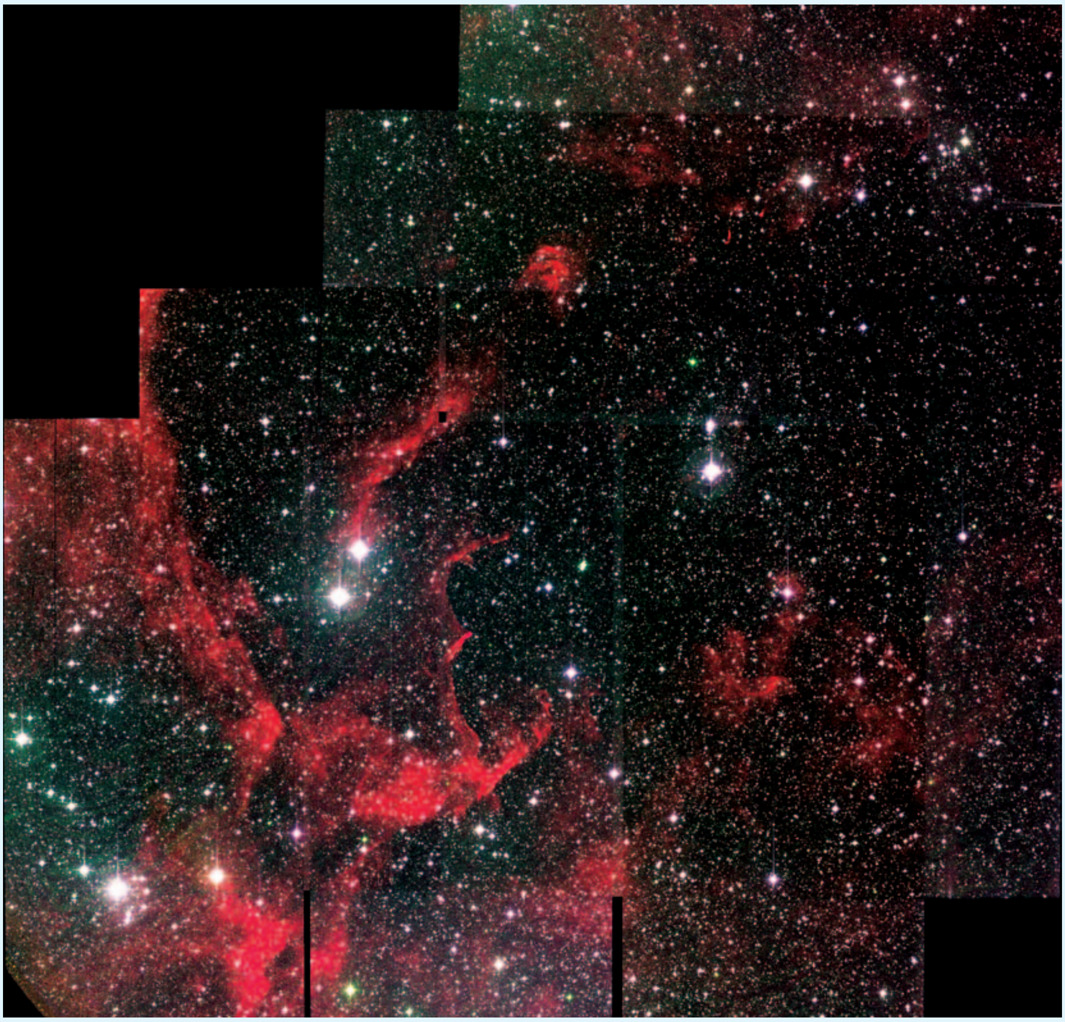
No. 9, March 2005

The Isaac Newton Group of Telescopes

NEWSLETTER



Filamentary Hα emission in Cygnus, observed as part of the INT WFC Northern Galactic Plane photometric Hα survey (IPHAS). The colour scheme is red for Hα, blue for the Sloan r' band, and green for Sloan i' band. As this is a significantly reddened region, as well as nebulous, there are many stars coming through strongly in the i' band, appearing here as a background of green stars. Colour image courtesy of Mike and Jonathan Irwin (IoA, Cambridge). For more information see the article by Janet Drew et al. on page 3.

Message from the Director

Dear Reader,

In the previous issue of this Newsletter I reported on the initiation of a project for the development of a Rayleigh laser guide star beacon, GLAS, for the WHT. Since then much work has gone into this project, and an important milestone was passed in January with the successful completion of the Preliminary Design Review. The positive outcome of that review implies that the project now moves towards the final design stage, and real money can now be spent on hardware. For example, the solid-state laser system will be purchased shortly. GLAS is a complex and demanding development, with exciting science prospects that make this project worthwhile; watch this space !

Another key event that will take place during the summer of this year is an independent international review of the ING, commissioned by the ING Board. The high-profile committee of four world-renowned astronomers will focus specifically on the medium-term future of the observatory. The views of the wider astronomical community —your views— will play an important role, and to that effect a community questionnaire has been released to provide an easy input channel. Until May 31st input can

The Isaac Newton Group of Telescopes

The Isaac Newton Group of Telescopes (ING) consists of the 4.2 m William Herschel Telescope (WHT), the 2.5 m Isaac Newton Telescope (INT) and the 1.0 m Jacobus Kapteyn Telescope (JKT), and is located 2350 m above sea level at the Roque de Los Muchachos Observatory on the island of La Palma, Canary Islands, Spain. The WHT is the largest telescope of its kind in Western Europe.

The construction of the ING telescopes was the result of a collaboration between the United Kingdom and the Netherlands. The site is provided by Spain, and in return Spanish astronomers receive 20 per cent of the observing time on the telescopes. The operation of the site is overseen by an International Scientific Committee, or Comité Científico Internacional (CCI).

A further 75 per cent of the observing time is shared by the United Kingdom, the Netherlands and the Instituto de Astrofísica de Canarias (IAC). The remaining 5 per cent is reserved for large scientific projects to promote international collaboration between institutions of the CCI member countries.

The ING operates the telescopes on behalf of the Particle Physics and Astronomy Research Council (PPARC) of the United Kingdom, the Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO) of the Netherlands and the IAC in Spain. The Roque de Los Muchachos Observatory, which is the principal European Northern hemisphere observatory, is operated by the IAC.

(Continued from front cover)

be provided through: `http://www.ing.iac.es/AboutING/questionnaire_form.html`.

In this issue of the Newsletter you will find a fine cross section of science results obtained from the telescopes. But let me point you also to the contributions by S. Hameed that so nicely captures the excitement of conducting astronomical observations, and the one by N. Douglas on a very special public outreach activity.

I end this introduction with two sad notes: Our friend and colleague, Charles Benneker, passed away in October last year. Charles had worked at the observatory for over a decade, specialising on electronics systems and instrument control systems. Charles will be dearly missed and not be forgotten by his friends and colleagues. A commemorative plaque will be located on the WHT.

We were equally shocked to hear that Emilios Harlaftis died as the result of a tragic accident. Emilios had spent several years working at the observatory as support astronomer. After moving back to the UK, and later to his home country, Greece, he always kept close scientific and personal ties with the observatory on La Palma. He will be remembered for his contribution to science and his unconditional enthusiasm for astronomy and the observatory.

René G. M. Rutten

The ING Board

The ING Board oversees the operation, maintenance and development of the Isaac Newton Group of Telescopes, and fosters collaboration between the international partners. It approves annual budgets and determines the arrangements for the allocation of observing time on the telescopes. ING Board members are:

Prof J. Drew, *Chairperson* – ICL
Prof T. van der Hulst, *Vice Chairperson* – University of Groningen
Dr G. Dalton – University of Oxford
Dr R. García López – IAC
Dr P. Crowther – University of Sheffield
Dr R. Stark – NWO
Dr C. Vincent – PPARC
Dr S. Berry, *Secretary* – PPARC

The ING Director's Advisory Group

The Director's Advisory Group (DAG) assists the observatory in defining the strategic direction for operation and development of the telescopes. It also provides an international perspective and acts as an independent contact point for the community to present its ideas. DAG members are:

Dr M. McCaughrean, *Chairperson* – Astrophysikalisches Institut Potsdam
Dr M. Balcells – IAC
Dr P. A. James – Liverpool John Moores Univ.
Dr N. Tanvir – Univ. of Hertfordshire
Dr E. Tolstoy – Univ. of Groningen

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The ING Newsletter is published twice a year in March and September. If you wish to submit a contribution, please contact Javier Méndez (`jma@ing.iac.es`). Submission deadlines are 15 July and 15 January.

SCIENCE

IPHAS: Surveying the Northern Galactic Plane in Hα

J. E. Drew[1], D. J. Lennon[2], R. Greimel[2], A. Zijlstra[3], J. Irwin[4], A. Aungwerowijt[5], M. J. Barlow[5], R. Corradi[2], C. J. Evans[2], B. Gaensicke[6], P. Groot[7], A. Hales[5], E. Hopewell[1], M. J. Irwin[4], M. Jaigirdar[2], C. Knigge[8], P. Leisy[2], A. Mampaso[9], M. Matsuura[3], L. Morales Rueda[7], R. Morris[10], Q. A. Parker[11], S. Phillipps[10], P. Rodríguez Gil[9], G. Roelofs[7], I. Skillen[2], D. Steeghs[12], Y. C. Unruh[1], K. Viironen[9], J. Vink[1], N. A. Walton[4], A. Witham[8], N. Wright[5], A. Zurita[13]

1: Imperial College London; 2: Isaac Newton Group of Telescopes; 3: Manchester University; 4: CASU, Cambridge; 5: University College London; 6: Warwick University; 7: Nijmegen University, The Netherlands; 8: Southampton University; 9: Instituto de Astrofísica de Canarias; 10: Bristol University; 11: Macquarie University, Australia; 12: Harvard-Smithsonian Centre for Astrophysics, USA; 13: Granada University, Spain.

Hα emission is ubiquitous in our Galaxy. It traces ionised gas of assorted nebulae such as HII regions, planetary nebulae, Wolf-Rayet nebulae, and supernova remnants. It is a strong signature of active stars, interacting binaries, very massive stars (especially supergiants, Luminous Blue Variables and Wolf-Rayet stars), Be stars, post-AGB stars, pre-main-sequence stars and so on. These objects represent important evolutionary phases which are generally short lived, and are hence few in number and difficult to find. Their discovery is therefore well worth the effort of a concerted programme and in August 2003 a major new survey project was started using the Wide Field Camera (WFC) on the Isaac Newton Telescope (INT) to do just that. It is called the INT Photometric Hα Survey of the Northern Galactic Plane, or IPHAS for short.

Figure 1. The crescent nebula, NGC6888, which surrounds the Wolf-Rayet star PPM 84423, seen in Hα emission by IPHAS. Colour image courtesy of Jonathan Irwin.

IPHAS is a collaborative UK/NL/ES venture led by Janet Drew in UK, Paul Groot in The Netherlands, and Antonio Mampaso in Spain. Its goal is to conduct an Hα survey of the entire northern Galactic Plane in the latitude range $-5° < b < +5°$, a sky area of 1800 sq. deg., covering the magnitude range $13 < r' < 20$. That such a survey is needed can be deduced from Figure 2, and when complete it will represent an enormous improvement over previous work. For example it is expected that in excess of 10,000 new emission line stars alone will be discovered, an order of magnitude increase on known sources.

