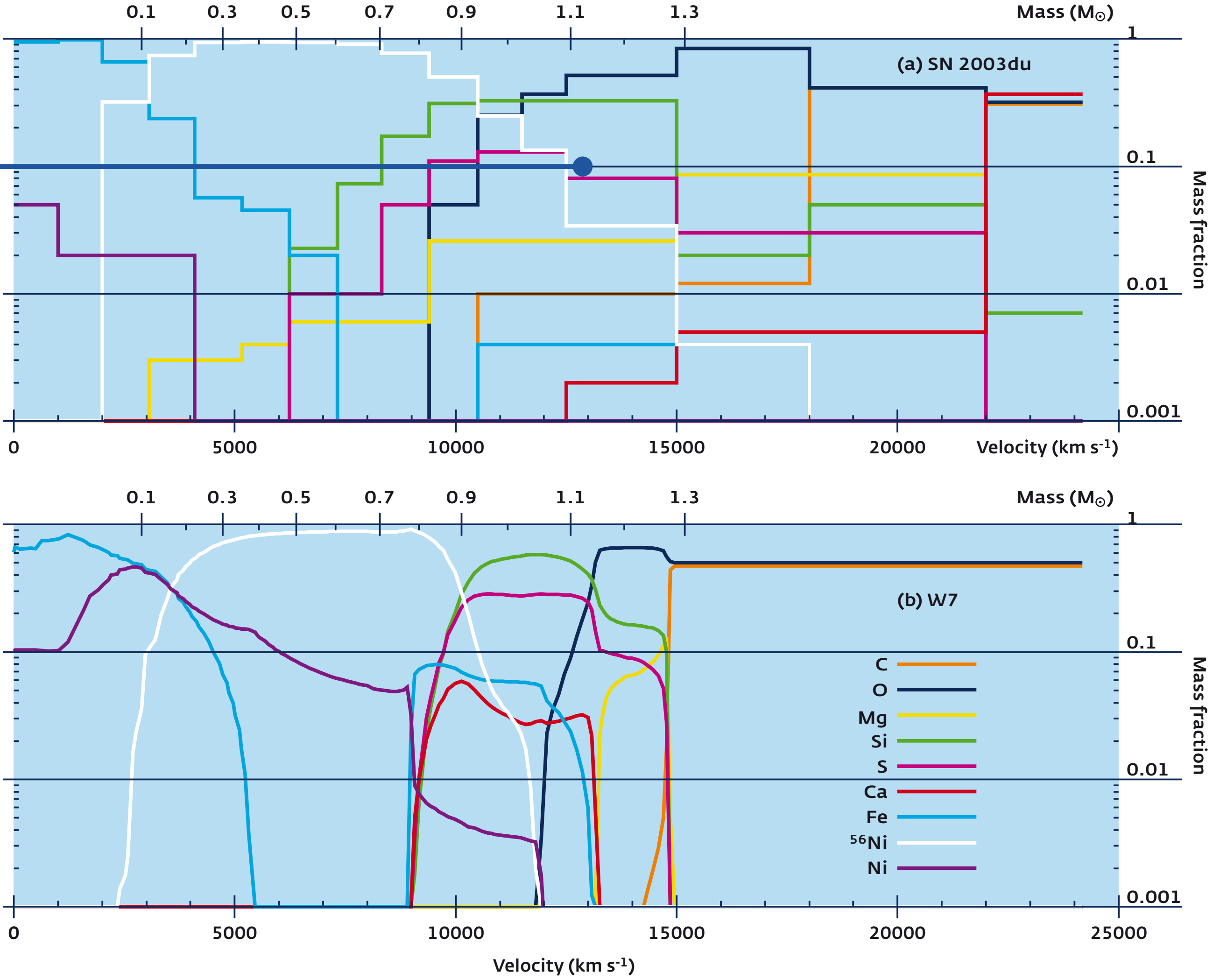


Fig. 11. Radial abundance distribution for SN 2003du (top) compared with a classical explosion model (W7, bottom). The ejection velocity drops as the same time as deeper and deeper layers are exposed, so the abscissa corresponds to a radial coordinate with the surface at the right. Note that the distribution of the species is broader in the real supernova, indicating significant mixing.

bright SNe 2008Q and 2008hv, but attention is now turning to the detailed analysis. The first results of SNe 2002bo and 2004eo have already been published, and the analysis of SN 2003du is nearly complete.

SNe Ia are believed to be due to the thermonuclear explosion of a carbon/oxygen white dwarf (WD). Detailed models predict that the expanding ejecta will have a layered chemical composition: Fe-group elements in the centre; a layer of intermediate-mass elements like Si, S, Mg and Ca further out, possibly followed by unburnt C and O from the original WD at the surface (see Fig. 9). Because the ejecta expand and the density drops with time, observations taken at later phases probe deeper and deeper. As a result, different species are seen in the spectra of SNe Ia at different epochs and convey information about the stratification of the ejecta.

The recently developed technique of "Abundance Tomography" models this evolution in detail (Fig. 10). A combined analysis of the light curve and late-time spectra allows to recover the distribution of the different species in the ejecta (Fig. 11). Because different explosion models predict somewhat different chemical compositions, deriving the properties of the explosion directly from the data puts constraints on these models. For example, results from the first few objects indicate that significant mixing occurs in the ejecta, which is not predicted by the models. More objects will be analysed to further refine the models of SN Ia explosions.

V. Stanishev, Lisbon; P. Mazzali, Garching;
M. Tanaka, Tokyo; and collaborators

The enigmatic supernova SN2008D

The transient Universe will likely be at the forefront of observational astrophysics in the next decade. Due to its flexible operation, efficient support and stable instrumentation, the NOT is well suited to play a strong role in this field and has already proved very competitive in both gamma-ray burst and supernova research (see above).

A recent interesting example is SN2008D. Core-collapse supernovae mark the death of massive stars and are divided into Types II, Ib, and Ic, depending on how far mass loss has removed the outer layers of the progenitor before the explosion. Hydrogen lines in the spectra of Type II SNe arise in matter from the original envelope. Types Ib and Ic show no hydrogen, but helium lines in Type Ib indicate that some of the helium shell remained.

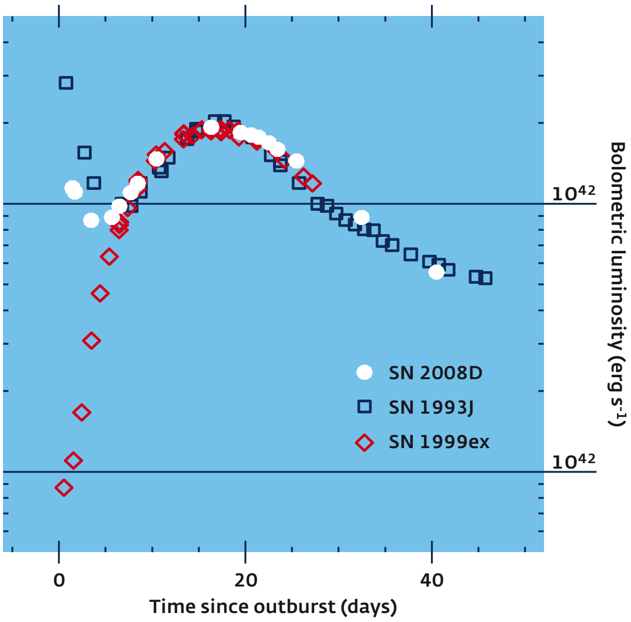
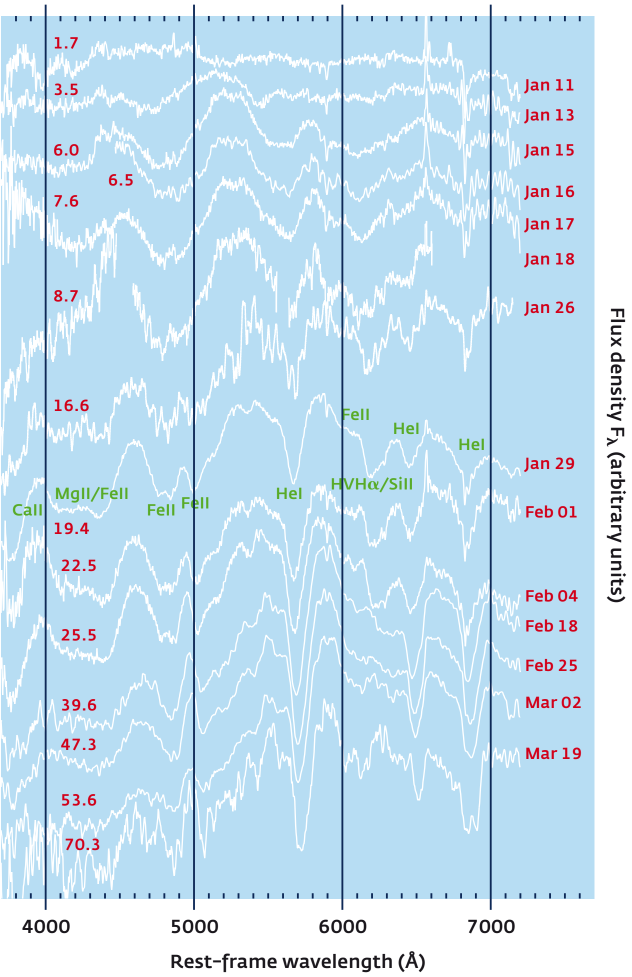


Fig. 12 Bolometric light curves of SN 2008D and SN 1999ex (both Type Ib) and SN 1993J (Type IIb).

Fig. 13: Spectral evolution of SN 2008D from 1.75 days to 10 weeks after the explosion, as noted on the left of each spectrum. Most of the spectra are from the NOT.



SN2008D was caught exploding on 2008 January 9, when the *Swift* satellite detected a bright X-ray transient while observing another supernova in the nearby spiral galaxy NGC 2770 ($z = 0.007$). Its power-law spectrum and light curve shape were reminiscent of GRBs and X-ray flashes, but the energy release was at least 2 orders of magnitude lower than for even a subluminous GRB. Optical observations soon established that the new source was in fact a supernova of type Ib, and we have monitored its evolution over the first ~75 days at the NOT, both with photometry, spectroscopy and polarimetry.

Fig. 12 compares the bolometric light curves (i.e. total energy output) of SN 2008D as derived from our optical and near-infrared light curves with those of similar supernovae, and Fig. 13 shows the parallel evolution of the spectra. The later spectra, acquired during the radioactivity-powered phase (similar in the three SNe), showed He lines from January 17 and established that SN 2008D is an unambiguous Type-Ib SN.

Polarimetry of SNe provides information on the geometry of the expansion: If the SN is not spherical, a net polarization is produced. Typical SNe Ib are fairly spherical, so they tend to show little optical polarization unlike the Ic hypernovae associated with GRB explosions, which show polarization up to 5%. We observed SN 2008D with ALFOSC in the *V*-band at three epochs and found significant polarization each time. Moreover, the behaviour of the polarization parameters corresponds to an axisymmetric geometry of variable eccentricity as expected for a GRB progenitor, but not for a Type Ib. Never trust a supernova to behave as you expect!

J. Fynbo, D. Malesani, Copenhagen;
J. Gorosabel, Granada; and collaborators

Discovery of a New Pulsar Wind Nebula

A pulsar wind nebula (PWN) is a cloud of plasma that surrounds mainly young pulsars – the neutron star remnants of supernova explosions. It emits synchrotron emission powered by the relativistic wind and strong magnetic field of the pulsar and reveals itself particularly clearly in polarised light. Young PWNe are often found inside supernova shells and drive them outward. The famous Crab Nebula is the prototype, which can be studied in exquisite detail.

PWNe have been studied from radio to X-rays, and the spectral energy distribution of the emission gives hints on how the relativistic particles heat and cool, the strength of the magnetic field, and how the pulsar converts its spin-down power into radiation. The optical and IR part of the spectrum is needed to get the full spectral distribution, and good spatial resolution here helps to map the spatial distribution of the synchrotron emission as well. However, apart from the Crab Nebula, only the PWN of a young pulsar in the Large Magellanic Cloud had an optical detection so far.

3C 58 is a Crab-like supernova remnant containing the young pulsar J0295+6449, which powers a compact torus-like PWN visible in X-rays. In 2006 we obtained deep images of the field with ALFOSC in the *B* and *V* bands and became the first to detect the PWN of 3C 58 as a faint elliptical object with magnitudes $B = 24.06 \pm 0.08$ and $V = 23.11 \pm 0.04$. Its morphology and orientation are in excellent agreement with the torus region of the PWN, seen almost edge-on in X-rays with Chandra and more recently in the mid-infrared with the Spitzer space observatory. We estimate that the pulsar itself contributes <10% to the observed optical light.

Our discovery makes 3C 58 only the third torus-like PWN system identified in the optical and mid-infrared (see the paper by Shibanov et al. listed on p. 31). In November 2008 we observed 3C 58 again in the near-IR with NOTCam to bridge the optical and *Spitzer* results; these results are now being analysed.