Survey Details

The 1800 square degrees will be tiled with 7635 pointings of the WFC, each of which is paired with a second pointing at an offset of 5 arcmin W and S. The purpose of the offset field is to ensure that we cover stars in the gaps between detectors, but also means that the majority of sources are observed at least twice. Each field is to be observed with the Sloan r' and i' filters, plus a narrow band Hα filter, with exposure times of 30 s, 10 s and 120 s respectively. The use of a guide star is not necessary for such short exposure times and is dispensed with to save on overheads, while for each Hα$-r'-i'$ sequence at a given pointing the CCD readout, filter movements, and final telescope movement, are overlapped for additional savings. Finally, human

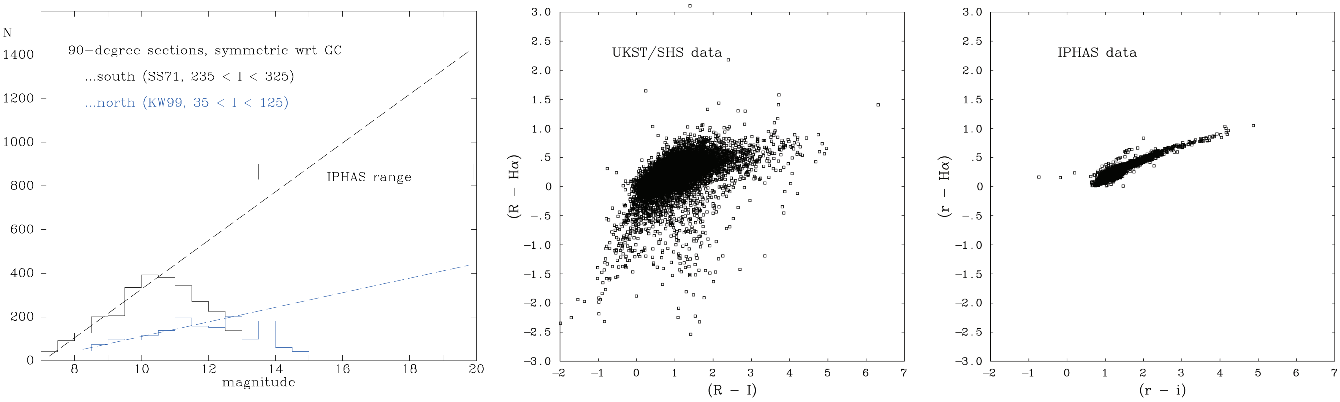


Figure 2. The left-hand panel illustrates the effect of a simple extrapolation of numbers of catalogued emission line stars from previous Hα surveys of Kohoutek & Wehmeyer (1999) in the north, and Stephenson & Sanduleak (1971) in the south. Based on a rough extrapolation of these earlier surveys it is estimated that of order ~10^4 emission line stars will be discovered. The central and right-hand panels compare the quality of the current IPHAS colour-colour diagrams with those for the same sky area taken from the UK Schmidt southern Hα photographic survey. Notice the superb delineation of the field population of normal stars and M dwarfs in the IPHAS data (cf. Figure 3).

interaction is avoided as much as possible by the use of automatic observing scripts, which typically run for about 3 hours, broken only to take standard star observations.

All data are transferred using external discs to the Cambridge Astronomical Survey Unit (CASU) where they are processed using the CASU pipeline: calibration steps consist of bias correction, flat-fielding, de-fringing, astrometric solution, flux calibration and object catalogue generation (see the article by Irwin et al. on WFS in this issue). Work is progressing on the construction of a unified object catalogue and flux calibration for the complete survey, with an expected first data release of final data products expected in early 2006. It is hoped that completion of the full survey will occur during 2006, with the full data release coming during 2007.

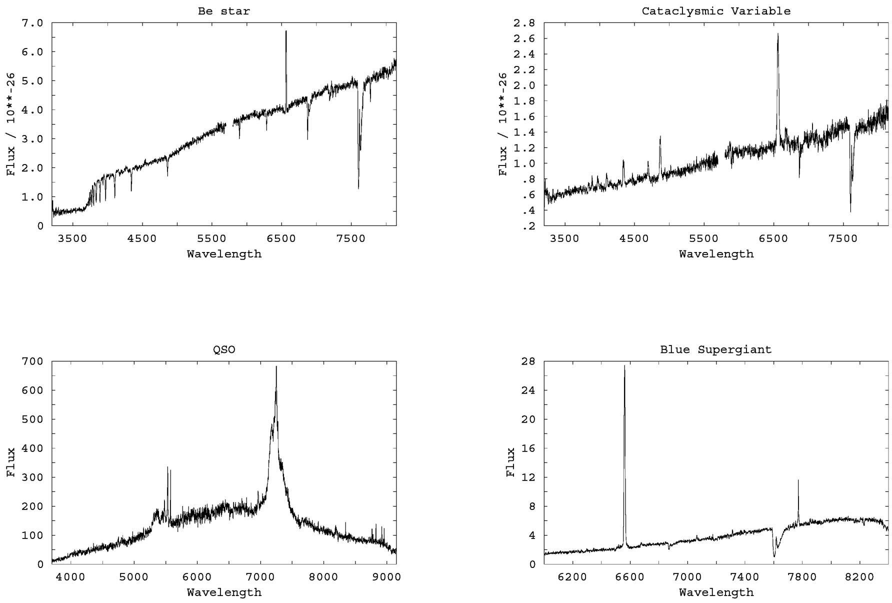


Figure 3. Sampling the Hα zoo as discovered by IPHAS. Clockwise from top left; a typical Be star, a cataclysmic variable, a potential luminous blue supergiant in Cygnus and a low redshift QSO (the QSO was detected as a peculiar outlier in the colour-colour plane).

Some Expected Science

Strong Hα emission line stars are of course reasonably easily selected from the sample since they are well separated from the bulk population in the (r'–i', r'–Hα) diagram. Indeed an initial blue selection of such objects has already been made using the 2003 data and some subsequent follow-up spectroscopy has revealed the vast majority of these to be Be-like stars, with a sprinkling of CVs, compact PN, potential luminous blue supergiants and the odd QSO (Figure 3).

Not all emission line objects are as easily discovered however and it is crucial that effort is put into understanding the IPHAS colour-colour plane so that future object selections can be made with some confidence. This problem has been attacked on two fronts; through the construction of synthetic photometry using a library of observed flux-calibrated stellar spectra, and by conducting spectroscopic surveys of selected fields as a visual check on predicted spectral types. Figure 4 illustrates the result of this process for a sample field in Cygnus. Several thousand spectra in a number of selected fields have now been amassed using Hectospec on the MMT and AF2 on the WHT. In general this demonstrates that the synthetic photometry is well matched to the observations, although detailed studies of this field, and additional test fields indicate that some further investigation of the calibration for very red objects is required.

IPHAS is also producing new discoveries of nebulae, one of the first to be discovered has been named after the wedding of Su Alteza Real El Príncipe de Asturias Don Felipe de Borbón with Doña Letizia Ortiz Rocasolano which took place around

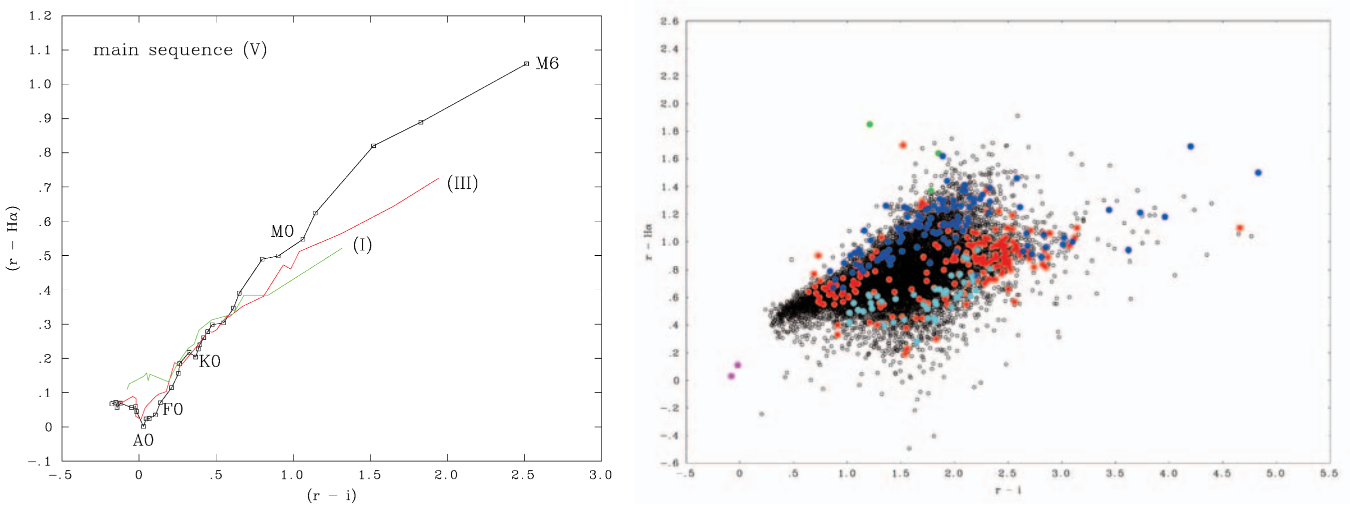


Figure 4. Left-hand panel shows the simulated positions of the unreddened main sequence (black), giant (red) and supergiant (red) stars in the (r'–i', r'–Hα) plane according to spectral type. The right-hand panel shows the observed sources in a field in the Cygnus region (black points), with some spectroscropically determined spectral types overplotted in colour; light blue points are early-type stars, red points are mostly G and K stars, while dark blue points are M stars. The magenta points are strong Hα absorbers, in fact they are white dwarfs, while the green points are emission line stars, in fact Be stars. Note that the trend from early-type to late-type stars is well reproduced by the synthetic colours (there is a zero point offset due to extinction which drives stars diagonally upward and to right this diagram). The central gap in the spectroscopic sample is simply a selection effect due to the algorithm used to select targets for follow-up. All spectroscopy for this field was carried out using Hectospec on the MMT.

the time of the PN's discovery. PNG 126.62+1.32 is a rare quadrupolar nebula, and it was spectroscopically confirmed as a PN in 2004 using the WHT. A deeper image, compared to the discovery image, is shown in Figure 5, which illustrates the initially undetected faint lobes of the nebula.

Besides looking for new nebulae, IPHAS has proved to be exceptionally useful for taking a new look at previously known nebulae; ING users may be familiar with the image of the Wolf-Rayet NGC6888 which adorned the ING Christmas card in 2004 (Figure 1). However Figure 6 shows the spectacular 5°×3.5° mosaic of images covering the supernova remnant S147. Bear in mind that this image, which is binned for the purposes of this article, has immense detail on the arcsecond scale.

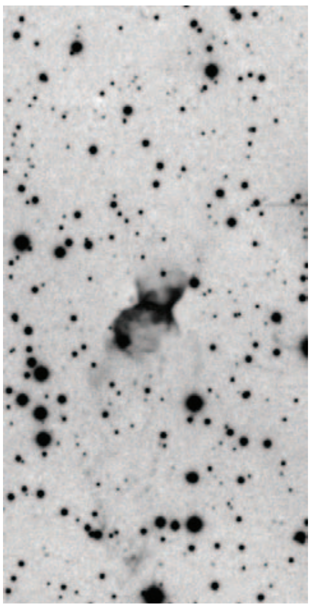
To date the survey is approaching its half-way point in terms of completed fields. However as we look forward to the completion of the northern hemisphere survey it's clear that we are already seeing new discoveries, and generating additional exciting ideas for follow-up science and data mining. For example the colour-colour plane morphologies across the Galactic Plane will provide useful insights into the structure of the northern Milky Way, while linking IPHAS photometry with *JHK* survey data from 2MASS and the UKIDSS Galactic Plane Survey will add further powerful diagnostic capabilities.

We thank the many observers who have contributed to this programme. Finally, for more complete details interested parties should refer to the first survey paper which is currently in preparation (Drew et al., 2005, to appear in *MNRAS*), and to the IPHAS home page at `http://astro.ic.ac.uk/Research/Halpha/North/`. ¤

Janet Drew (j.drew@imperial.ac.uk)

Survey area:	~1800 sq deg in 2×7600 overlapping pointings
Region:	$-5° < b < +5°$, $25° < l < 225°$
Depth:	$13 < r' < 20$
Seeing:	< 1.7 arcsec
WFC pixel size:	0.33" × 0.33"
WFC field size:	~0.25 sq deg in four 2k×4k CCDs
Filters:	r': λ_c=6420 Å, FWHM = 1347 Å, t_{exp}=30 s
	i': λ_c= 7743 Å, FWHM = 1519 Å, t_{exp}=10 s
	Hα: λ_c=6568 Å, FWHM= 95 Å, t_{exp}=120 s
IPHAS Home:	`http://astro.ic.ac.uk/Research/Halpha/North/index.html`

Table 1. IPHAS essentials.



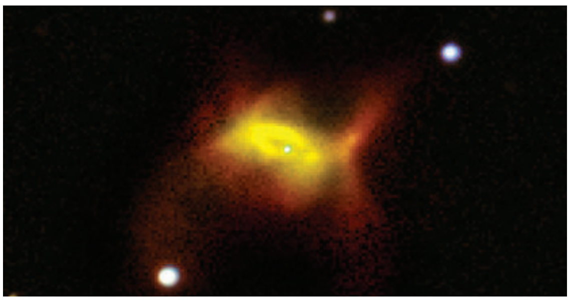
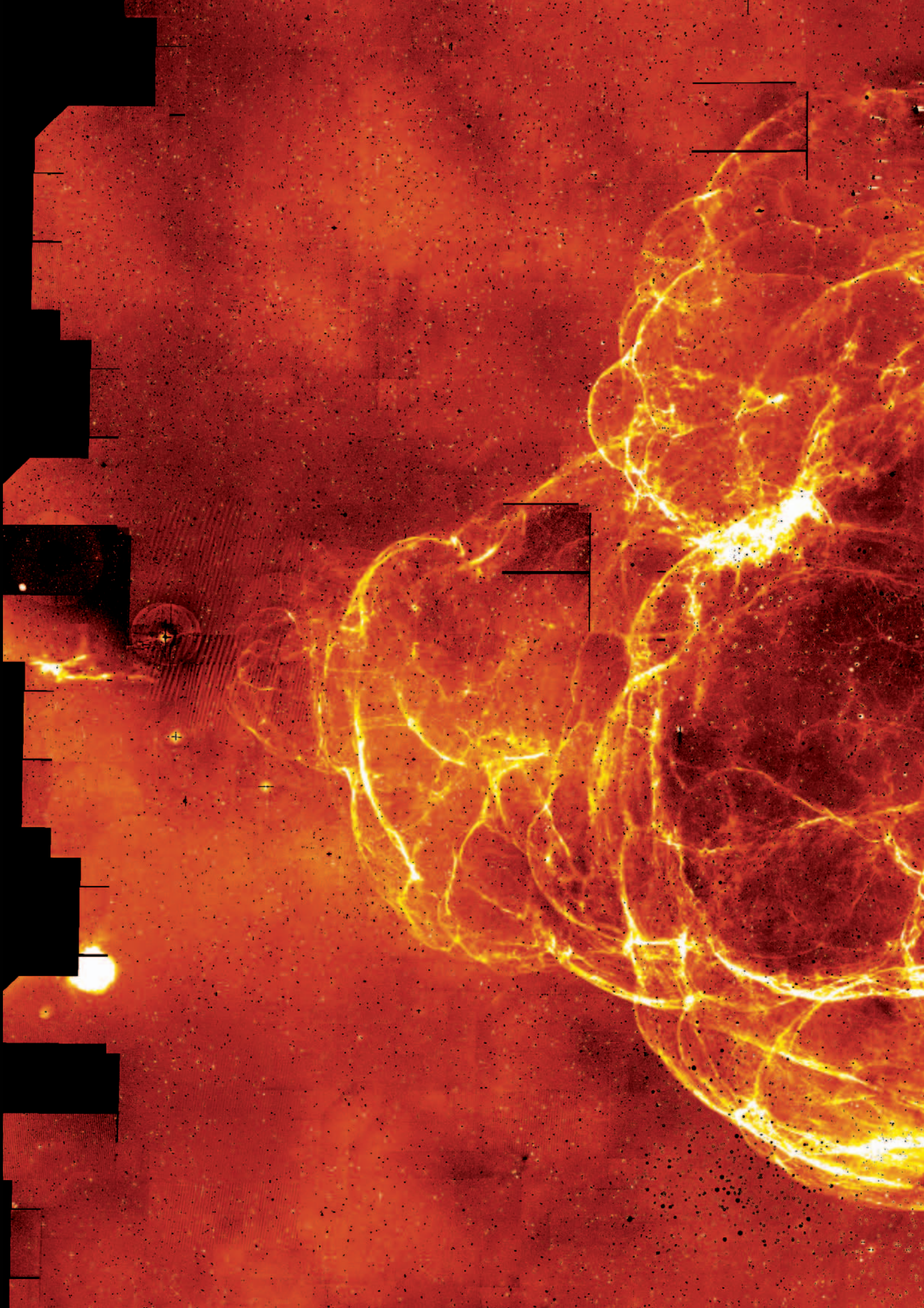
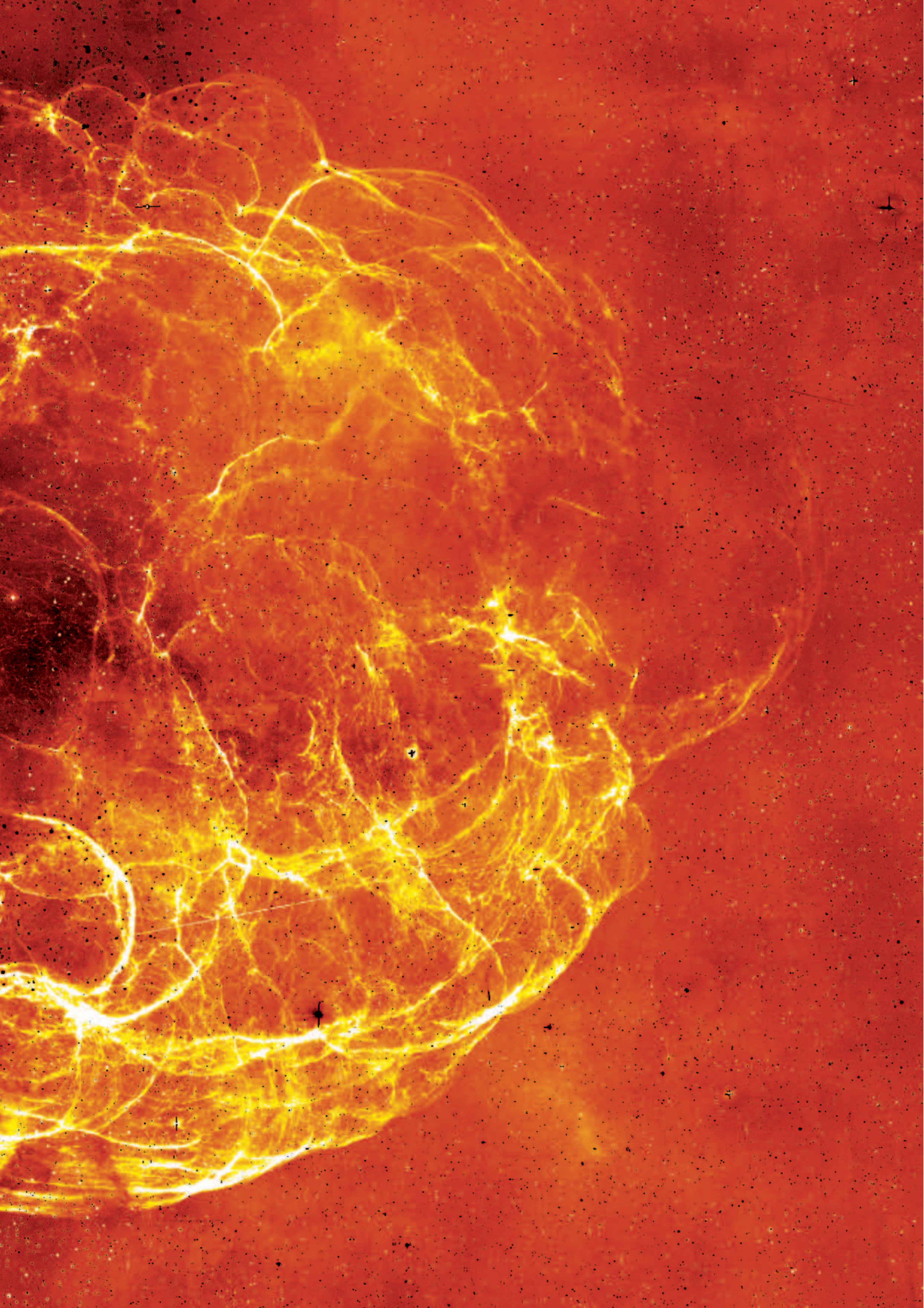


Figure 5. Left: The newly discovered Planetary Nebula PN 126.62+1.32, the 'Prince of Asturias', is a rare quadrupolar nebula (central region), with extended fainter lobes extending over 16 arcminutes from the central star. Top: Publicity version of the discovery image.

Figure 6 (next two pages). A 5°× 3.5° mosaic of the supernova remnant S147 in Hα. North is to the top and East to the left. Courtesy of Albert Ziljstra and Jonathan Irwin.





Wide Field Survey: Final Data Products

M. Irwin, R. McMahon, N. Walton, E. González-Solares, S. Hodgkin, J. Irwin, J. Lewis (IoA, Cambridge)

We present the final data products from the Wide Field Survey and the online database access to them.

1. The INT Wide Field Survey

Major survey programmes covering a variety of wavelengths are the mainstay of observational astronomy. Recent highlights include the Two Micron All Sky Survey (2MASS) project which has covered the entire sky at a resolution of 4 arcsec in the *JHK* bands (`http://www.ipac.caltech.edu/2mass/`) and the Sloan Digital Sky Survey (SDSS; York et al., 2000; `http://www.sdss.org/`) which covers large areas of the Northern Hemisphere, with the goal of covering one quarter of the sky. These wide area surveys are having a significant impact, both as target selectors for 8m class telescopes and for inherent survey science programmes. The INT WFS provides deeper data than the SDSS covering significant areas of the sky, with many fields being observed by comparable facilities at other wavelengths.

The INT WFS has been using the Wide Field Camera (with a field of view of the order of 0.3 deg^2) on the 2.5m Isaac Newton Telescope (INT). The survey proposal was approved by the Joint Steering Committee in October 1997 with a subsequent 'Announcement of Opportunity' closing in March 1998. The WFS International Review Panel approved three main programmes in the first year with subsequent review and continuation into the following years. The project was initiated in August 1998 with duration of up to five years. The WFS is an umbrella for competitively judged science programmes which were assessed on the usual criteria plus the wider worth of the data set and the management competence of the proposing teams. Multicolour data have been obtained over several square degrees to a typical depth of ~25 mag (*U* through *Z*). Importantly, the data have been publicly accessible by the UK and NL communities from day one, with access to the rest of the world after one year. The processing and calibration (up to object catalogue generation) is the responsibility of the WFS project.

1.1 WFS Programmes

The main science programmes were chosen to provide a wide area survey programme, a more focused but deeper smaller area programme, and a programme to address time variability. In the second period of observations two more programmes were selected.

The INT Wide Angle Survey (WAS; R. McMahon, M. Irwin, N. Walton) is the largest approved programme and includes sub-projects ranging from determination of cosmological parameters (e.g. via SN Type Ia studies) to searches for Solar System objects. It is the umbrella programme for the WFS project and leads coordination with the other programmes on, for instance, field and filter selection to maximise the scientific leverage of the project.

The WAS additionally incorporates two distinct science programmes in the summer semesters centred on Virgo and the equatorial strip of the North Galactic Cap:

— A multicolored large area survey of the Virgo cluster (J.I. Davies) which aims to obtain the luminosity function (LF) of Virgo galaxies (using the *U*, *g'*, *Z* filters) as a function of colour and position in the cluster from *L** to the luminosity of local dwarf spheroidals.

— The Millennium Galaxy Catalogue (MGC; S. Driver —see `http://www.eso.org/~jliske/mgc/`) was a 37.5 deg^2, medium deep, B-band survey, covering a 35 min wide strip along the equator from $10^h\,00^m$ to $14^h\,45^m$. The limiting magnitude is B=26 mag/arcsec^2.

Deep UBVRI Imaging Survey with the WFC (G. Dalton) of four contiguous regions of 10 deg^2 to a limiting magnitude of B=26 and I=24.5. It enables the study of the evolution of galaxy clustering as a function of colour at faint magnitudes and provides a catalogue of rich galaxy clusters at intermediate red-shifts. Furthermore, quasars can be detected at z>5. In good seeing, observations of two 5 deg^2 fields to U=26 were observed to investigate clustering of Lyman-break galaxies at z>3.