Yu. Shibanov, D. Zyuzin, St. Petersburg; N. Lundqvist, P. Lundqvist, J. Sollerman, Stockholm

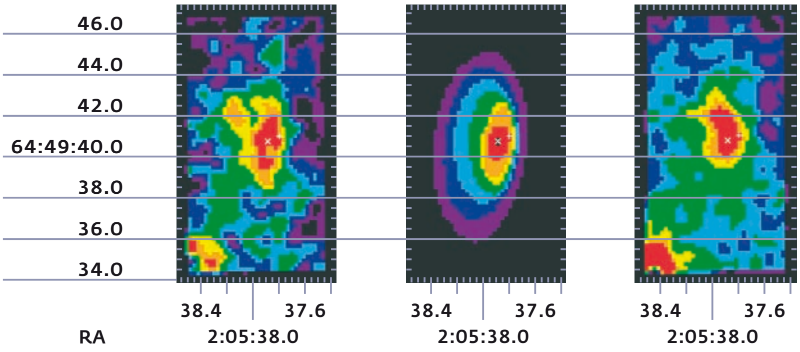


Fig. 14. The central 13"x6" region of 3C 58 with the optical counterpart of the pulsar/PWN system in the B (left) and V (right) bands, and a B-band surface brightness fit with elliptical isophotes (middle). The "+" sign shows the X-ray position of the pulsar, while the "×" sign marks the centre of the brightest part of the optical source; they are only ~0.6" apart, less than the uncertainty of the pulsar X-ray position.

Searching for ancient substructure in the Milky Way

The Milky Way is a typical large spiral galaxy. Its formation and evolution are still not fully understood, but we know that the history of our home Galaxy is quite complex. Theory and observations have recently made much progress, and we can now look for signatures of past accretion events. Already well-known examples are the Sagittarius and Canis Major dwarf spheroidal galaxies at some distance from the Galactic disk, but can we also find traces of ancient such merger events in the solar neighbourhood?

F- and G-type dwarf stars are very useful in studying the ancient history of our galaxy since they are long-lived and numerous, and their atmospheres reflect their initial chemical composition. We have studied the complete, homogeneous data on the kinematics, metallicities and ages for about 14.500 F- and G-type stars by Nordström et al. (2004). From their Galactic orbital parameters (eccentricity and angular momentum), Helmi et al. (2006) identified several new coherent groups of stars and suggested that they might correspond to remains of disrupted satellites – similar to the scene illustrated in Fig. 15. These groups also have distinct metallicity and age distributions, providing further evidence of their extragalactic origin.

We want to measure the detailed chemical abundances of stars belonging to these groups and compare them with "ordinary" disk stars. Our first hypothesis is that such detailed compositions would show fossil signatures of past mergers, and that these should be detectable in the Milky Way disk today. Identifying substantial amounts of debris in the Galactic disk, whose origin can be traced back to more than one satellite galaxy, would provide evidence that the Milky Way formed by hierarchical mergers.

In order to investigate this, we have used the high-resolution spectrograph FIES at the NOT to observe spectra for 86 F-G-type dwarf stars from three of the kinematic groups

Fig. 15. An ongoing galaxy merger: The pair NGC 1532/1531 observed with the Danish 1.5m telescope at La Silla (A. Hornstrup, Copenhagen).

identified by Helmi et al. We are now deriving abundances for about 20 chemical elements in these stars to check the homogeneity of the groups.

G. Tautvaišienė, E. Stonkuté, Vilnius;
B. Nordström, Copenhagen

FORMATION, STRUCTURE, AND EVOLUTION OF STARS AND PLANETS

Stars form, evolve, and build up heavy elements in their interiors. Eventually, they die as white dwarfs or supernovae, leaving the enriched gas behind as raw material for new stars. Thus, stars are also key actors in galactic evolution. Well-developed theoretical models of stellar evolution enable us, e.g., to determine stellar ages, but much remains to be understood.

Photospheric and chromospheric activity in an M dwarf

Young and/or fast-rotating cool stars show large spots and other surface activity similar to, but much stronger than that seen on the Sun today. Studying stellar activity in its more extreme manifestations is one way to understand the underlying mechanism, believed to be a form of dynamo effect in the stellar interior, driven by differential rotation. Studying the activity cycles of active stars is a long-standing field of research at the NOT, primarily with the SOFIN spectrograph (see the Annual Report 2007 p. 17-19 and earlier years).

EY Dra is a very active star discovered in extreme ultraviolet light from space. Optical spectroscopy has revealed an M1-2e dwarf with strong, variable Hα emission and molecular lines and very rapid rotation – v sini ~61 km/s. EY Dra is in fact one of the most active stars in the solar neighbourhood, and its fast rotation makes it a fairly easy object. Accordingly, we studied the photospheric and chromospheric activity of EY Dra with spectroscopy and broadband photometry during the NORDFORSK summer school at the NOT in 2006 (see the Annual Report 2006, p. 22).

The behaviour of Hα is a diagnostic of chromospheric activity and was studied with ALFOSC and grism #17, which gives high resolving power in this spectral region. To highlight changes in the Hα profile, we subtracted the mean line profile from the individual spectra obtained on several nights. Fig. 16 shows the dynamic spectrum of EY Dra – the evolution of the difference spectra as a function of phase (vertical axis). The phases actually observed are shown by crosses along the right-hand side; data for other phases were obtained by interpolation.

The dynamic spectrum clearly shows enhanced emission in Hα around phases 0.75-1.1. The features with enhanced or reduced Hα emission often seem to move from blue to red (i.e. first approaching us, then receding as the star rotates), and could correspond to chromospheric plages and prominences. Especially the enhanced emission at phases 0.75-1.1 could be associated with a plage, while the weaker

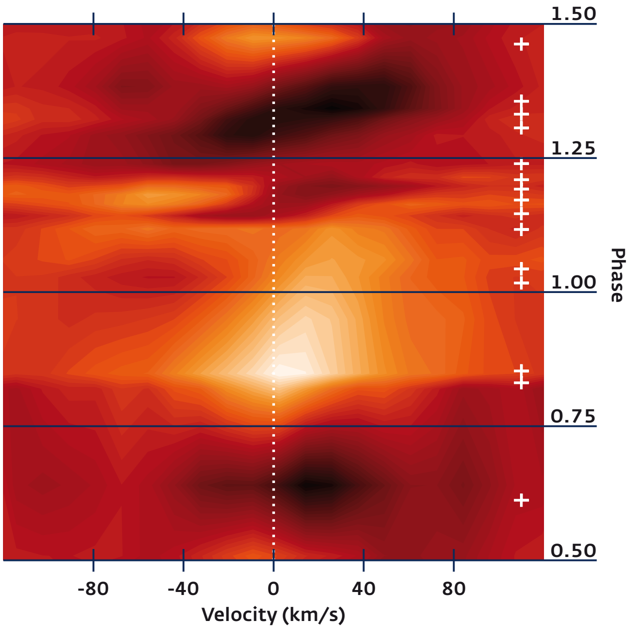


Fig. 16. Dynamic spectrum of the Hα line in EY Dra, i.e. differences from the mean line profile as a function of phase (vertical axis). Brighter colours indicate stronger Hα emission. Crosses on the right show the observed phases, and the dashed line the zero velocity.

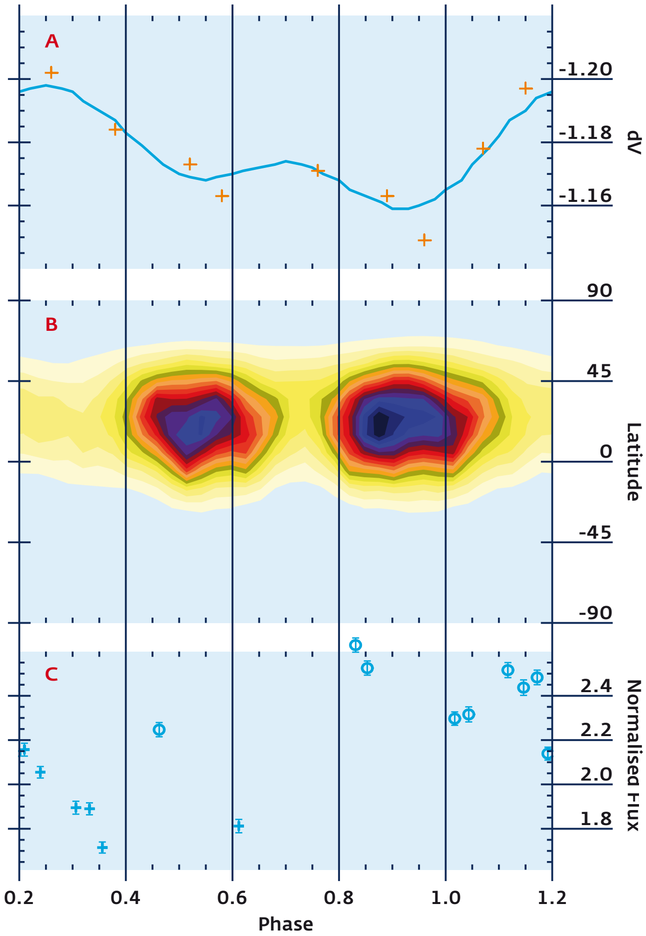


Fig. 17. Correlating photospheric and chromospheric activity on EY Dra. A: Differential V band observations (crosses) with a fit (solid line) corresponding to the spot model shown below. B: Spot intensity map (darker colour means higher spot filling factor); note that the one-dimensional light curve contains no information on spot latitudes, only on longitudes. C: Variation in integrated Hα flux. Phases are plotted from 0.2 to 1.2 in all panels to show the active regions better.

Hα emission at phases 1.25-1.5 could be associated with a prominence cloud.

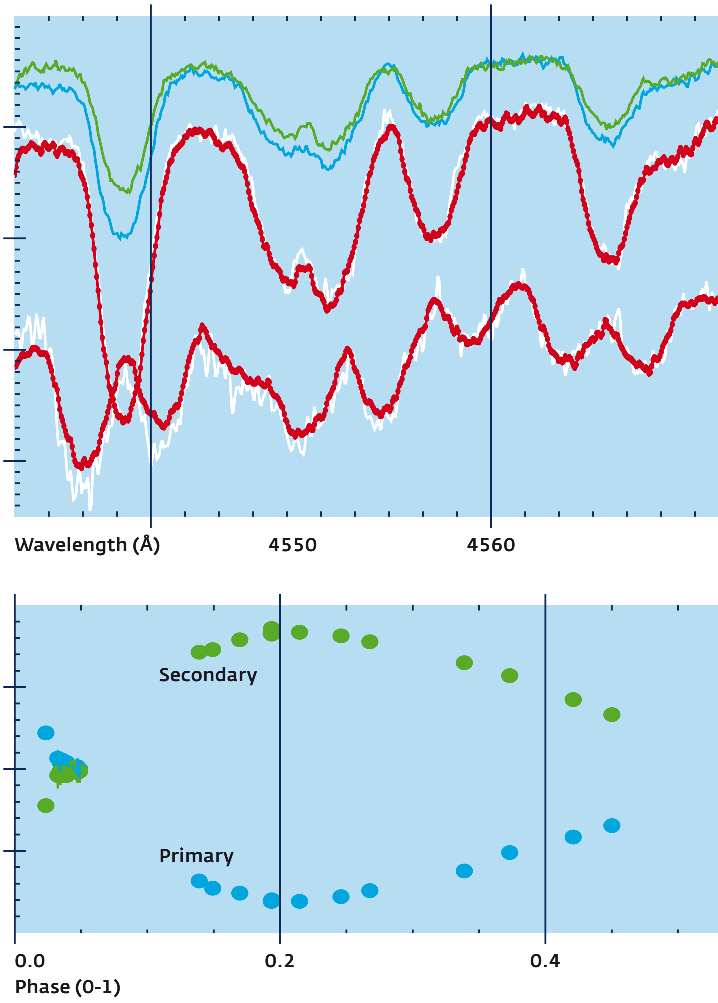
Fig. 17a shows the V-band light-curve of EY Dra, also obtained with ALFOSC. Two minima are seen at phases 0.3-0.75 and 0.85-1.15, with a main maximum around phases 0.15-0.3. Starspot positions derived from the light-curve analysis (Fig. 17b) show that the main photospheric active regions (dark spots) occur at longitudes corresponding to phases 0.53 and 0.91. Indeed, the Hα emission peaks at these same phases (Fig. 17c), suggesting that bright chromospheric plages are associated with the active regions (spots) in the photosphere – one result from the summer school that led to a published paper in a professional journal.

H. Korhonen (tutor) with students K. Brogaard, K. Holhjem, S. Ramstedt, J. Rantala, C.C. Thöne

Constraining models of stellar structure and evolution

The star HD 172189 has many interesting characteristics that can teach us about stellar structure and evolution: It is a binary system in which the two stars eclipse each other as seen from the Earth, and both stars appear in the spectrum; together, these features provide constraints on the mass, radius, effective temperature, and (rapid) rotation of the two stars. It is also a member of an open star cluster, which provides independent information on its distance, luminosity, and age. Finally, one of the stars is a pulsating variable (see the Annual Report 2007, p. 16), and the frequency spectrum of the pulsations provides an independent probe of the interior structure of the star.