The Faint Sky Variability Survey (FSVS; van Paradijs — see `http://staff.science.uva.nl/~fsvs/`) searched an area of ~20 deg^2, studying photometric and astrometric variability on scales of one hour to a year to a magnitude of V=25. Example areas of investigation include: the evolution of specific Galactic populations (e.g. CVs, RR Lyraes, halo AGB stars, brown and white dwarfs, Kuiper Belt objects, sdB stars), the structure of the Galactic halo, statistics of optical transients related to gamma-ray bursts, and deep proper motion studies.

The Local Group Census (N. Walton — see `http://www.ing.iac.es/WFS/LGC/`) was a deep narrow band (Hα, [OIII], [SII], HeII) image survey of all Local Group (LG) galaxies in the

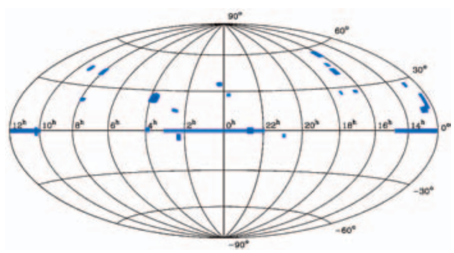


Figure 1. Location of the WFS fields.

northern hemisphere M_V brighter than –14. Old and new emission line populations (e.g. planetary nebulae (PNe), HII regions, LBVs, symbiotic stars) were the main targets of interest. Complementary broad band data were obtained to enable the study of linkages between stellar populations (e.g. AGB to PNe).

As far as PNe are concerned, the LGC observations have been fully exploited, providing a much more complete view of the PN population of the LG than previously known, especially for dwarf galaxies. Details are presented by Corradi et al. (2003) and in the five refereed papers and many contributions at international conferences published so far (including the invited review in the first workshop entirely dedicated to extragalactic PNe, held in Garching on May 2004). The PNe discovered by the LGC allowed discussion of the use of PNe as luminosity indicators in external galaxies and in the intergalactic space, and form a valuable database for (ongoing) follow-up spectroscopy to determine their physical and chemical properties. This allow us to discuss stellar and galactic evolution over the large range of metallicites covered by the LG galaxies.

An Imaging Programme for the XMM-Newton Serendipitous X-ray Sky Survey (M.G. Watson— see `http://www.ast.cam.ac.uk/~xmmssc/data_release/xid_data/`) obtained multi-colour optical imaging of ~200 fields drawn from the XMM-Newton Serendipitous X-ray survey programme. The INT data has provided an optical catalogue for ~20,000 X-ray sources over 25 deg^2.

1.2 Pipeline Processing

The WFS data was fully processed by the Cambridge Astronomical Survey Unit (CASU) at the IoA. A detailed description of the pipeline processing carried out is found in (Irwin & Lewis, 2001) and is briefly summarised here. The data is first debiased, bad pixels and columns are flagged and recorded in confidence maps which are used during catalogue generation. The CCDs are found to have significant non linearities so a correction using look-up-tables is applied to all data. Flatfield images in each band are constructed by combining multiple sky flats obtained in bright sky conditions during twilight. Master fringe frames are created by combining all the science exposures for each band and used to correct the images (i' and Z bands only). Finally an astrometric solution is applied which results in an internal astrometric precision better than 100 mas over the whole WFC array. Global systematics are limited by the precision of the APM and PMM astrometric catalogue systems and are at the level of 250 mas. The data are photometrically calibrated using a series of Landolt standard stars. Data from non photometric nights are flagged by the pipeline and each area is calibrated using the overlap regions (~10%) between pointings.

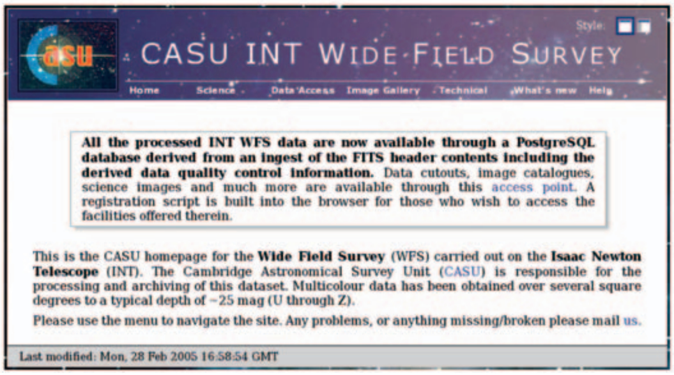


Figure 2. INT Wide Field Survey main page at CASU.

Object detection is performed in each band separately using a standard APM-style object detection and parametrisation algorithm. Standard aperture fluxes are measured in a set of apertures of radius $r/2$, r, $\sqrt{2}r$, $2r$, $2\sqrt{2}r$ where $r=3.5$ pixels (the median seeing — 1 pixel equals 0.333 arcsec) and an automatic aperture correction based on the average curve-of-growth for stellar images is applied to all detected objects.

A number of key quality control performance measures are extracted on a nightly basis from the generated object catalogues. These indicators include instrumental information such as sky brightness, image quality (ellipticity, FWHM) and throughputs from extraction of standard star fluxes and comparison with known zero point data. More details about the data products and the format of the catalogues can be found in the CASU web page (Figure 2; `http://www.ast.cam.ac.uk/~wfcsur`).

2. Final Data Products

All the processed INT WFS data are available online through a PostgreSQL database derived from an ingest of the FITS header contents including the derived data quality control information. FITS header information, including quality control parameters, are ingested on a regular basis, and a series of flat files point to the processed object catalogues and image data. This has allowed us to offer optional further processing stages driven from a survey Data Quality Control (DQC) database.

The main DQC interface is accessible from the WFS web page at CASU and provides a large number of search options (RA, Dec, run number, object name, observation date,...) and constraints (airmass, exposure time, filters, seeing,...). Figure 3 shows an example query in which the RA and Dec coordinates of a particular object are inserted into the form.

The data query returns a table with all the images that satisfy the constraints. All those fields which contain the search position are selected by default (see Figure 4). A range of visualisation options are available from here. It is possible to display image cutouts around the selected position (eg. Figure 7) with optional overlay of already predefined catalogues (the WFS catalogue, FIRST, 2MASS and IRAS catalogues are also available) and user supplied catalogues. It is also possible to display the whole CCD or the mosaic of all CCDs as well as view the catalogues in various formats (see Figures 5 and 6) with the federation between them being done on the fly. A registration script is built into the browser for those who wish to access the facilities offered therein.

Finally the interface allows the automatic retrieval and downloading of catalogue and image products; the ability to group and remotely process images using CASU facilities including the CASU VDFS (Vista Data Flow System) image subtraction, image stacking and image mosaicing software utilities and retrieval of the results etc. (Figure 8).

2.1 The INT WFS Legacy

The WFS archive contains 3.5 Tb of reduced and calibrated imaging data online corresponding to about 1200 deg^2. The use of such database extends beyond the original proposal programmes described in section 1 and highly increases the value of the WFS as a legacy survey. Several of the fields observed are located in very well known regions of the sky. For example the 9 deg^2 observed in each of the two northern areas covered by the European Large Area ISO Survey (ELAIS) have been essential to characterise the population of infrared sources detected (Rowan-Robinson et al., 2004). Furthermore, these two regions have been observed in the mid- and far-IR by the Spitzer Wide-area Infrared Extragalactic Survey (SWIRE; Lonsdale et al., 2003). The WFS optical data have been used to provide the optical identifications of the infrared sources detected and have been also included in the first SWIRE data release.

3. Summary

The INT WFS programme is now completed. All the data is available online from the CASU WFS web page at IoA. Data cutouts, image catalogues and science images are available from this access point. The database also supports on the fly multipassband merging of catalogues and optional

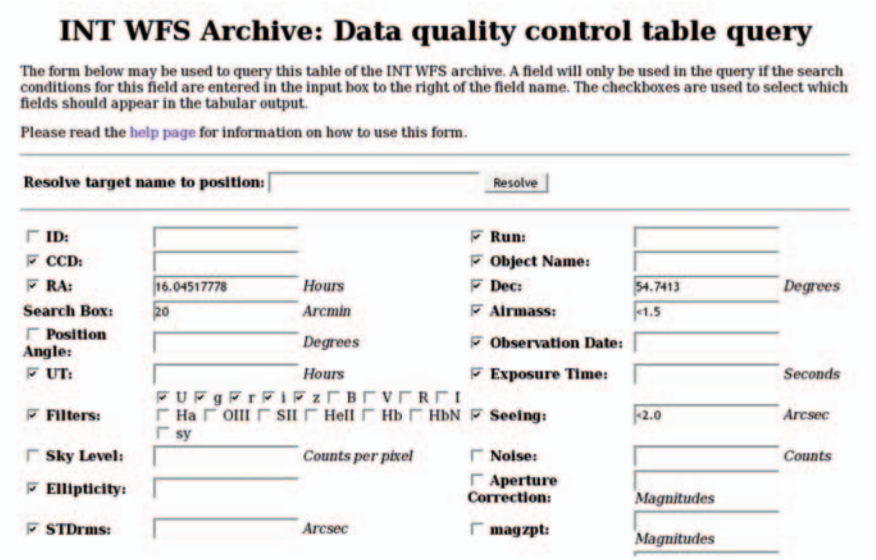
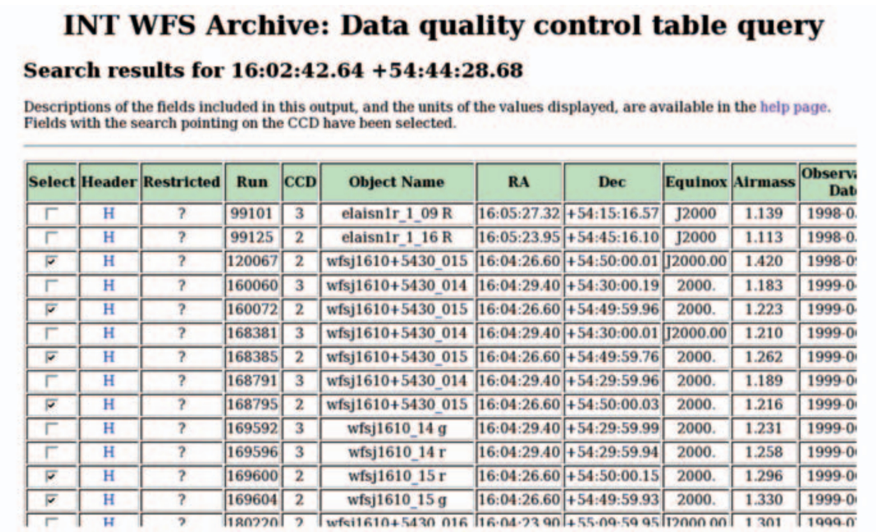


Figure 3. Example query of images in a search box of 20 arcmin around a RA, Dec position. All images observed in the U, g', r', i' and Z are requested if the seeing is better than 2" and they have been observed at an airmass lower than 1.5. No other constraints have been imposed, but the run number, object name, observation date, exposure time among others have been selected to be displayed into the ouput table.



INT WFS Archive: Data quality control table query

Search results for 16:02:42.64 +54:44:28.68

Descriptions of the fields included in this output, and the units of the values displayed, are available in the help page. Fields with the search pointing on the CCD have been selected.

Select	Header	Restricted	Run	CCD	Object Name	RA	Dec	Equinox	Airmass	Observa Dat
☐	H	?	99101	3	elaisn1r_1_09 R	16:05:27.32	+54:15:16.57	J2000	1.139	1998-0
☐	H	?	99125	2	elaisn1r_1_16 R	16:05:23.95	+54:45:16.10	J2000	1.113	1998-0
☑	H	?	120067	2	wfsj1610+5430_015	16:04:26.60	+54:50:00.01	J2000.00	1.420	1998-0
☐	H	?	160060	3	wfsj1610+5430_014	16:04:29.40	+54:30:00.19	2000.	1.183	1999-0
☑	H	?	160072	2	wfsj1610+5430_015	16:04:26.60	+54:49:59.96	2000.	1.223	1999-0
☐	H	?	168381	3	wfsj1610+5430_014	16:04:29.40	+54:30:00.01	J2000.00	1.210	1999-0
☑	H	?	168385	2	wfsj1610+5430_015	16:04:26.60	+54:49:59.76	2000.	1.262	1999-0
☐	H	?	168791	3	wfsj1610+5430_014	16:04:29.40	+54:29:59.96	2000.	1.189	1999-0
☑	H	?	168795	2	wfsj1610+5430_015	16:04:26.60	+54:50:00.03	2000.	1.216	1999-0
☐	H	?	169592	3	wfsj1610_14 g	16:04:29.40	+54:29:59.99	2000.	1.231	1999-0
☐	H	?	169596	3	wfsj1610_14 r	16:04:29.40	+54:29:59.94	2000.	1.258	1999-0
☑	H	?	169600	2	wfsj1610_15 r	16:04:26.60	+54:50:00.15	2000.	1.296	1999-0
☑	H	?	169604	2	wfsj1610_15 g	16:04:26.60	+54:49:59.93	2000.	1.330	1999-0
☐	H	?	180220	2	wfsj1610+5430_016	16:04:23.90	+55:09:59.95	J2000.00	1.301	1999-0

Figure 4. Returned query listing the available images. Those fields with the search pointing on the CCD are selected by default.

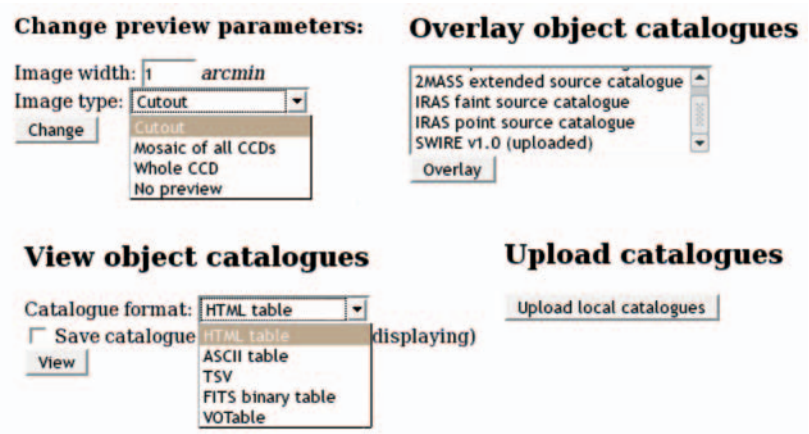


Figure 5. Display options available. Note the 'Overlay object catalogues' box is updated with one user supplied catalogue; sources in that catalogue can be displayed in the image cutouts as well as be federated with the other catalogues.

r180480 U						
Delta RA	Delta Dec	x	y	Magnitude	Magnitude Error	Classification
Arcsec	Arcsec	Pixels	Pixels	Mag	Mag	
0.28	0.32	1452.9	2007.6	19.876	0.013	Non-stellar
r169604 g						
0.11	0.28	1461.8	1964.3	19.439	0.003	Non-stellar
r160072 r						
0.06	0.22	1516.0	1992.3	18.916	0.003	Non-stellar
r168795 i						
0.23	0.08	1447.8	1960.8	18.237	0.003	Non-stellar
r168385 z						
0.06	0.03	1458.9	1968.9	17.802	0.004	Non-stellar

2MASS XSC									
Delta RA	Delta Dec	x	y	J Magnitude	J Magnitude Error	H Magnitude	H Magnitude Error	K Magnitude	K Magnitude Error
Arcsec	Arcsec	Pixels	Pixels	Mag	Mag	Mag	Mag	Mag	Mag
0.40	1.46	1446.0	1970.0	15.209	0.093	14.639	0.148	14.472	0.178

SWIRE v1.0								
Delta RA	Delta Dec	x	y	flux_36	flux_48	flux_58	flux_80	flux_24
Arcsec	Arcsec	Pixels	Pixels					
0.45	0.22	1443.0	1967.0	571.520	376.350	254.830	1977.420	1855.340

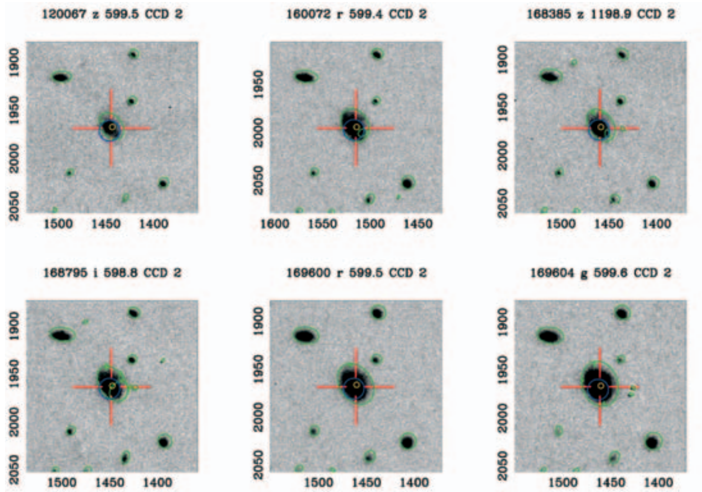


Figure 6 (left). Example catalogue federation output for one source (display rearranged due to page size limits). Together with the WFS optical magnitudes, also the magnitudes from 2MASS are displayed as the properties from our user supplied catalogue. Figure 7 (right). Example cutouts in different wavebands returned from the DQC query around our selected source with object catalogues overlaid.

federation with user supplied catalogues as well as image mosaicking and stacking. The INT WFS imaging data has also been used by external programmes. ¤

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Run Number	Centre RA	Centre Dec	Filter	Available	Download Images	Download Object catalogues	Stacking group	Mosaic group
120067	16:04:26.60	+54:50:00.01	z	y	☑	☑	1	1
168385	16:04:26.60	+54:49:59.76	z	y	☑	☑	1	2
160072	16:04:26.60	+54:49:59.96	r	y	☑	☑	2	3
169600	16:04:26.60	+54:50:00.14	r	y	☑	☑	2	4
347495	16:04:26.60	+54:50:00.09	r	y	☑	☑	2	5
168795	16:04:26.60	+54:50:00.03	i	y	☑	☑	3	6
169604	16:04:26.60	+54:49:59.94	g	y	☑	☑	4	7
219706	16:04:26.60	+54:49:59.84	g	y	☑	☑	4	8
305239	16:04:26.60	+54:50:00.06	g	n			4	9
305240	16:04:26.60	+54:49:59.89	g	n			4	10
180480	16:04:26.60	+54:50:00.01	U	y	☑	☑	5	11
					All	All		By Filter

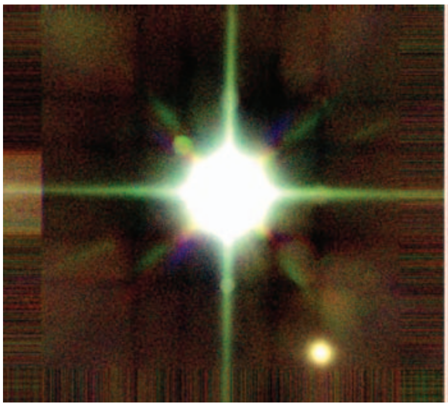
Figure 8. Data retrieval form. We have selected to retrieve the catalogues from all the images as well as per band stacked images. Note that two of the images and catalogues are not available to the user because they are propietary.

Direct Detection of Giant Exoplanets

J. A. Caballero (IAC), V. J. S. Béjar (Proyecto Gran Telescopio Canarias, IAC)

Since the discovery in 1995 of the first extrasolar planet candidate around a solar type star using the radial velocity method (Mayor & Queloz, 1995), to date (beginning of 2005), 135 candidate planets around main sequence stars have been discovered by the transit and the radial velocity (RV) methods. Their minimum masses are in the range 0.045 to 13 $M_{\rm Jup}$. The proximity of these planets to their host stars has prevented direct imaging and spectroscopy, making a precise characterisation of their physical structure and chemical composition difficult.

The least massive objects imaged and spectroscopically confirmed outside the Solar System are the so called isolated planetary-mass objects (IPMOs) discovered in the σ Orionis cluster (age ~3 Myr, distance ~350 pc), with masses in the range 3 – 13 $M_{\rm Jup}$ (Zapatero Osorio et al., 2000, 2002; Béjar et al., 2001). Very recently, Chauvin et al. (2004) have announced the discovery of a ~ 5 $M_{\rm Jup}$ object at a projected separation of 55 AU of a brown dwarf of the TW Hydrae association (age ~ 8 Myr, distance ~ 70 pc). This object awaits confirmation by proper motion studies and high signal to noise spectroscopy. Slightly more massive is G 196-3B, a substellar companion of a young nearby M dwarf (Rebolo et al., 1998). Its mass could be significantly lower than 25 M_{Jup} if the age of the system is confirmed to be much less than 100 Myr (McGovern et al., 2004).



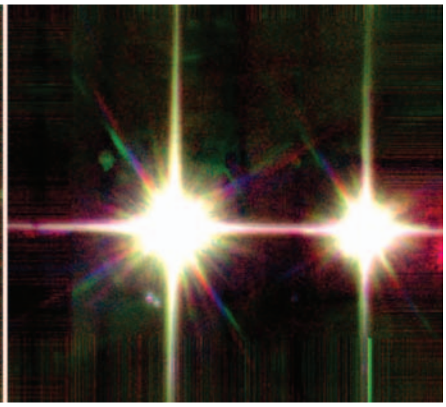


Figure 1 (left). JHKs composite image of the G 196-3AB system. The images were taken with the NAOMI+INGRID Adaptive Optics system at the William Herschel Telescope. North is up and East is left. Size is 41 arcsec×41 arcsec. G 196-3A, an extremely young nearby M star, is in the centre of the field of view. G 196-3B, 13.5 arcsec to the SWS, is a late L spectral type brown dwarf that shares common proper motion with the A component. Estimated mass of G 196-3B is 25 M_{Jup} or less. These images are sensitive to discover superjupiters at separations ≥50 AU to the central star.

Figure 2 (right). Same as previous figure, but for the V639 and V647 Herculis system. The double object at 6.5 arcsec SSE of the brightest star is a blue background object of unknown nature. It does not belong to the stellar system. The FWHM of the JHKs images is better than 0.2 arcsec.

The JOVIAN Project

The aim of the JOVIAN project (Jupiter-like Objects in the Visible and in the Infrared: their Astrophysical Nature; P. I.: R. Rebolo) is to achieve the direct detection and characterisation of objects down to the mass of Jupiter, and help, through selected observations, to shed light on the formation of massive planets.

In the last six years we have followed two major strategies for direct detection of such objects: wide field imaging searches for 1 to ~13 M_{Jup} objects in several very young open clusters; and high spatial-resolution imaging, with Adaptive Optics (AO) or the Hubble Space Telescope (HST), of young nearby late-type stars in the solar neighbourhood (age 600–30 Myr, distance <50 pc). In both strategies, youth is a key parameter given the large overluminosity of ultra-low mass objects during the contraction phase. We summarise below some of the results achieved in the ongoing JOVIAN project.

IPMOs in the σ Orionis Cluster

The σ Orionis cluster has revealed as a paradigmatic place for understanding the formation of stellar and substellar objects. Following our first discoveries of massive brown dwarfs (50–30 M_{Jup}) in the120 Myr-old Pleiades cluster (Rebolo et al., 1995, 1996), we decided to investigate in a much younger cluster the formation of less massive objects down to the deuterium burning limit. The region around the multiple stellar system σ Orionis was selected because of its proximity, youth and low extinction. We have conducted *RIZ* surveys with the IAC-80 telescope (Observatorio del Teide) and the Wide Field Camera at the Isaac Newton Telescope (Observatorio del Roque de los Muchachos). From these surveys we covered the whole brown dwarf domain. Most of the one hundred brown dwarf candidates discovered were confirmed as bona fide cluster members, by follow-up near-infrared photometry and optical spectroscopy. Many of them have been confirmed using the ISIS spectrograph at the William Herschel Telescope or LRIS at Keck Observatory.

From these studies we have characterised the complete spectral sequence of the cluster in the brown dwarf domain from spectral type M6 to L1.5 (roughly 75 M_{Jup} to 13 M_{Jup}). We have found that the substellar mass spectrum increases toward lower masses and can be represented by a power-law, $dN/dM \sim M^{-0.8\pm0.4}$ (Béjar et al., 2001). Our results indicate that brown dwarfs are very common in the cluster and suggest that a similar behaviour of the mass spectrum is possible at lower masses.