Our observations with the FIES spectrograph at the NOT, combined with data from other telescopes, were designed to determine the orbits and masses of the two stars in the system and extract independent “clean” spectra of them for further analysis.

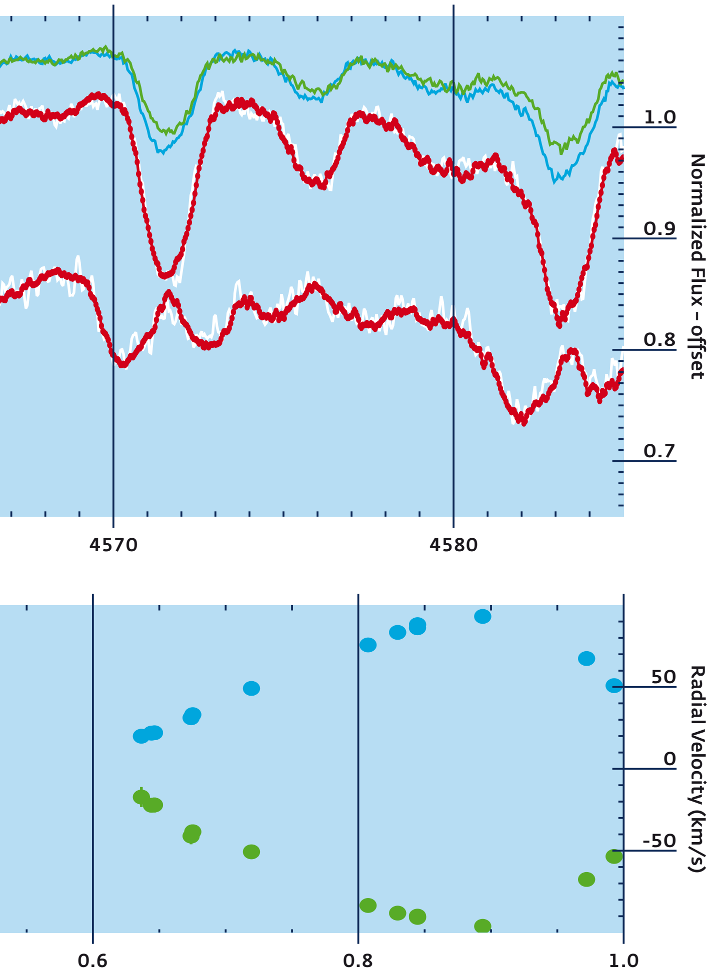


For this we used a technique known as "spectrum disentangling", where one analyses an ensemble of combined spectra (38 in our case) with different velocity separations, i.e. relative wavelength shifts, knowing that the two underlying spectra are the same and that the orbital velocity shifts are described by just seven parameters. The code then returns the best statistical estimates of the two spectra and the orbital elements. Fig. 18 shows the observed and reconstructed spectra and the best-fit orbit, which constrains the masses to an accuracy of ~1%.

We are now analysing the disentangled spectra to determine the chemical composition of the two stars and the nature of the pulsations, and to compare our comprehensive data set with models for the evolution of such stars.

O.I. Creevey, K. Uytterhoeven, La Laguna; S. Martín-Ruiz, P.J. Amado, Granada; E. Niemczura, Wroclaw

Fig. 18. Bottom: Radial-velocity curves for both stars in HD 172189. Top: Observed (black lines) and reconstructed individual spectra (blue and green). Red lines show the reconstructed combined spectrum at phases 0.00, when the two spectra coincide (top), and 0.25 when their separation is largest (bottom). For clarity, the spectra are offset vertically.

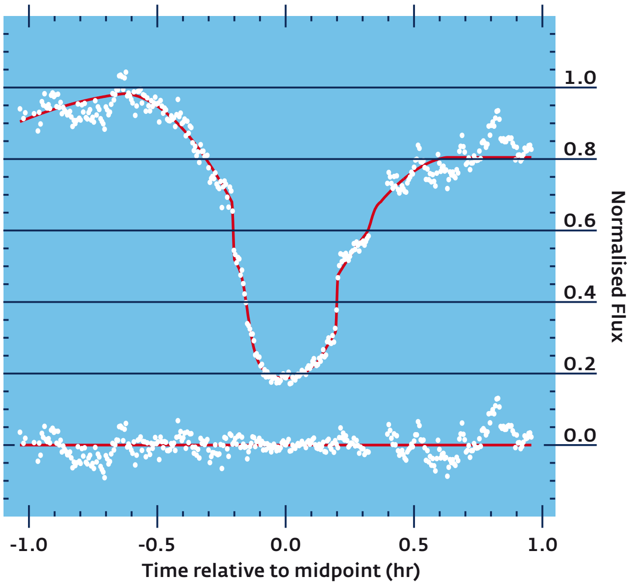


Masses and radii of the stars in a cataclysmic binary

Cataclysmic binary stars are important probes of the structure of dying stars and accretion discs. They consist of a white dwarf (WD), the extremely dense remnant of the slow death of an intermediate-mass star, accompanied by a much larger but less massive red dwarf star. The two stars orbit very close to each other, and the huge gravitational field of the white dwarf progressively rips apart its unwilling companion. The mass lost by the low-mass star accumulates in a large, bright accretion disc, which dominates the light of the overall system and makes it very difficult to determine the properties of the stars themselves.

We are seeking to improve our understanding of cataclysmic binaries by characterising the population of these objects discovered by the Sloan Digital Sky Survey. During this project we have discovered that SDSS 1006 is a rare eclipsing example: Every 4.46192 hours the white dwarf and its surrounding accretion disc pass behind the larger secondary star as seen from Earth, and the system becomes temporarily much fainter. The shape and duration of the eclipse are governed by the system properties, so eclipse observations can tell us about them.

Fig. 19. NOT/ALFOSC light curve of SDSS 1006 (points) compared to our best-fitting model (red line). The "flickering" outside eclipse is common in cataclysmic binaries and is caused by quasi-random fluctuations in the mass-transfer rate.



On February 1st and December 21st, 2008, we obtained high-speed photometry of two eclipses of SDSS 1006 with ALFOSC in service mode at the NOT, with follow-up spectroscopy obtained with the William Herschel Telescope. By analysing the spectroscopy and modelling the ALFOSC light curves, we have measured the masses and radii of the two stars in SDSS 1006 (see Figs. 19 and 20). We find that the secondary star is bloated by the effects of the mass loss, whereas the mass and radius of the white dwarf are entirely normal. With time, SDSS 1006 will gradually fade into oblivion as the white dwarf devours more and more of its companion.

J. Southworth, R.D.G. Hickman, A. Rebassa-Mansergas, B.T. Gänsicke, T.R. Marsh, Warwick

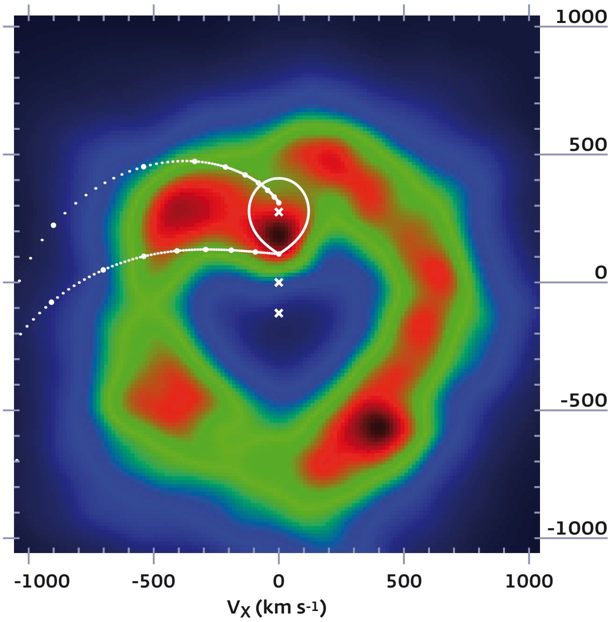


Fig. 20. Decomposition into velocity space of the calcium emission line seen in spectra of SDSS 1006. The centre of mass of the system is at zero velocity; the distorted surface of the red dwarf is drawn to scale, while the position of the white dwarf is marked by a "+" below the mass centre. The large, roughly circular feature centred on the white dwarf corresponds to emission from the accretion disc.

A strongly magnetic white dwarf in a binary system

A subclass of cataclysmic binaries (see above) is called "Intermediate Polars". These systems also consist of a white dwarf star, which has ceased to generate its own energy and is fading slowly from view, and a red dwarf, a dim low-mass star which is still generating energy, but at a very low rate. The stars are so close together that material is torn off the low-mass star into an accretion disc before eventually falling onto the heavier and much denser white dwarf, giving rise to intense X-ray emission. A strong magnetic field is believed to control the flow of mass in many cataclysmic binaries (see sketch of the white dwarf in Fig. 21).

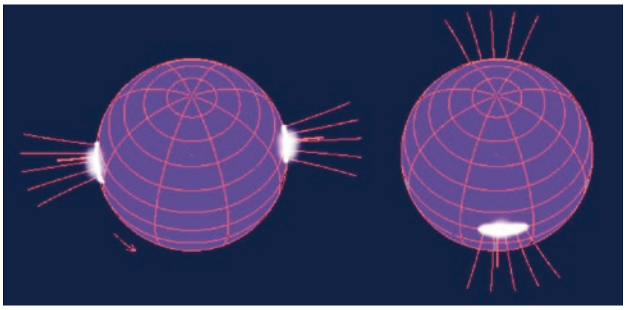


Fig. 21. Sketch of the spinning magnetic white dwarf in V405 Aur, showing cyclotron emission arcs near the magnetic poles. The two views correspond to zero (left) and maximum circular polarization (right) as seen in Fig. 22.

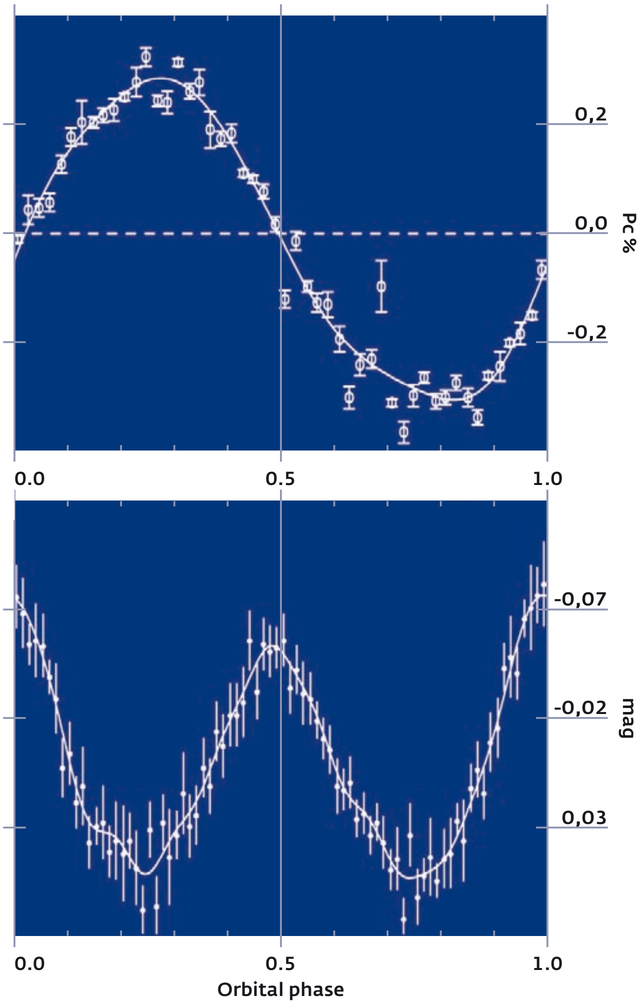


Fig. 22. a) Circular polarization over the 9.1 min spin period of the white dwarf in V405 Aur (blue light). b) The corresponding light curve.