In order to detect fainter and less massive objects, we have performed and planned to conduct deeper surveys in the optical (*I* band, using the Wide Field Camera) and in the near-infrared (*JHKs* bands,with ISAAC/VLT, INGRID– LIRIS/WHT, Omega-2000/3.5m Calar Alto). From the new processed data we have identified about 15 new cluster member candidates with masses in the planetary domain. Our faintest candidate, S Ori 70, resulted from a *JH*-band mini-survey performed with INGRID at the WHT. Near-infrared low-resolution spectroscopy obtained at the Keck Observatory led us to derive a T6 spectral type and a mass in the range 2 to 8 M_{Jup}.

Substellar Companions of Stars

In order to detect faint cool companions of young nearby stars, we have used the NICMOS instrument with the coronograph at the HST and AO systems attached at 4 m-class telescopes: Alfa+Omega-Cass at the 3.5-m Calar Alto, AdOpt@TNG+NICS at Telescopio Nazionale Galileo and, especially, NAOMI+INGRID at the WHT. The data taken by our group allow to resolve faint objects down to separations of ~1 arcsec of relatively bright stars. This separation in a stellar system at 10 pc corresponds to ~10 AU. The sensitivity to planetary-mass companions improves when the spatial resolution is higher (i.e. nearby stars) and the contrast is lower (i.e.

primaries are low-mass stars and planets are intrinsically brighter due to youth).

We are studying more than fifty stellar systems closer than 50 pc, with spectral types later than solar and with features indicative of youth (high lithium abundance, X-ray and/or UV emission, membership to young proper motion associations, etc.). The ages of the stellar systems range between 30 and 600 Myr. Forty of them have been completely analysed, comparing first and second astrometric epochs and performing photometry when possible. Although the data would allow us to discover objects with masses down to 3–10 $M_{\rm Jup}$ in several of the systems, we have not detected any previously unknown substellar companion at distances between ~30 and ~1000 AU of the primaries. We have only detected two, possibly three, stellar companions in very close orbits and a previously known L-type dwarf secondary. From our study, the frequency of substellar companions at intermediate and large separations of the primary stars is <4%.

This apparently disappointing result is of great interest, since together with work performed by other authors, allows to conclude that only ~1% of the solar-like stars have massive planetary companions and brown dwarfs at intermediate and large distances (e.g. McCarthy & Zuckerman, 2004). This figure must be compared with the 7.3±1.5% of the solar-like stars that have exoplanet candidates discovered at small separations with the RV method.

Future Prospects

The ultimate goal of the JOVIAN project is to set observational constraints on the scenarios of formation of giant planets with masses from 1 to ~13 $M_{\rm Jup}$ (jupiters and superjupiters). These objects appear to be quite abundant, as they exist at close distances of relatively old solar-like stars, but also free floating in very young open clusters. Is the lack of massive giant planets at intermediate and large distances related to the

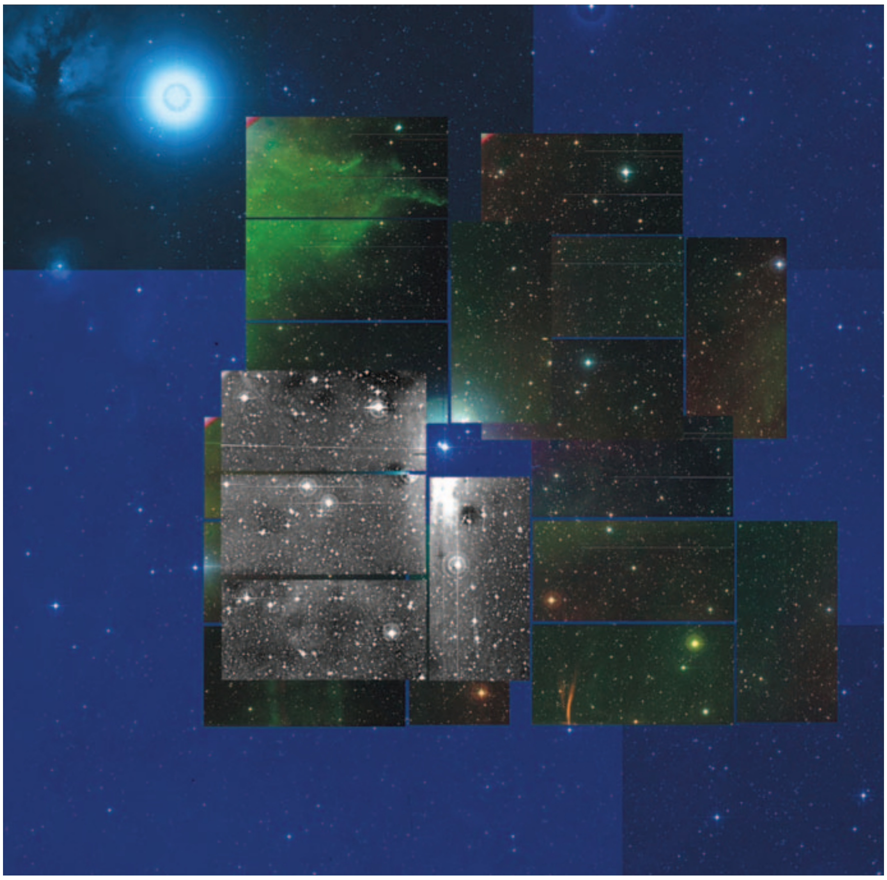


Figure 3. The σ Orionis region and the WFC surveys. The bright star to the up left corner (North East) is Alnitak, one of the stars of the Orion Belt. Blue background: I-band image from Digitised Sky Survey. Coloured intermediate level: WFC survey in VRI-bands (note the emission in R band (or Hα) of the nebula associated to Alnitak and the Horsehead Nebula). Grey foreground: very deep I-band WFC survey (I_{lim} about 24.5).

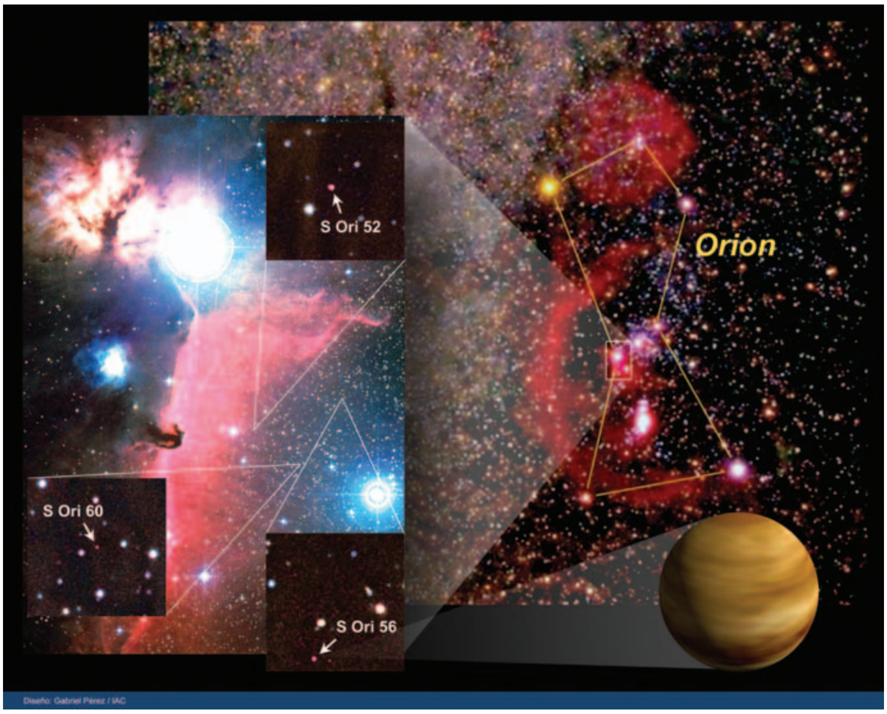


Figure 4. Pictorical view of several isolated planetary-mass objects (IPMOs) in the σ Orionis cluster (Zapatero Osorio et al., 2000).

existence of IPMOs? Is there any scenario that could explain qualitatively and quantitatively the observational features? Are IPMOs the result of direct collapse and fragmentation of clouds? These questions will also be addressed by the JOVIAN project using the first light instruments of the Gran Telescopio Canarias.

Members of the JOVIAN project at Instituto de Astrofísica de Canarias: R. Rebolo, E. Martín, V. J. S. Béjar, J. A. Caballero, G. Bihain and J. Licandro (also at ING); LAEFF/INTA: M. R. Zapatero Osorio and D. Barrado y Navascués; Universidad Politécnica de Cartagena: A. Díaz, A. Pérez and I. Villo; Max-Planck-Institut für Astronomie: C. Bailer-Jones and R. Mundt; Thüringer Landessternwarte Tautenburg: J. Eisloeffel.

More information on JOVIAN can be found at `http://www.iac.es/project/jovian/`. ¤

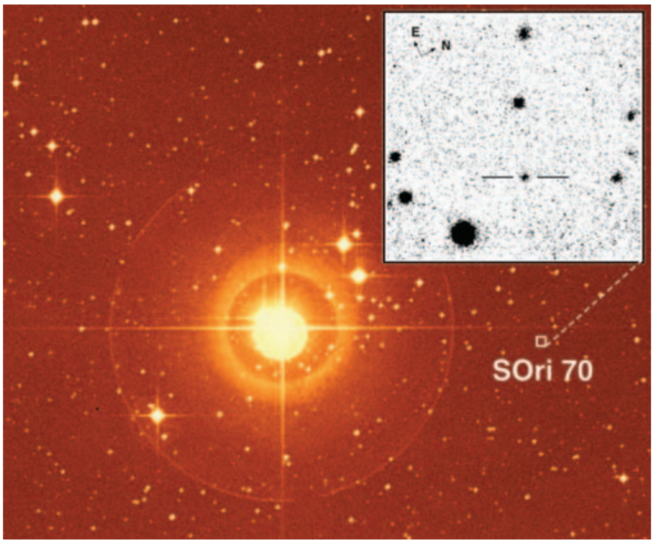


Figure 5. Near-infrared image of S Ori 70 (marked with two lines), overimposed onto a Digitised Sky Survey image centred in the multiple stellar system σ Orionis, that gives the name to the cluster. The mass of S Ori 70 is calculated to be in the range 2 to 8 Jupiter masses.

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LIRIS Observations of SN 2004ao

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The knowledge of the properties of supernovae (SNe) at optical wavelengths has experienced enormous progress in the current decade. In contrast, comparatively little is known about the SN behaviour in the near-infrared (NIR) window. Such a knowledge would give us relevant clues to key questions related to the nature of SN progenitors and to the interaction with SN environments. Hence, programs for NIR spectrophotometry of SNe of all supernova types are clearly useful, and the Long-Slit Intermediate Resolution Infrared Spectrograph (LIRIS) could be a good choice (see Acosta-Pulido et al., 2002, 2003, for more details on the instrument).

Currently, the most widely accepted scenario to explain the SN types Ib and Ic involves the core-collapse of a hydrogen-naked massive star. However, it is still a matter of debate whether these two SN types (Ib and Ic) constitute two completely separate classes of events, produced by different classes of progenitors or, on the contrary, both SN types correspond to variations within a more or less continuous sequence of core-collapse SNe (Matheson et al., 2001; Hamuy et al., 2002). It should be emphasised that the main distinguishing difference between the Type Ib and the Type Ic SNe is based on the strength of their optical HeI lines: these lines are clearly present in the SNe Ib optical spectra, whereas these lines appear weak, or even are absent in Type Ic SN optical spectra.

The He abundance in Type Ib/c SN atmospheres is critical for deciding between alternative progenitor models. It should be noted that the HeI λ10830 line is strong even in the case of weak HeI lines at optical wavelengths (Jeffery et al., 1991). Thus, this NIR HeI line is a more sensitive tracer of small amounts of He (Wheeler et al., 1993). In this sense, NIR spectra of SN types Ib and Ic could be a very useful tool to better establish the He abundances in these objects.

SN 2004ao, in UGC 10862, was discovered on March 7.54 (Singer & Li, 2004). The supernova lies close to the southern arm of its host galaxy. From an optical spectrum obtained on March 14.53 the supernova was classified as a Type Ib approximately one week after maximum (Matheson, Challis & Kirshner, 2004). SN 2004ao was fairly bright at the date of its discovery (V~15; Singer & Li, 2004), thus we decided that this target could be appropriate to get useful results with the scheduled LIRIS configuration without a high cost in observing time. Here we present the first NIR observations of Type Ib SN 2004ao, that we performed as a test of the LIRIS capabilities for SN spectrophotometry in the NIR window.

Results

On June 8.1 UT, (~three months after discovery), we used LIRIS on the WHT to obtain a 24-second exposure through the *J* filter of the SN 2004ao field and a *ZJ* spectrum (range 0.89–1.53 µm, $\Re \sim 700$) of the supernova.

SN 2004ao is quite a bright supernova. The object was clearly detected in the *J*-band image (Figure 1) at the date of the run, three months after its discovery. A magnitude of *J*~16.6 was derived from differential photometry using three field stars. A plot of the SN 2004ao spectrum (1200s exposure) is also displayed in Figure 1. The spectrum shows a set of broad emission bands superimposed on a quite flat continuum, indicating that the SN was close to reaching the nebular phase at the date of our observation. Special attention should be paid to the P-Cygni feature, with the absorption at ~1.043µm, as well as to the emission bands at λλ~0.924, 1.130 and 1.191µm (all these wavelengths are referred to the host-galaxy rest frame, which corresponds to $z=0.0056$).

Currently, few NIR spectra of core-collapse SNe are found in the literature. In particular, this fact is more evident for Type Ib SNe at phases older than ~one month after maximum (that would be useful for comparison with our spectrum of SN 2004ao). Thus, as a first step of our study, we have compared the LIRIS SN 2004ao spectrum with the available spectra of core-collapse SNe acquired at nearly similar SN ages. We found that the features detected in our spectrum were also found in the spectra of the peculiar Type Ic SN 1998bw at phase ~+50 days (Patat et al., 2001). In addition, all these features were also detected in the spectra of the Type IIn SN 1998S at phases ~+60 and ~+110 days (Fassia et al., 2001) as well as in those of the Type II SN 1987A at phase ~+110 days (Meikle et al., 1989). In all of these NIR spectra, the He I λ1.083µm is identified as the main contributor to the P-Cygni feature, whereas the three emission bands at λλ~0.924, 1.130 and 1.191µm are attributed, respectively, to O I λ0.926, O I λ1.129 + S I λ1.131 + Na I λ1.138 and Mg I λ1.183 + Si II λ1.205µm. From the absorption minimum of the He I line, we derived an expansion velocity of ~11,000 km s^{-1} for the ejecta of SN 2004ao. Note that this value is similar to the velocity values derived in other "normal" Type Ib/c SNe (e.g., SN 1990W) from their NIR HeI lines (Wheeler et al., 1994), significantly lower than the velocity derived in "peculiar" hyper-energetic core-collapse SNe (eg., $v\sim$13,000–18,000 km s^{-1} in SN 1998bw; Patat et al. 2001). From the spectral data, we suggest that this supernova probably was a "normal" (i.e., non hyper-energetic) Type Ib SN, despite it being a fairly bright object.

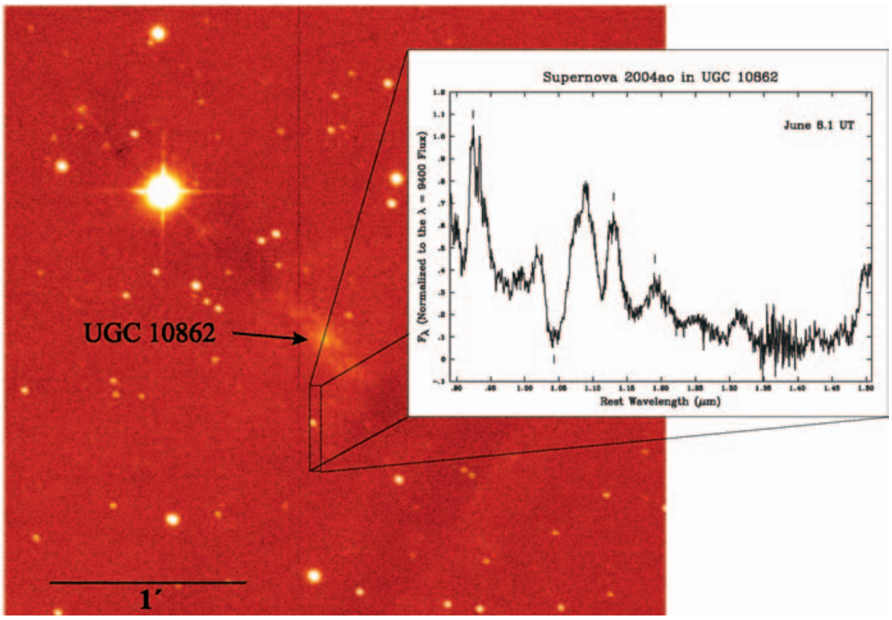

Figure 1. J-band image (left) and NIR spectrum (right) of SN 2004ao, obtained on 8 June, 2004 (t~+90 days) with LIRIS on the WHT. The nucleus of the host galaxy UGC 10862 is visible to the northwest of the supernova. The slit position has been marked with a box enclosing the supernova. North is to the top and East is to the left. On the spectrum, the main features referred in the text have been marked with a vertical line.

The SN 2004ao data recorded in this observing test show the feasibility to undertake programmes of spectrophotometric follow-up of SNe in the NIR window with LIRIS.

We thank all of the LIRIS Team for the acquisition of SN 2004ao spectrum and images during guaranteed time. ¤

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LIRIS Discovers Supernovae in Starburst Galaxies

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In the nuclear regions of M82 and other nearby starburst galaxies one core-collapse supernova (CCSN) is expected to explode every 5–10 years. Furthermore, in luminous infrared galaxies (LIRGs) such as the interacting system Arp299 (NGC3690 + IC0694) at least one CCSN can be expected every year. However, due to the high dust extinction astronomers have been unable to detect these SNe. By observing in the near-IR *Ks*-band the extinction is strongly reduced, making searches for such dust obscured SNe look feasible (Mattila & Meikle, 2001). In fact, recent near-IR searches have been able to detect a couple of SNe in starburst galaxies (Van Buren et al., 1994; Maiolino et al., 2002). These are however only extinguished by a few of magnitudes in the visual wavelengths (Mattila, Meikle & Greimel, 2004). Now also the newly commissioned near-IR imager LIRIS on WHT has discovered two new SNe within the nuclear regions of Arp 299 and NGC 2146.

We have been carrying-out a near-IR *Ks*-band search campaign for SNe obscured by dust in the nuclear regions of nearby starburst galaxies with the William Herschel Telescope (WHT) since August 2001. Initially, the search started using the INGRID near-IR imager (for details see Mattila et al., 2002a). In March 2004 observations with LIRIS commenced. By that time the search had only produced the detection of a possible SN (Mattila et al., 2002b) in old images making any follow-up observations and definite confirmation of this SN impossible. We estimated that the lack of SN detections from the INGRID SN search database indicates an average extinction towards the nuclear SNe exceeding $A_V = 10$ (see Mattila, Meikle & Greimel, 2004). Such high extinctions would certainly be expected for most of the SNe within the nuclear regions of starburst galaxies such as M 82 (see Mattila & Meikle, 2001).

Already on the first run on 6 March 2004 LIRIS observed a SN, SN 2004am, within the nuclear regions (~500 pc) in one of our primary targets, M 82. The discovery of this event, however, had already been reported (Singer, Pugh & Li, 2004) just one day before our LIRIS observation. Our 0.89–1.53-micron LIRIS spectrum showed broad (FWHM ~2800 km/s) hydrogen lines demonstrating that this was a type II event (Mattila et al., 2004). The LIRIS *JHKs* images show a moderately reddened source exactly coincident with a bright starburst knot within the nuclear regions of M 82. The optical-near-IR colours also showed that the extinction towards this SN was $A_V \sim 5$. In Figure 1, a *JHKs* image of M82 (+SN2004am) observed by LIRIS as a part of our monitoring campaign on 2004 Nov 25 is shown together with a subtracted *Ks*-band image clearly showing the location of the SN. Note that by this time the SN had already dimmed considerably.

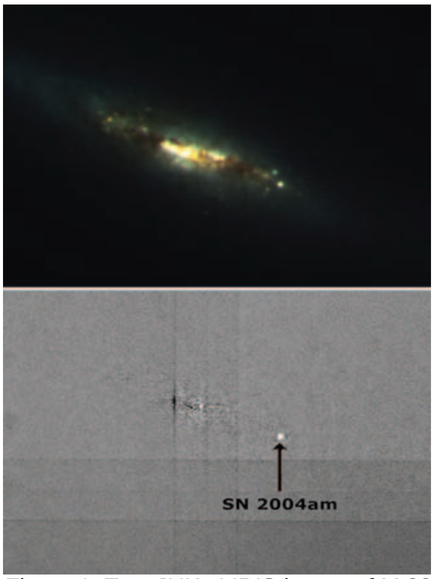

Figure 1. Top: JHKs LIRIS image of M 82 (+ SN 2004am) observed on 2004 Nov 25. Bottom: The result of alignment, image matching and subtraction (Alard, 2000) between LIRIS Ks band images from March 2004 and November 2004.

Our most recent LIRIS run on 2005 January 30 has, at last, produced discoveries of subsequently confirmed SN events in the interacting luminous infrared galaxy Arp 299 (distance ~45 Mpc) and in the nearby starburst galaxy NGC 2146 (distance ~13 Mpc). Both Arp 299 and NGC 2146 have high expected CCSN rates of ~1–2 and ~0.2 SNe per year, respectively, as indicated by their far-IR luminosities (Mattila & Meikle, 2001). SN 2005U (Mattila et al., 2005a), with m(*Ks*)= 16.2, was discovered at 3.7" west and 4.9" south of (or 1.3 kpc from) the *Ks*-band nucleus A (Gehrz et al., 1983) of Arp 299 (see Figure 2). A couple of days later it was classified as a type II within a few weeks past explosion (Modjaz et al., 2005). The near-IR colour of the SN estimated from our LIRIS images, $J–K$ = +0.4±0.5, indicates an extinction of $A_V \sim 4$ towards the SN. Another SN, SN 2005V (Mattila et al., 2005b), was also discovered by LIRIS on the same night. SN 2005V has a magnitude of m(*Ks*)= 13.8, and is located at 1.8" east and 3.4" north of (or 330 pc from) the *Ks*-band nucleus of NGC 2146 (Figure 3). On February 1, it was spectroscopically classified as a type Ib/c SN, about 1–2 weeks past maximum light (Taubenberger & Pastorello, 2005). The near-IR colours from LIRIS, $J–H$= +0.13±0.33 and $H–K$=+0.18± 0.34, indicate an extinction of $A_V \sim 3–4$ towards SN 2005V.

Figure 2. JKs LIRIS image of Arp 299 (+SN 2005U) observed on 2005 Jan 30.

In Figure 4, a LIRIS *Ks*-band image of the Antennae (NGC 4038/9) is shown. This image obtained on 2005 January 30 shows also SN 2004gt located within the circumnuclear regions of the galaxy. The SN is clearly visible in the subtracted image. However, SN 2004gt had already been discovered optically on 2004 December 12 (Monard, 2004), and therefore is likely to have a modest extinction. It has been spectroscopically classified as a type Ib/c (Kinugasa et al., 2004; Ganeshalingam et al., 2004).

Our combined INGRID and LIRIS SN search database now includes repeat images for 40 nearby starburst galaxies, on average ~4.3 epochs per target. However, the nuclear SN detection efficiency falls rapidly as the seeing quality declines. Therefore, the depth of the search varies strongly between the images with different seeings. During the search there have been four confirmed CCSN events discovered in our starburst galaxy sample, two of which were discovered by us. In addition, we have a number of unconfirmed possible SNe present in our *Ks*-band data. All these were detected in old images, and therefore no optical/near-IR follow-up was possible. Although, several CCSNe have now been discovered in starburst galaxies at near-IR wavelengths, they are all extinguished by only a few magnitudes in A_V. The expected population of highly extinguished supernovae within the nuclear regions of starburst galaxies therefore still remains unrevealed. The final conclusion from our study will require extensive statistical analysis of the near-IR SN search database. This is now underway (Mattila et al., in prep.).