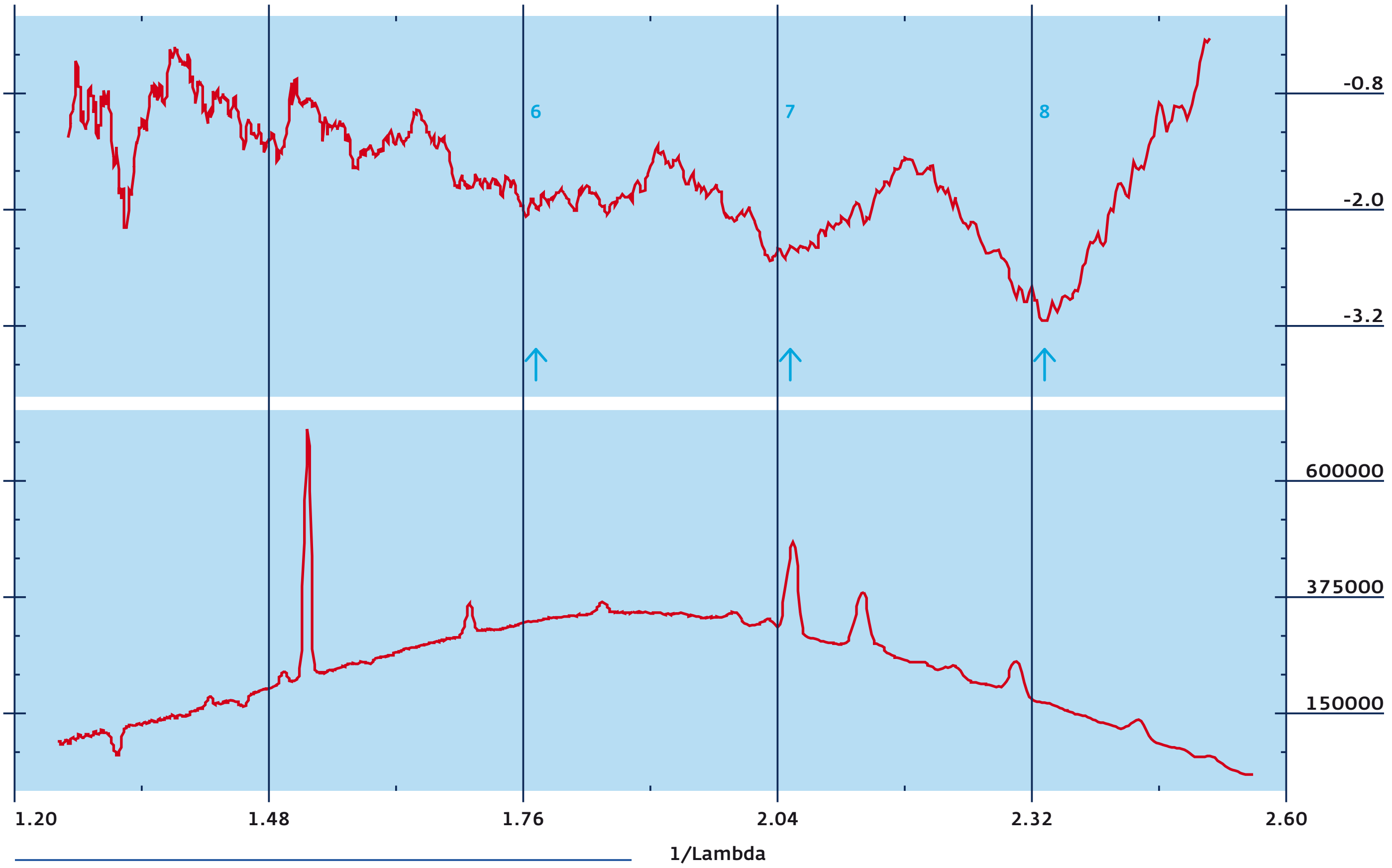
V405 Aurigae is such a system, with the stars so close together that they circle each other in just 4.15 hours. Because polarised light is a classic indicator of the presence of a magnetic field, we have monitored the brightness and polarisation of the star's optical light during several full orbital cycles with the Turpol polarimeter at the NOT. In V405 Aur, the polarised light varies as an almost perfect sinusoid with an amplitude of ~3% across the visible spectrum (Fig. 22ab). Such high polarisation levels are rare and indicate that this may be the strongest magnetic field ever seen in such a star.

In V405 Aur the hot, magnetized plasma emits optical and near-infrared cyclotron emission, which allows an accurate measure of the magnetic field. Spectropolarimetry with ALFOSC at the NOT (Fig. 23) leads to a value of $B = 31.5 \pm 0.8$ million Gauss, the first ever direct measurement of a magnetic field in an Intermediate Polar. The high value found has implications for the possible models of the evolution of different types of magnetic compact binaries.

The magnetic field in V405 Aur is very similar to that in a type of white dwarf/red dwarf binary known as "polars", in which the matter stripped from the red dwarf is not stored in an accretion disk, but falls directly onto the white dwarf. Furthermore, the rotation of the stars is synchronised, so the magnetic fields control how the matter falls onto a "hot spot" on the white dwarf. It has been thought that Intermediate Polars can evolve into Polars over a few billion years, and V405 Aur appears to be in just such a transition state (see paper listed on p. 30).

V. Piirola, T. Vornanen, A. Berdyugin, Turku;
G.V. Coyne, S.J., Vatican.

Fig. 23. Harmonics 6, 7, and 8 in the cyclotron emission from the strong magnetic field of V405 Aur as seen in the circular polarization spectrum (top). The narrow spikes in the intensity spectrum (bottom panel) are bright emission lines of hydrogen and helium from the accretion stream.



Hunting brown dwarfs

Brown dwarfs are intermediate bodies between stars and giant planets. Their mass, about 7% of the mass of the Sun (or 70 Jupiter masses), is too low to maintain nuclear burning in their interiors over a long time, unlike our Sun. Thus a brown dwarf just gets colder and colder after being formed.

Two classes of brown dwarfs are known: L dwarfs (temperatures of 1200-2000°C), which have clouds of dust and aerosols in the upper atmosphere, and T dwarfs (temperatures below 1200°C), which have spectra dominated by methane. At even lower temperatures the atmosphere contains ammonia, defining a new class called Y dwarfs (see below).

The first brown dwarfs were detected in 1995. Since then, a few hundred brown dwarfs have been discovered in dedicated surveys. In the Canada-France Brown-Dwarf Survey (CFBDS), we use deep multi-colour optical images obtained with MegaCam at the Canada-France-Hawaii Telescope (CFHT) to identify candidate brown dwarfs and high-redshift quasars from their very red colours. In order to separate quasars and brown dwarfs, we then obtain near-infrared J-band imaging at several observatories, mainly La Silla (NTT) and La Palma (NOT). The excellent seeing at the

NOT is important, because sensitivity on faint point sources strongly depends on seeing.

Our J-band photometry pinpointed a few high-redshift quasars that contain important clues on the reionization of the Universe. It also very effectively rejected any remaining observational artifacts as well as “ordinary” M stars scattered into the brown dwarf/quasar region by observational noise. What remained were numerous L and T dwarfs (168 and 52, respectively). Their optical-near-IR colour distribution is shown in Fig. 24. We expect that complete J-band follow-up of all our candidates will yield about 100 new T dwarfs and over 450 L or very late-M dwarfs, roughly doubling the number of known brown dwarfs. Moreover, one of our brown dwarf candidates could be the first Y dwarf discovered, with a temperature 500° higher than Jupiter’s atmosphere.

The atmosphere of cool brown dwarfs is similar to that of giant planets. However, observing the atmospheres of extrasolar planets is very hard indeed, because the light from the planet is dwarfed by the much stronger light from the host star. As isolated bodies, brown dwarfs are much easier to observe, so studying brown dwarfs with temperatures close to those of giant planets will help to constrain models of extrasolar planet atmospheres.

C. Reylé, Besançon; L. Albert, CFHT;
P. Delorme, X. Delfosse, T. Forveille, Grenoble;
C. Willott, Ottawa; and collaborators

Discovering transiting extrasolar planets

Over 300 planets outside our Solar System have been found since the first was discovered in 1995. Since then, great progress has been made in understanding their properties and pushing the detection limit towards habitable planets, but many questions still remain about the processes by which planets form and evolve. The vast majority of exoplanets cannot be seen directly because they are so faint and so close to their host star that their faint light is overwhelmed by the glare from the star. Indirect techniques are therefore used to detect them.

Sometimes we are lucky enough that, by chance, we see a planet passing directly in front of its host star in its orbit. The planet temporarily blocks out a little of the starlight and causes an apparent drop in intensity, typically by ~1% for about 3 hours. The depth of this dip is proportional to the projected area of the planet, enabling us to measure its radius. The trick is to find such systems.

The robotic SuperWASP telescopes monitor a huge number of stars every night, searching for the tiny dips in brightness which signal a transiting planet. SuperWASP-North has been running for the last 2 years and taken 5 million images. By sophisticated data analysis, we search the light curves for objects that display transit signatures. Our best candidates are then followed up with spectroscopy to verify that the object is indeed a planet.

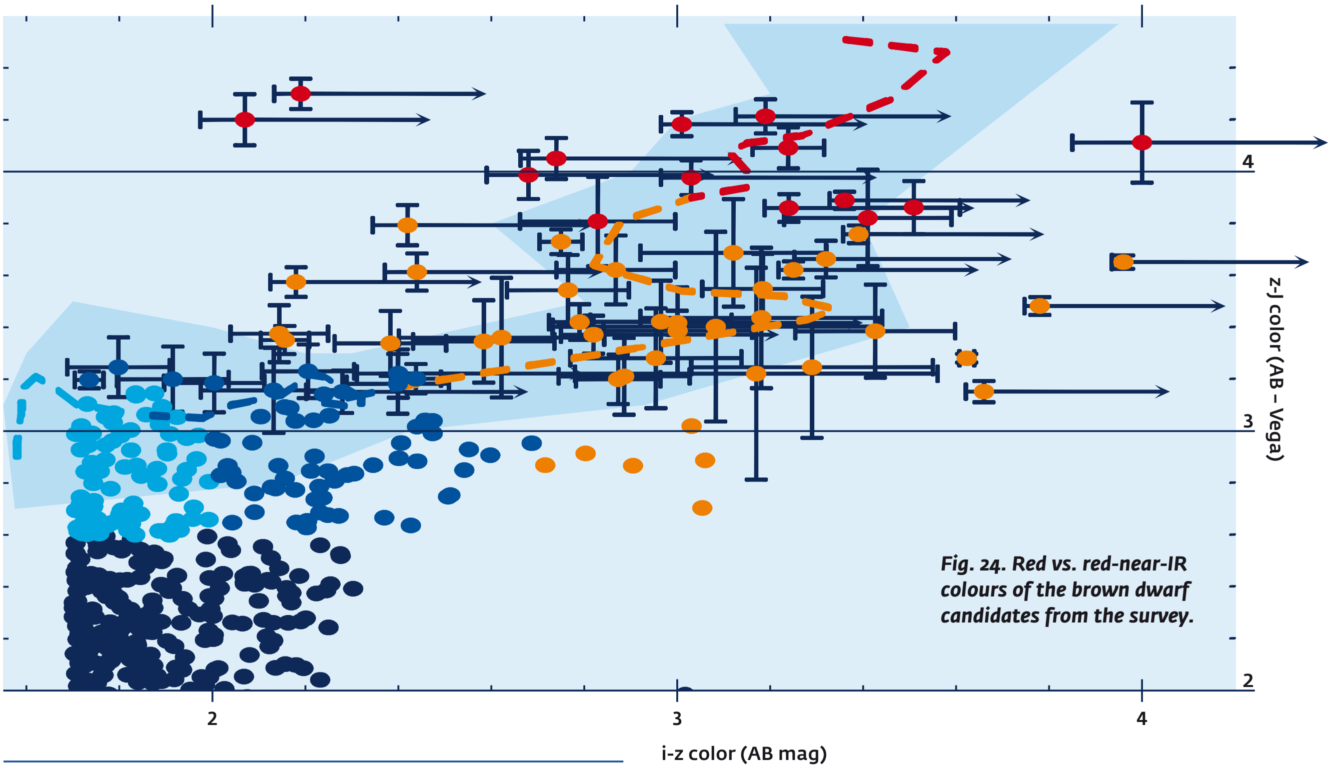


Fig. 24. Red vs. red-near-IR colours of the brown dwarf candidates from the survey.

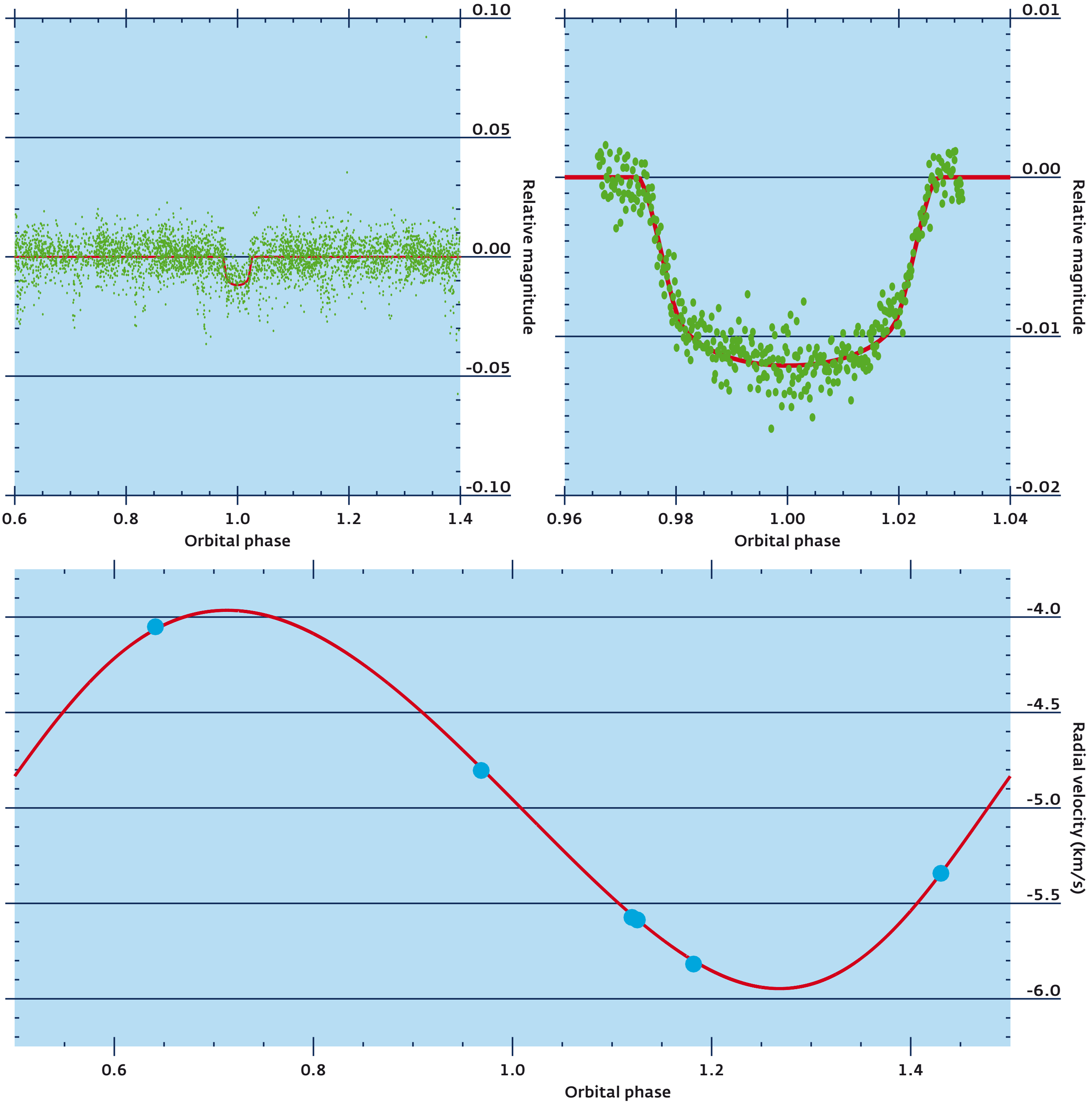


Fig. 25. Light (top) and radial-velocity curve (bottom) of one of the new transiting planet candidates, from SuperWASP and FIES.

As the star and planet orbit around their common centre of mass, we see the stellar spectral lines being slightly Doppler shifted as the star wobbles towards and away from us. The amplitude of this shift is proportional to the planet's mass and orbital radius. Combining this with the planet's radius as measured from the light curve, we can estimate the planet's density and composition. Transiting planets are therefore extremely valuable, but also rare – only about 15% of the known planets. About a quarter of them have been discovered with SuperWASP.

In 2008, we used the FIES spectrograph at the NOT to confirm 4 new transiting planets (over 10% of all transiting planets known at the time). FIES is capable of measuring the velocity of our planet-hosting stars to an incredible 10m/s, enabling us to push towards Saturn-mass planets and beyond. The four planets have orbital periods around 3 days and range from 0.5 to 8 Jupiter masses. They also vary hugely in density, challenging existing theories of planet formation and evolution. We will observe new planet candidates with FIES in 2009 as well, and hope that more exciting discoveries will come our way in the near future.

E. Simpson, D. Pollacco, D. Christian, Y. Joshi, Belfast;
I. Skillen, ING; L. Hebb, E. Stempels, St. Andrews

Much progress towards an integrated, efficient operation of the telescope and instruments was made in 2008. We summarise a few specific instrument developments below.

General

2008 saw much progress on optimising the overall operation of the NOT and its instruments, from the planning stage of a project through execution, data reduction and archiving. For this, we have developed a "sequencer" which controls the telescope, instrument, and detector with scripts, such that an entire observing sequence can be launched with a single command – by a remote observer as well as from the control room (see p. 23 for the use of this option in education). Implementing this system for all standard observing modes will be an important step towards an actual queue scheduling system. As another step towards a more efficient future, the new, fast CCD controller developed at Copenhagen University made sufficient progress that we now hope to receive the first unit during 2009. Stay tuned!

NOTCam

The new detector array in NOTCam continues to perform well. Fig. 26 shows two near-IR pictures of the famous Ring Nebula Messier 57 in Lyra – the glowing outer layers of a puffed-up dying star being blown away from the hot core (centre). Continuum (blue/green) and narrow-band molecular hydrogen images (H_2, red) from NOTCam are combined at left, while an Hα image from ALFOSC (blue) is added at right. The co-existence of molecular and ionized hydrogen in the intense radiation field and fast stellar wind from the hot central star shows that the H_2 must have a clumpy structure. The faint petal-shaped outer structures probably represent the wind breaking through denser gas shells from earlier mass-loss episodes in the star.

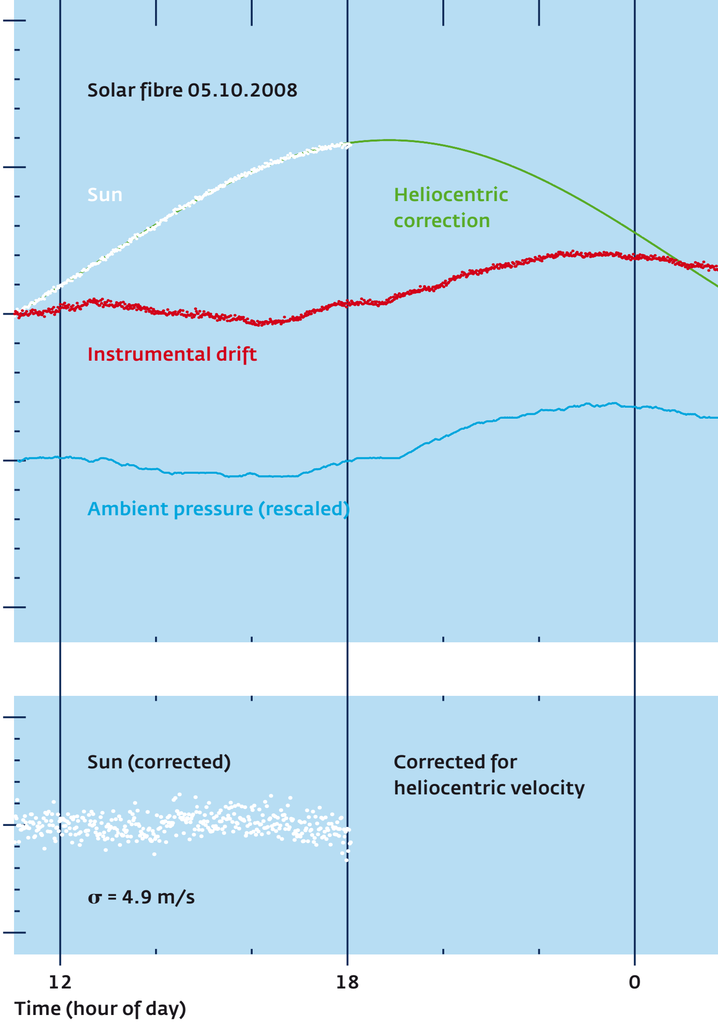
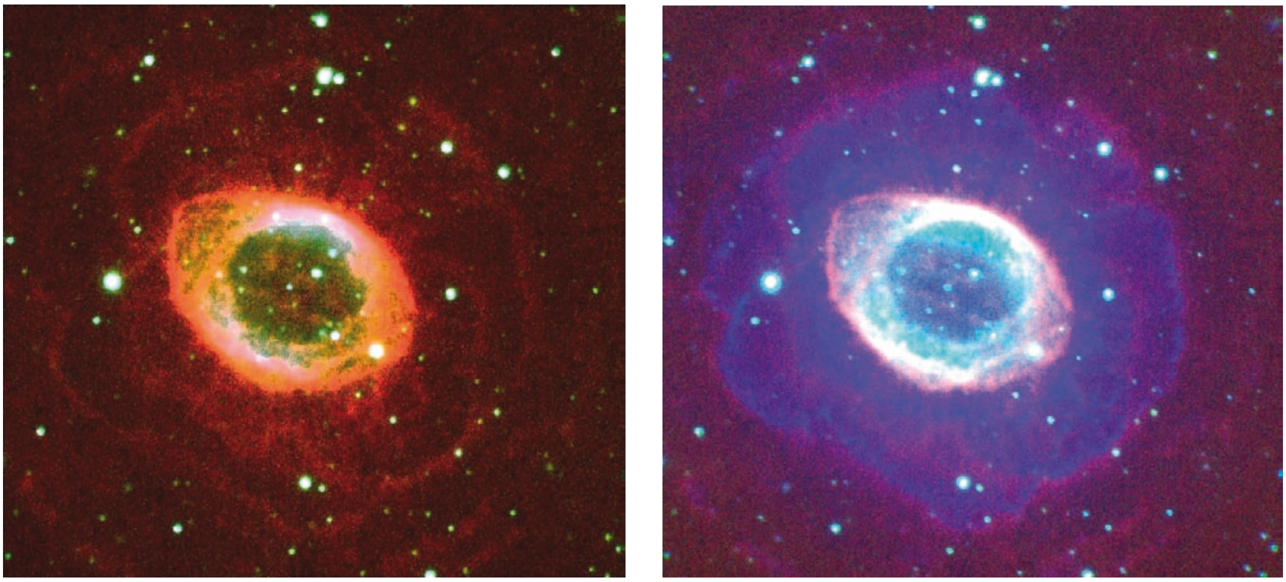
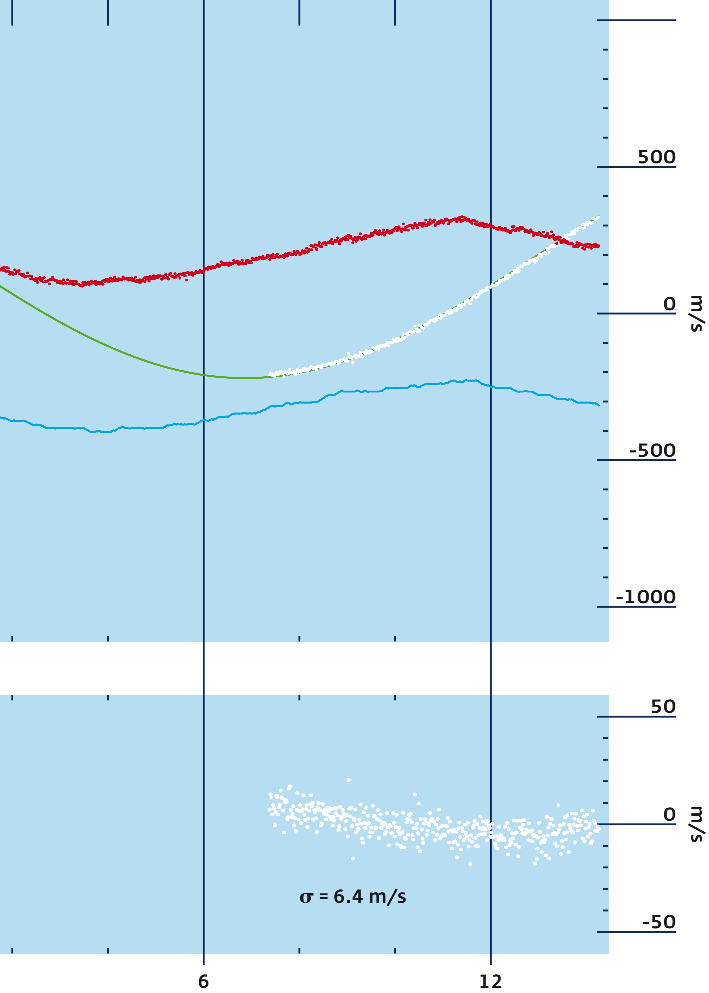


Fig. 27. Daytime sky velocities (green), instrument zero-point (red) and air pressure (blue) for FIES over 24 hours, and residual sky velocities after correction for the observer's motion (black).

Fig. 26. Near-IR JHK+H2 images of M57 (left); same, with Hα added in blue (right).





Stability of FIES

The fibre-fed high-resolution spectrograph FIES offers three fundamental advantages: *(i)* freedom in scheduling, regardless of what instrument is at the main focus; *(ii)* stability and reproducibility, and *(iii)* potentially very accurate spectropolarimetry.

In 2008 we focused on improving the stability of FIES. Mechanical stability is assured in its separate building; thermal stability was improved by a better-optimised control unit, which keeps the temperature constant within ±0.2 °C. The determination of instrumental drifts from ThAr reference spectra with the automated reduction software FIEStool was also improved.

The performance of the new system was monitored continuously for 24 hours with ThAr as well as sky spectra. Fig. 27 shows the derived radial velocity curve of the Sun (in black; daytime only). When the sinusoidal variation due to the Earth's rotation is removed, the residual velocities scatter only ~5 m/s. Planet signatures are within reach!

Fig. 27 also shows the variations in zero-point (red) and atmospheric air pressure (blue – note the tidal wave!). Air pressure is clearly the main cause of the drift, so we must expect a drift of 1-200 m/s during any night. The simultaneous ThAr reference technique clearly compensates very well for this.

E. Stempels, St. Andrews; S. Frandsen, Aarhus; J. Telting, NOT

Diffraction-limited optical imaging with FastCam

FastCam is an instrument developed by Instituto de Astrofísica de Canarias (IAC) and Universidad Politécnica de Cartagena, Spain, to obtain diffraction-limited *I*-band images from ground-based telescopes (see Report for 2007). The instrument uses a low-noise, fast-readout L3CCD to obtain thousands of images with very short exposure times (30 ms) and select subsets with the sharpest images. Diffraction limited images are achieved even in fairly standard seeing conditions of ~1".

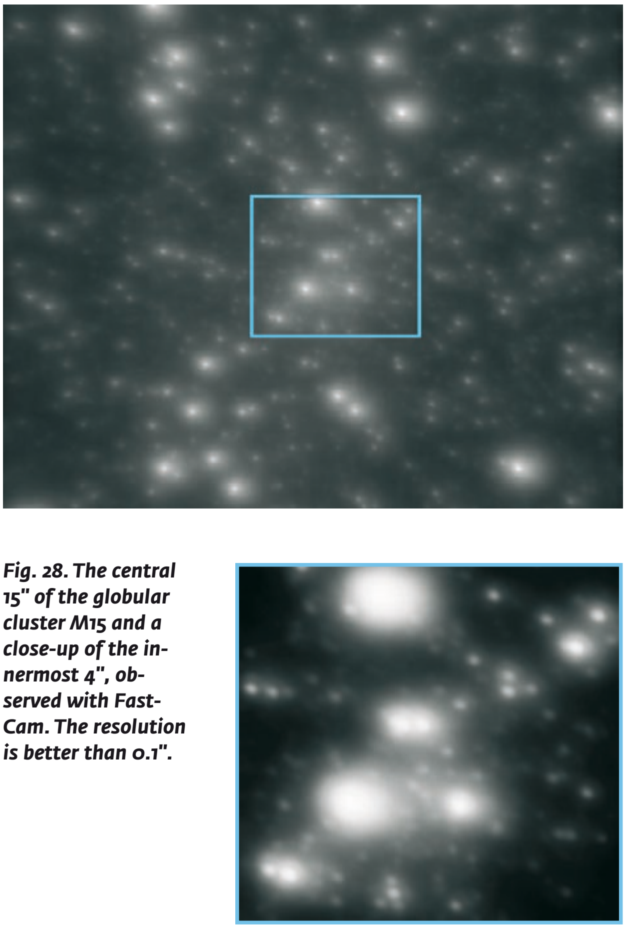


Fig. 28. The central 15" of the globular cluster M15 and a close-up of the innermost 4", observed with FastCam. The resolution is better than 0.1".

Fig. 28 shows an *I*-band image of the central ~15" of the globular cluster M15. Using the best 10% of 100.000 raw images yields a resolution close to the diffraction limit of 0.09". This allows us to determine accurate proper motions of stars in the cluster core by combining the FastCam observation with archival data from the Hubble Space Telescope. The resulting velocity dispersion profile may tell whether an intermediate-mass black hole exists in the compact core of M15. We are also conducting a search for binaries in nearby low-mass and T Tauri stars with FastCam to their determine orbits and dynamical masses

A. Pérez, Cartagena; and the FastCam Team

General

Using a research-grade telescope to train students draws mixed reactions from astronomers. One school of thought believes that hands-on experience with real observations and data is essential for any astronomer. Others consider this a waste, because tomorrow's astronomer will never see a telescope, only receive her data at her desk, from the ground as from space. A third opinion holds that astronomers with practical experience are needed to design and build the instrument systems of the future, and a final camp maintains that using a real telescope on a dark night is what turns young people on to science in the first place.

Each of these statements probably has a grain of truth, but it seems safe to assume that a certain amount of access to professional telescopes will remain of interest for at least some students for another several years. But different services are needed for different groups of students with different abilities, needs, and constraints: Tweaking the ultimate performance out of an instrument for a PhD project is different from a group of 20 undergraduates having fun with a first-year lab exercise, both in terms of capacity, instruction, and logistics.

We have gained considerable experience with the NOT in a wide variety of training contexts. 2008 was a record year, as we spent nearly 25 observing nights on activities ranging from the established NEON observing schools, funded by the Marie Curie programme and OPTICON, over undergraduate courses and half-night visits by high-school classes on La Palma to a course in Lithuania conducted by remote observing (see below). All were successful, and all provided new challenges for the students and ourselves.

We have learned several things: *(i)* The NOT is an excellent telescope for training purposes, because it is so easy to use that a couple of hours' instruction suffice for the students to run it themselves under supervision. *(ii)* 12 students in a group is the maximum we can handle at the observatory. *(iii)* Much planning and preparation are needed on both sides. *(iv)* While we have been lucky so far, expecting good weather on a single, specific night is risky, given the time and expense of taking a group of students and teachers all the way to La Palma.

We are now working to turn this experience into a coherent programme of educational services for a wide range of (primarily university) students, describing the pros and cons of each approach and providing a recipe for success with each of them. On-site courses will remain a mainstay of the programme also in the future, but for limited numbers of PhD and MSc students for reasons of economy of time and travel cost. For such courses we now provide special facilities to enhance the benefit for the students.

As an alternative, we can now offer a remote observing facility that, with good network connections, preserves as much of the "look and feel" of the real telescope as possible without actually going to La Palma. This has proved to be a very valuable option for courses combining use of the NOT with other (optical or radio) telescopes, or when just a few hours of observations are needed for a course in observational techniques embedded in the regular university term structure.

The final stage in the programme is the Research Studentships. We host a few (4-6) PhD or advanced MSc students on La Palma for periods of order a year to gain hands-on experience with all aspects of the telescope, instruments, and operations in an international atmosphere while working on their thesis projects. The studentships continue to be in great demand, and over 80% of our former students are still pursuing careers in astronomy or related sciences. One, Helena Uthas, gave a vivid account of her own experience in the Annual Report for 2007 (p. 26).

To arrange a new observational course at the NOT, the Director should be contacted at least a year in advance to settle any formalities and agree on the schedule. Practical information can also be obtained from Thomas Augusteijn (tau@not.iac.es) or Raine Karjalainen (rkarjala@not.iac.es).

In the following, Thomas Augusteijn describes our course offers in more detail, and Grazina Tautvaišiéne and Jan-Erik Solheim give a few highlights from this year's summer school in Lithuania, where students used the remote control facility to observe with the NOT and FIES in parallel with the local telescopes.

EDUCATIONAL USE OF THE NORDIC OPTICAL TELESCOPE

PhD-level courses in observational astronomy at NOT have been held previously at ~3-year intervals, both on-site and remotely from the Molétai Observatory in Lithuania, with support from NorFA/NORDFORSK. Similar courses at NOT are now being offered annually by the Danish Astrophysics Research School (DARS), with access for other Nordic students. For several years, Stockholm Observatory has also organized a hands-on undergraduate course at NOT as the final stage in a regular course in modern instrumentation and data reduction techniques. Here we describe in general what we offer to groups that want to use the NOT for observational courses, at the observatory or remotely.

The "classroom" in the service building, with tables and the projection screen.

On-site observing courses

The NOT facilities at the observatory consist of the telescope building and a "service" building ~50m away. In the service building we provide a "classroom" area with a large projection screen (1.5m × 3m). During the night this screen is used to project a live copy of the display of the data acquisition computer in the telescope control room. The sound from the control room is also transmitted, providing a reasonable impression of "live" observing. Webcams and a headset provide direct communication with the control room for any instructions or questions.

Our facilities accommodate a maximum of 12 students plus 2 or 3 teachers. The students are generally divided into groups of 2 or 3, who operate the telescope and instrument(s) in shifts. The remaining students can observe what is going on at the telescope from the classroom and/or spend their time analyzing or discussing the (previous) observations. As part of the course facilities we provide a full set of 12 laptops for the students, all with a common "standard" software installation on a Linux platform. In principle this includes all basic astronomy reduction and analysis packages, but the specific installation can be adapted for each course.

We also provide help with planning travel and arranging for lodging at sea-level and with arranging for lodging and food at the observatory.

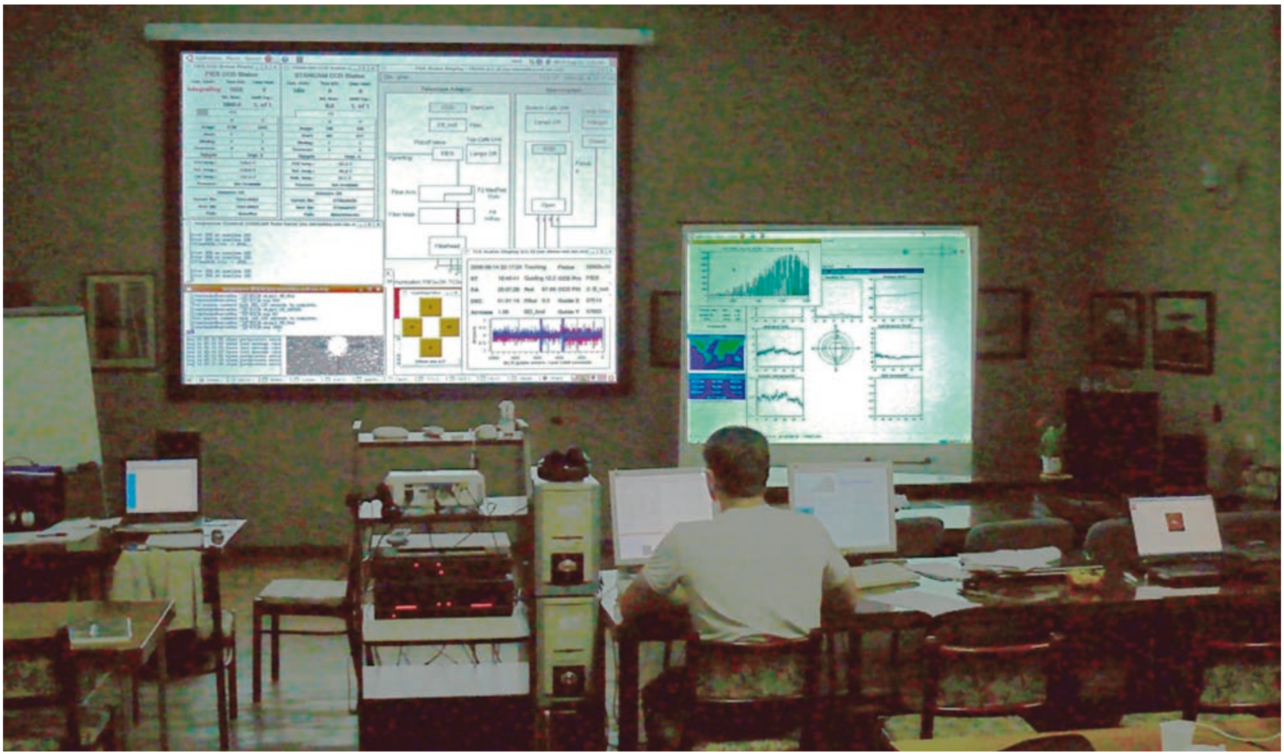
Remote observing courses

For remote observing courses our main objective is to mimic the "look and feel" of observing at the telescope as much as possible, but we depend on the reliability and speed of the Internet connection and need to take safety issues at the telescope into account.

To begin, the observer logs in remotely and operates the instrument and telescope as much as possible by typing commands directly into remote windows on our data acquisition computers. In addition, there are a limited number of graphical status displays. Partly governed by the issue of bandwidth, the specific observing system setup and appearance will be different for remote and on-site observations, and a specific remote observing system is provided. A matching system is set up at the telescope to monitor any safety issues and provide advice and support in case of problems.

Proper preparation is an important general issue. This applies to the course itself (course programme, literature

The remote 'control room' at Molétai, showing the projection screens
Photo: G. Barisevicius



Students and faculty at the 2008 NordForsk Research Course at Molétai Observatory, Lithuania

studies, observing plan, telescope and instrument set-up, data reduction, etc), but the set-up for remote observing must also be defined and tested. Below we describe the various steps that are involved in the set-up for remote observing.

- Any of the NOT core instrument suite of ALFOSC, FIES, NOTCam, MOSCA and StanCam can be used in remote observing. However, we do need to know well in advance which instrument and observing mode(s) are going to be used so any specific preparations can be made.

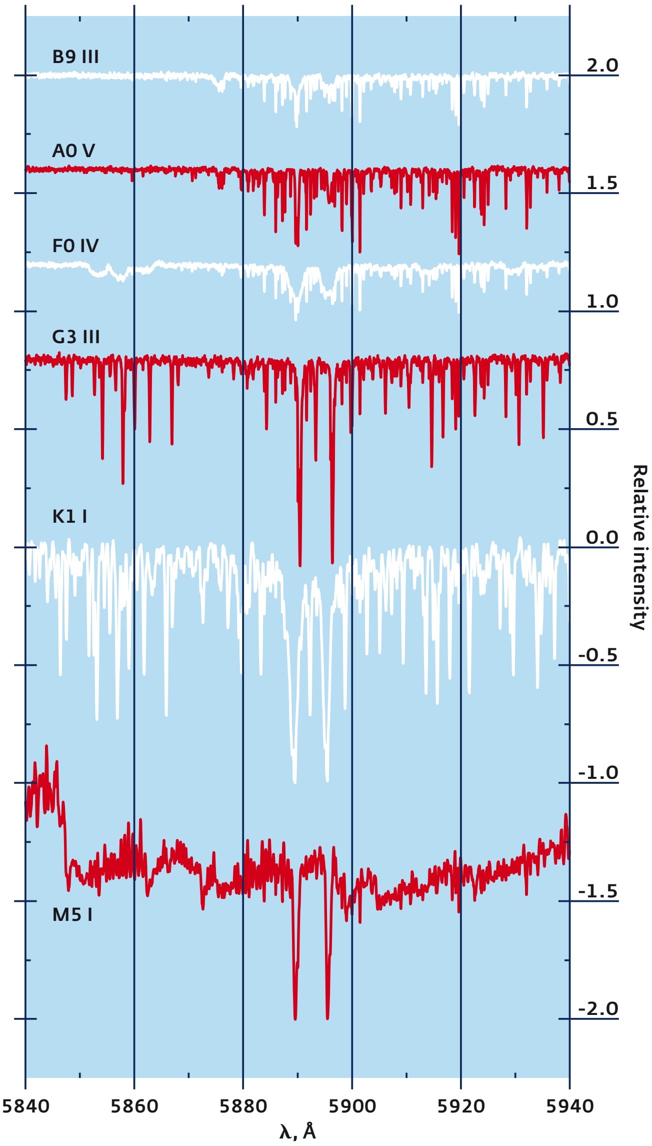
- For safety reasons we provide a support astronomer at the telescope, who monitors the observations and executes certain tasks which are potentially dangerous if executed remotely (e.g., powering up the telescope). The support astronomer can also provide immediate advice and help if needed.

- A good communication link between the remote observing site and the NOT is essential. In general, we use a Voice-over-Internet connection.

- A specific issue with any remote observing is transfer of the data. At the NOT, the data are automatically put on our FTP server for retrieval. We provide a simple programme for at the remote observing site that transfers the data automatically.

- Pointing the telescope can be done by simply typing commands in the remote window on the observing system. Guide star selection, centering and starting the autoguider is done automatically by the Telescope Control System. The status of the telescope and autoguider is shown on a specific remote status display.

- There is also a need to monitor the observations, assess the data and do some quick analysis. Depending on the instrument and observing mode we provide quick-look procedures that can be used to assess the quality of the data. These procedures can be applied automatically to the data before or after transmission from the telescope to the remote observing side. In principle, as these procedures only present the result (e.g., a number or a one-dimensional spectrum), demands on the bandwidth of the connection are typically lower than if all the raw data are transferred.



Spectral region around Na I D line in stars of different spectral type and luminosity class. The spectra are arbitrarily offset for clarity. Na is one of the elements sometimes affected by non-canonical mixing in red giants.

A NORDIC-BALTIC RESEARCH COURSE USING THE NOT FROM LITHUANIA

Four NordForsk courses held at Molėtai Observatory in Lithuania have shown that the combination of local telescopes and good premises for board and lodging at the observatory creates a good environment for teaching at an advanced level. The opportunity for remote observing with a front-line research telescope as the NOT makes this even more interesting for the students. The Nordic-Baltic Research Course "Observational Stellar Astrophysics", held at the Molėtai Observatory in Lithuania in August 2008 with support from NordForsk, was the third time that remote observations with the NOT were successfully included in these courses. 5 half-nights were allocated on the high resolution spectrograph FIES.

The course focused on investigations of stellar abundance peculiarities which appear while stars evolve as red giants, including canonical and "extra" mixing along the Red Giant Branch. We compared classical predictions of the so-called first dredge-up with observational data in various stars and showed how spectroscopic diagnostics may probe the nucleosynthesis and internal mixing mechanisms that operate in Red Giant stars.

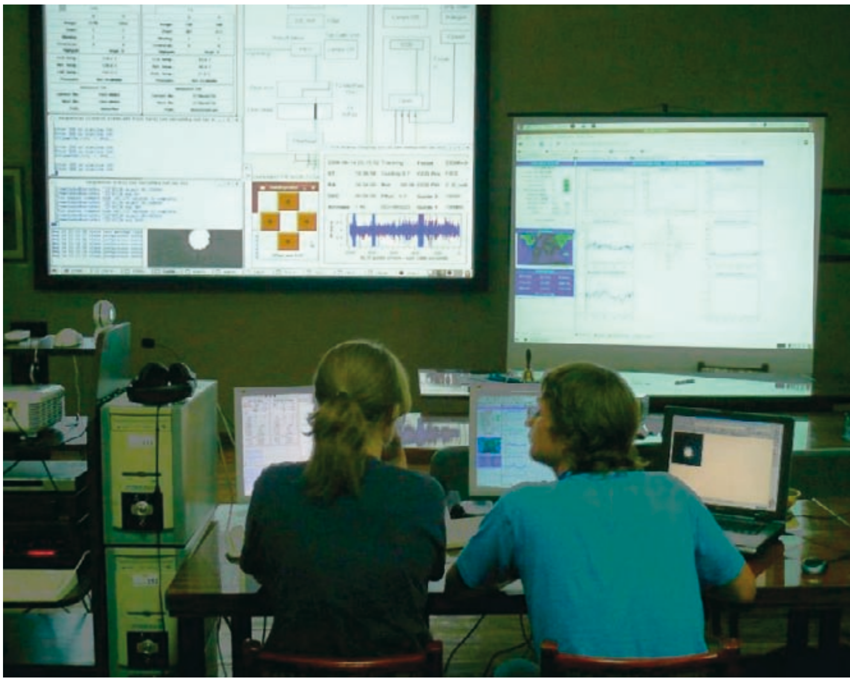
From their own spectroscopic observations with FIES at the NOT, the students discovered the existence of non-standard and shallow mixing processes that change stellar surface abundances. A series of lectures discussed the current understanding of the connection between this extra-mixing and stellar structure and evolution.

20 students from all the Nordic and Baltic countries and NW Russia were introduced to modern methods of stellar observations. About a half of the students had no observing experience. During the course, pairs of experienced/unexperienced students worked together on exercises and observing runs. More than half of the students were PhD students; the rest were still in the final stage of their MSc studies.

The course lasted two full weeks. The daily schedule consisted of four lectures before a lunch break, afternoon exercises and preparations for observations, and night observations on the local and remote telescopes. The last two days of the course the students worked on a large assignment, and the result was presented on the final day. Students were invited to publish their results in a book produced after the course, and 16 of them did so. The 129-page book was published at the end of the year.

As in previous courses, we were amazed to experience how students, who did not know each other beforehand, worked and lived together and helped each other in stress situations, solving difficult problems during these two weeks. At the end we had a very well-integrated and devoted team working together towards a common goal – a great omen for the future of our science!

G. Tautvaišienė, Vilnius; J.-E. Solheim, Oslo



Students doing remote observations with the NOT telescope.

A local inhabitant inspecting our resources...
Photo: Peter Sørensen.

FINANCIAL MATTERS

NOTSA is a non-profit organisation funded to operate NOT as a tool for Nordic astronomy. Annual budgets are approved by the Council, and the Director is responsible for managing the operation within budget as specified in the *Financial Rules*. NOTSA's accounts for 2006-2009 are audited by the *National Auditing Office of Iceland*, supplemented by a Swedish auditor to comply with Swedish regulations.

Accounts for 2008

NOTSA's accounts and budget for 2008 are summarised and compared with the accounts for 2007 in the table below. Budget headings cover the following items:

Directorate: Directorate staff and operations, committee travel, bank charges, stipends to Spanish Ph.D. students at Nordic universities, OPTICON, ASTRONET, and NORDFORSK activities, and the Annual Report.

La Palma staff: Salary and social charges for all staff and students on La Palma; training courses, etc.

La Palma infrastructure: Telescope and office facilities; electricity, water, and cleaning; computers and networks; and cars and other transportation.

La Palma operations: Accommodation and meals at the observatory for staff and students; communications and shipping; telescope, laboratory, and office equipment and consumables, etc.

Telescope and instrument operation and maintenance: Operation, repair, and spare parts for the telescope and instruments; cryogenics, electronics, optics, and data acquisition and archiving equipment.

Development projects: Major telescope or instrumentation projects.

Contributions: A *basic contribution* of 1 336 400 Euro is shared between Associates as specified in the Agreement (Denmark 19.8%, Finland 29.7%, Iceland 1%, Norway 19.8%, and Sweden 29.7%); *additional contributions* totalling 245 000 Euro were provided as well.

Other income: EC refunds of OPTICON travel and access cost; the NORDFORSK grants, and bank interest.

Financial result of 2008

As seen in the table, the costs of the directorate and operations were essentially on budget in 2008. The increase in *Staff* is due to the arrival of a postdoc paid from the NORDFORSK grant, on *La Palma infrastructure* partly to a sharp increase in the price of electricity, partly to the purchase of a set of laptop computers for on-site training courses. Total expenditure in 2008 was thus 63 kEuro above budget. *Other income* was boosted by the prompt payment of two grants from NORDFORSK totalling 174 kEuro, plus an increase in interest rates. Overall, the result of 2008 was 100 kEuro better than budgeted, and our reserves at the end of 2008 are healthy.

BUDGET LINE	Expenses 2008 Euro	Budget 2008 kEuro	Expenses 2007 kEuro
Directorate	227 762	220	227
La Palma staff	1 146 870	1 111	1 066
La Palma infrastructure	186 077	145	144
La Palma operations	122 040	108	101
Telescope operation and maintenance	27 923	32	40
Instrument operation and maintenance	25 647	40	23
Telescope development projects	0	25	0
Special development projects	7 738	0	9
Total expenses	**1 744 058**	**1 681**	**1 609**
Contributions	1 581 600	1 582	1 470
Other income	253 160	91	128
Total income	**1 834 760**	**1 673**	**1 598**
Result of the year	**90 702**	**-9**	**11**
Reserves at beginning of the year	359 073	292	370
Reserves at end of the year	449 775	283	359

Observing time is our key scientific asset. Competition is strong, so the time allocation process must be seen as competent, transparent, and impartial. We describe it below.

Time allocation procedure

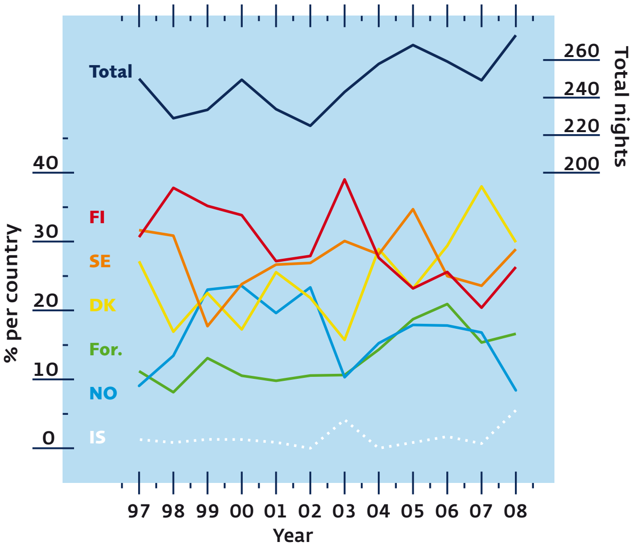
Calls for Proposals for observing time at the NOT are announced widely, with proposal deadlines on the first working days of May and November for the semesters beginning the following October 1 and April 1. In addition, proposals for up to 4h of observing time can be submitted at any time by a simple 'Fast-track' procedure; (see *http://www.not.iac.es/observing/proposals/*); if approved by the OPC, projects are then executed by our staff on one of several service nights reserved throughout each semester.

The Observing Programmes Committee (OPC; inside back cover) of five independent, respected Nordic scientists is appointed by the Council to peer review all observing proposals. The OPC ranks all proposals on a numerical scale and advises applicants on potential improvements; technical feasibility is assessed by the NOT staff, with feedback provided as appropriate. Each member has a substitute to broaden scientific coverage and avoid conflicts of interest. Based on the ranking and various practical constraints (object visibility, Moon phase, etc.) the Director drafts a schedule, which is checked by the OPC before it is finalised.

To encourage competition and raise scientific standards, proposals are reviewed on an equal footing, regardless of national origin, and "foreign" interest in NOT is keen, not only when supported via the OPTICON trans-national access programme (*http://www.otri.iac.es/opticon/*) – see below. Should a more broadly-based common telescope facility result from the ASTRONET 2-4m telescope review (see p. 4), the entire access and time allocation process will need thorough revision as well. OPTICON may play a catalyst role in the process, although the modest funds in the FP7 contract limits its influence on the result.

Observing time in 2008

Observing statistics are compiled by allocation period, so this report covers the year April 1, 2008, to April 1, 2009. The *"pressure factor"* (nights requested/nights available) increased again slightly to 2.4. In total, 319 nights were used for scientific observations, including the 25% of all time that is reserved for Spanish and CCI international projects. 245 nights were available to the Nordic community, including training courses (22.5 nights). 12 nights or 4% were allocated to projects by NOT staff and 53.5 nights or 20% went non-Nordic ("foreign") projects; only half of these (28 nights) were refunded as OPTICON access time. The rest (208 nights) was distributed as follows: Denmark 62 nights (30%), Finland 55 (26%), Iceland 13.5 (6%), Norway 17.5 (8%), and Sweden 60 (29%).



Total nights allocated annually by NOT in 1997-2008 (top), and the Nordic and "foreign" shares.

Instruments were used as follows: ALFOSC 154.5 nights (42%), FIES 94.5 (26%), MOSCA 21 (6%), NOTCam 38 (10%), SOFIN 15 (4%), TurPol 21 (6%), and visitor instruments 21 nights (6%). The increasing interest in FIES, which is notable also for fast-track projects, now causes the demand for bright time to equal that for dark time.

Service observing was provided on a total of 56 scheduled service nights in 2008, as well as on parts of many technical and visitor nights. The "fast-track" service proposal system is seeing sharply increasing interest, with 12 and 24 accepted proposals in the first and second semesters (i.e. 36 total, up 33% from 2007); 20, 11, and 5 of these were rated as Grade 1, 2, and 3, respectively (1 is highest). Projects remain in the queue for up to three semesters (two observing seasons) if necessary, and all projects older than this have in fact been completed. Overall status for the programme is, for Grade 1: 16 projects fully and 7 partly completed out of 31; Grade 2: 8 fully and 3 partly out of 16; and Grade 3: 4 fully and 1 partly out of 8. Note that many of these proposals were submitted during the current semester and will be completed in the near future, weather permitting.

The national distribution of time fluctuates considerably over time because observing time is allocated by scientific merit, not as national quotas set by the budget (see figure). Over the last five years, the Nordic time was shared with 30% to Danish projects, 25% to Finland, 2.2% to Iceland, 15% to Norway, and 28% to Sweden. Staff and "foreign" (including OPTICON) time were 6% and 20% of the total.

Publications are the standard indicator of scientific output, and we maintain lists of refereed papers based on NOT data at http://www.not.iac.es/news/publications. Papers published in 2008 are listed below; for papers with 9 or more authors, the first six names and the total number are given.

International refereed publications:

Amanullah, R., Stanishev, V., Goobar, A. et al. (17 authors): *“Light curves of five type Ia supernovae at intermediate redshift”*, 2008, A&A **486**, 375

Antón, S., Browne, I.W.A., Marchã, M. J.: *“The colour of the narrow line Sy1-blazar 0324+3410”*, 2008, A&A **490**, 583

Arentoft, T., Kjeldsen, H., Bedding, T.R., Bazot, M., Christensen-Dalsgaard, J., Dall, T. et al. (48 authors): *“A Multisite Campaign to Measure Solar-like Oscillations in Procyon. I. Observations, Data Reduction, and Slow Variations”*, 2008, ApJ **687**, 1180

Ascaso, B., Moles, M., Aguerri, J.A.L., Sánchez-Janssen, R., Varela, J.: *“The bright galaxy population of five medium redshift clusters – I. Color-magnitude relation, blue fractions, and visual morphology”*, 2008, A&A **487**, 453

Atek, H. Kunth, D. Hayes, M., Östlin, G., Mas-Hesse, J.M.: *“On the detectability of Ly-α emission in star forming galaxies – The role of dust”*, 2008, A&A **488**, 491

Baldwin, J.E., Warner, P.J., Mackay, C.D.: *“The point spread function in Lucky Imaging and variations in seeing on short timescales”*, 2008, A&A **480**, 589

Bouy, H., Huélamo, N., Pinte, C. et al. (18 authors): *“Structural and compositional properties of brown dwarf disks: the case of 2MASS J04442713+2512164”*, 2008, A&A **486**, 877

Caballero, J.A., Valdivielso, L., Martín, E.L., Montes, D., Pascual, S., Pérez-González, P.G.: *“Low-resolution spectroscopy and spectral energy distributions of selected sources towards σ Orionis”*, 2008, A&A **491**, 515

Covino, S., D’Avanzo, P., Klotz, S. et al. (54 authors); *“The complex light curve of the afterglow of GRB 071010A”*, 2008, MNRAS **388**, 347

Delorme, P., Willott, C.J., Forveille, T., Delfosse, X., Reylé, C., Bertin, E. et al. (12 authors): *“Finding ultracool brown dwarfs with MegaCam on CFHT: method and first results”*, 2008, A&A **484**, 469

Dillon, M., Gänsicke, B.T., Aungwerojwit, A., Rodriguez-Gil, P., Marsh, T.R., Barros, S.C.C. et al. (10 authors): *“Orbital periods of cataclysmic variables identified by the SDSS. III. Time-series photometry obtained during the 2004/5 International Time Project on La Palma”*, 2008, MNRAS **386**, 1568

Dobrinčić, M., Villaver, E., Guerrero, M.A., Manchado, A.: *“Kinematical Analysis of a Sample of Bipolar Planetary Nebulae”*, 2008, AJ **135**, 2199

Durbala, A., del Olmo, A., Yun, M.S., Rosado, M., Sulentic, J.W., Plana, H. et al. (10 authors); *“Seyfert’s Sextet: A Slowly Dissolving Stephan’s Quintet?”*, 2008, AJ **135**, 130

Erwin, P., Pohlen, M., Beckman, J.E.: *“The Outer Disks of Early-Type Galaxies. I. Surface-Brightness Profiles of Barred Galaxies”*, 2008, AJ **135**, 20

Esquej, P., Saxton, R.D., Komossa, S. et al. (11 authors): *“Evolution of tidal disruption candidates discovered by XMM-Newton”*, 2008, A&A **489**, 543

Frieman, J. A., Bassett, B., Becker, A., Choi, C., Cinabro, D., DeJongh, F. et al. (101 authors) *“The Sloan Digital Sky Survey-II Supernova Survey: Technical Summary”*, 2008, AJ **135**, 338

Freyhammer, L.M., Elkin, V.G., Kurtz, D.W.: *“On the spectroscopic nature of the cool evolved Am star HD151878”*, 2008, MNRAS **390**, 257

Gahm, G.F., Walter, F.M., Stempels, H.C., Petrov, P.P., Herczeg, G.J.: *“Unveiling extremely veiled T Tauri stars”*, 2008, A&A **482**, L35

Gålfalk, M., Olofsson, G.: *“A detailed study of the L1641N star formation region”*, 2008, A&A **489**, 1409

Grundahl, F., Clausen, J.V., Hardis, S., Frandsen, S.: *“A new standard: Age and distance for the open cluster NGC 6791 from the eclipsing binary member V20”*, 2008, A&A **492**, 171

Guerrero, M.A., Miranda, L.F., Riera, A., Velázquez, P.F., Olguín, L., Vázquez, R. et al. (9 authors): *“Multiple and Precessing Collimated Outflows in the Planetary Nebula IC 4634”*, 2008, ApJ **683**, 272

Harutyunyan, A.H., Pfahler, P., Pastorello, A. et al. (15 authors): *"ESC supernova spectroscopy of non-ESC targets"*, 2008, A&A **488**, 383

Holtzman, J.A., Marriner, J., Kessler, R. et al. (32 autors): *"The Sloan digital sky survey-II: photometry and supernova Ia light curves from the 2005 data"*, 2008, AJ **136**, 2306

Järvinen, S.P., Korhonen, H., Berdyugina, S.V., Ilyin, I., Strassmeier, K.G., Weber, M. et al. (8 authors): *"Magnetic activity on V889 Herculis – Combining photometry and spectroscopy"*, 2008, A&A **488**, 1047

Jaunsen, A.O., Rol, E., Watson, D.J., Malesani, D., Fynbo, J.P.U., Milvang-Jensen, B. et al. (15 authors): *"GRB 070306: A Highly Extinguished Afterglow"*, 2008, ApJ **681**, 453

Kankare, E., Mattila, S., Ryder, S.E. et al. (12 authors): *"Discovery of a Very Highly Extinguished Supernova in a Luminous Infrared Galaxy"*, 2008, ApJL **689**, L97

Larionov, V.M., Jorstad, S.G., Marscher, A.P., Raiteri, C.M., Villata, M., Agudo, I. et al. (72 authors): *"Results of WEBT, VLBA and RXTE monitoring of 3C 279 during 2006-2007"*, 2008, A&A **492**, 389

Law, N.M., Hodgkin, S.T., Mackay, C.D.: *"The LuckyCam survey for very low mass binaries – II. 13 new M4.5-M6.0 binaries"*, 2008, MNRAS **384**, 150

Licandro, J., Alvarez-Candal, A., de León, J., Pinilla-Alonso, N., Lazzaro, D., Campins, H.: *"Spectral properties of asteroids in cometary orbits"*, 2008, A&A **481**, 861

Lietzen, H., Nilsson, K., Takalo, L.O., Heinämäki, P., Nurmi, P., Keinänen, P., Wagner, S.: *"Clustering environment of BL Lacertae object RGB 1745+398"*, 2008, A&A **482**, 771

López, R., Sánchez, S.F., Garcia-Lorenzo, B., Gómez, G., Estalella, R., Riera, A., Busquet, G.: *"The nature of HHL 73 from optical imaging and Integral Field Spectroscopy"*, 2008, MNRAS **384**, 464

López-Sánchez, Á.R., Esteban, C.: *"Massive star formation in Wolf-Rayet galaxies. I. Optical and NIR photometric results"*, 2008, A&A **491**, 131

Manthey, E., Hüttemeister, S., Aalto, S., Horellou, C., Bjerkeli, P.: *"Stars and gas in the Medusa merger"*, 2008, A&A **490**, 975

Martínez, M.A., del Olmo, A. Coziol, R. Focardi, P.: *"Deficiency of Broad-Line AGNs in Compact Groups of Galaxies"*, 2008, ApJ **678**, L9

Mazzali, P.A., Sauer, D.N., Pastorello, A., Benetti, S., Hillebrandt, W.: *"Abundance stratification in Type Ia supernovae – II. The rapidly declining, spectroscopically normal SN2004eo"*, 2008, MNRAS **386**, 1897

Melita, M., Licandro, J., Jones, D., Williams, I.P.: *"Physical properties and orbital stability of the Trojan asteroids"*, 2008, Icarus **195**, 686

Michielsen, D., Boselli, A., Conselice, C.J. et al. (12 authors): *"The relation between stellar populations, structure and environment for dwarf elliptical galaxies from the MAGPOP-ITP"*, 2008, MNRAS **385**, 1374

Negueruela, I., Marco, A.: *"Stellar tracers of the Cygnus Arm – II. A young open cluster in Camelopardalis OB3"*, 2008, A&A **492**, 441

Nilsson, K. Pursimo, T., Sillanpää, A., Takalo, L.O., Lindfors E.: *"Detection of the host galaxy of S5 0716+714"*, 2008, A&A **487**, L29

Pereira, C.B., Miranda, L.F., Smith, V.V., Cunha, K.: *"High-resolution spectroscopic observations of the peculiar planetary nebula Me 1-1"*, 2008, A&A **477**, 535

Piirola, V., Vornanen, T., Berdyugin, A., Coyne, G.V.: *"V405 Aurigae: A High Magnetic Field Intermediate Polar"*, 2008, ApJ **684**, 558

Raiteri, C.M., Villata, M., Larionov, V.M., Aller, M.F., Bach, U., Gurwell, M. et al. (61 authors): *"Radio-to-UV monitoring of AO 0235+164 by the WEBT and Swift during the 2006/2007 outburst"*, 2008, A&A **480**, 339

Raiteri, C.M., Villata, M., Chen, W.P. et al. (61 authors): *"The high activity of 3C 454.3 in autumn 2007 – Monitoring by the WEBT during the AGILE detection"*, 2008, A&A **485**, L17

Raiteri, C.M., Villata, M., Larionov, V.M., Gurwell, M.A., Chen, W.P., Kurtanidze, O.M. et al. (75 authors): *"A new activity phase of the blazar 3C 454.3"*, 2008, A&A **491**, 755

Ramos-Larios, G., Guerrero, M.A., Miranda L.F.: *"The Unusual Distributions of Ionized Material and Molecular Hydrogen in NGC 6881: Signposts of Multiple Events of Bipolar Ejection in a Planetary Nebula"*, 2008, AJ **135**, 1441

Rossi, A., de Ugarte Postigo, A., Ferrero, P. et al. (31 authors): *"A photometric redshift of* $z = 1.8\pm0.3$ *for the AGILE GRB 080514B"*, 2008, A&A **491**, L29

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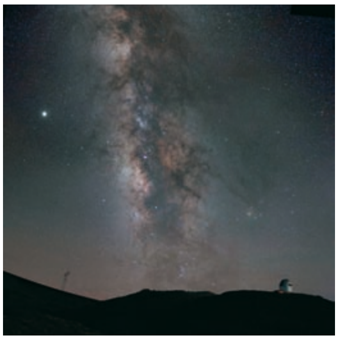

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