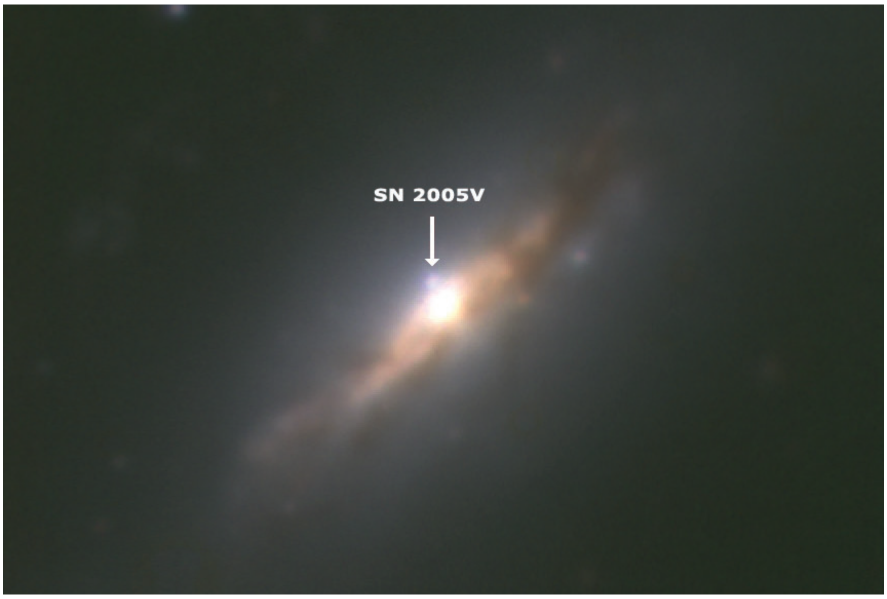

Figure 3. JHKs LIRIS image of NGC 2146 (+SN 2005V) observed on 2005 Jan 30.

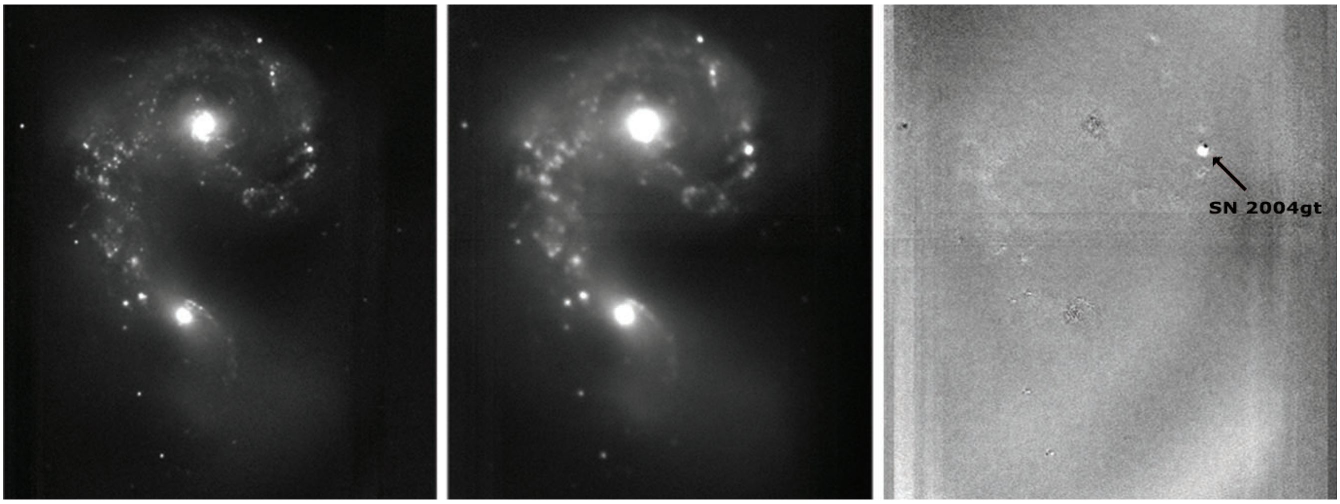

Figure 4. Left: Ks band INGRID image of the Antennae (NGC 4038/9) observed on 2002 January 3 with ~0.8" seeing. Middle: Ks band LIRIS image of Antennae (+SN 2004gt) observed on 2005 January 30 with ~1.6" seeing. Right: The result of alignment, image matching and subtraction between INGRID and LIRIS images using the Optimal Image Subtraction method (Alard, 2000).

The WHT 'Nuclear SN search' (`http://astro.imperial.ac.uk/nSN.html`) team also includes Stuart Ryder, Nic Walton, and Bob Joseph. We thank Chris Gerardy, Per Gröningsson, and Rubina Kotak for taking part in some of the observing runs. ¤

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Addressing the Question Posed by the Of?p Stars: HD191612

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There are three known Of?p stars in our galaxy, they are the well known peculiar stars HD108, HD148937 and HD191612. The question mark in their spectral classification was introduced by Walborn (1972) to indicate doubt that these stars are normal Of supergiants. They are characterised by their CIII λλ 4647, 4650, 4651 emission lines being comparable in strength to their NIII λλ 4634, 4640, 4642 emission lines, unlike normal Of supergiants where the CIII lines are always much weaker (Figure 1). In addition the ultra-violet spectra of Of?p stars also exhibit a stellar wind morphology more akin to O-type giants than to Of supergiants. HD108 has been extensively studied (Nazé et al., 2001) and is subject to large and so far unexplained spectroscopic variations, though with a variability timescale of approximately 56 years systematic study is difficult. HD148937 on the other hand, though relatively little studied does exhibit an impressive nitrogen rich ejection nebula, NGC6164 and NGC6165 (Figure 2). Apparently HD148937 has undergone a previous catastrophic mass loosing event, perhaps similar to those of Luminous Blue Variables such as P Cygni and Eta Carinae. Therefore, despite their rarity, the Of?p stars are well worth detailed study as they may represent an important phase in the short, and spectacular, career of a massive star approaching the end of its lifetime.

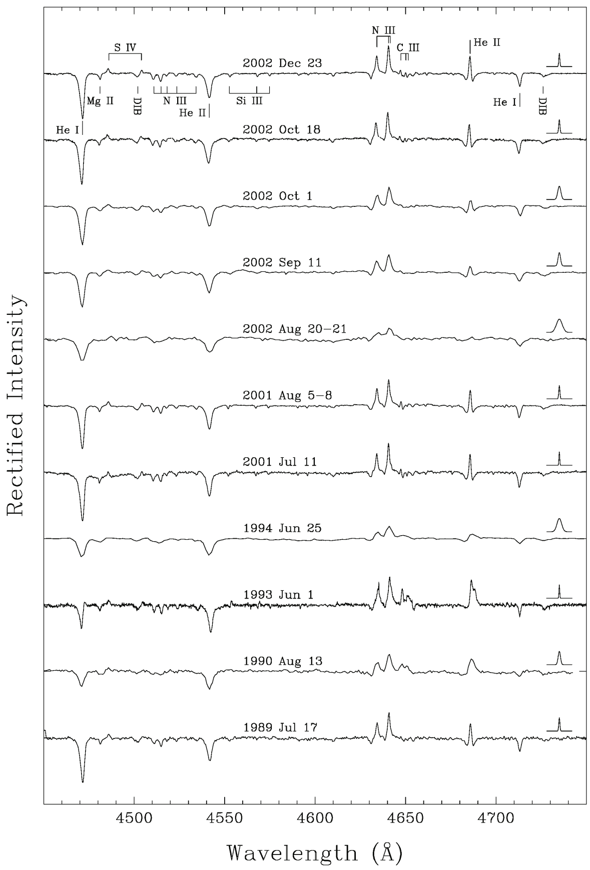

Figure 1. Montage of green region spectral data for HD191612. The June 1st 1993 spectrum of HD191612 was taken during its O6 like Of?p phase and illustrates a typical characteristic of these peculiar stars, namely the CIII λλ 4647, 4650, 4651 lines are comparable in strength to the NIII λλ 4634, 4640, 4642 lines. Note also the strong emission present in HeII λ 4686. Compare with December 2002.

HD191612 came to our attention when N. R. Walborn noticed that the spectrum discussed by Herrero et al. (1992) was different from the discovery spectrum of Walborn (1973). This realisation prompted a thorough check of the historical publication record and the ING archive at Cambridge, as well as a drive to obtain new spectra through ING's service programme. As a result the spectrum was found to be highly variable, appearing to switch between an O6–7 spectral type with the Of?p characteristics and an O8

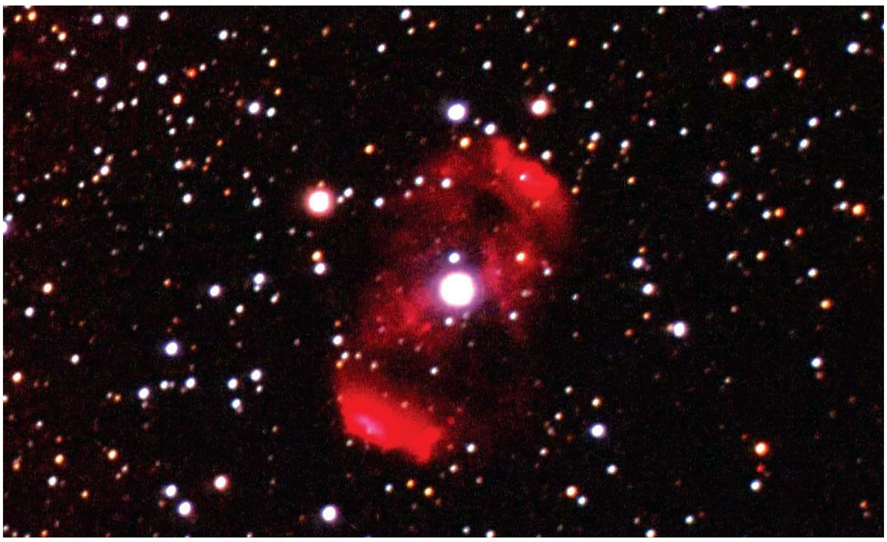

Figure 2. The ejection nebulae NGC 6164 and NGC 6165 surrounding the Of?p star HD148937. This image is courtesy of Mischa Schirmer (ING) from `http://aida.astroinfo.org/`. Note the point-symmetric nature of the nebulae around the central star.

spectral type in which the CIII emission lines are absent (Figure1). While the data precluded determining any periodic behaviour of the spectrum, Walborn et al. (2003, Paper I) suggested that spectroscopic states might persist for a decade, although one transition occurred on a time scale of only 13 months.

We continued to monitor HD191612 through 2003 and the first half of 2004 using the Isaac Newton and William Herschel Telescopes, as well as several other northern hemisphere telescopes; WIYN, OMM, MMT, OHP, Skinakas, and Loiano. While Paper I had left HD191612 in its O8 state at the end of 2002, May 2003 saw a return to the O6 state, where it remained until a possible transition in December of that year. After a gap of five months the star was recovered in its O8 state implying that stable spectral states last approximately 7–9 months. However an important breakthrough came with the discovery of a periodic behaviour of HD191612 in the Hipparcos photometric survey (Nazé, 2004), with a period of approximately 540±13 days. Combining this with the spectroscopic variability enabled us to refine this period to 538±3 days which is also consistent with Walborn's initial classification in 1973. Indeed all of the data from Paper I, plus data from the 2003/04 campaign, perfectly match this period, with the hotter O6 phase occurring during maximum brightness, accompanied by strong Hα emission and reduced HeI line strengths. This led us to predict that a transition should occur in October 2004 (Walborn et al., 2004, and Figure 3), a prediction subsequently confirmed by our on-going multi-site spectroscopic monitoring campaign which by now had expanded to include the NOT and TNG on La Palma. The blue points in Figure 3 show the onset of transition occurring as predicted with the very smooth change in Hα as it switches from absorption to emission, accompanied by a weakening of the HeI lines.

Despite the wealth of observational data now accumulated for HD191612, this star, like the others in its class, remains enigmatic. Its characteristics cannot be explained by known

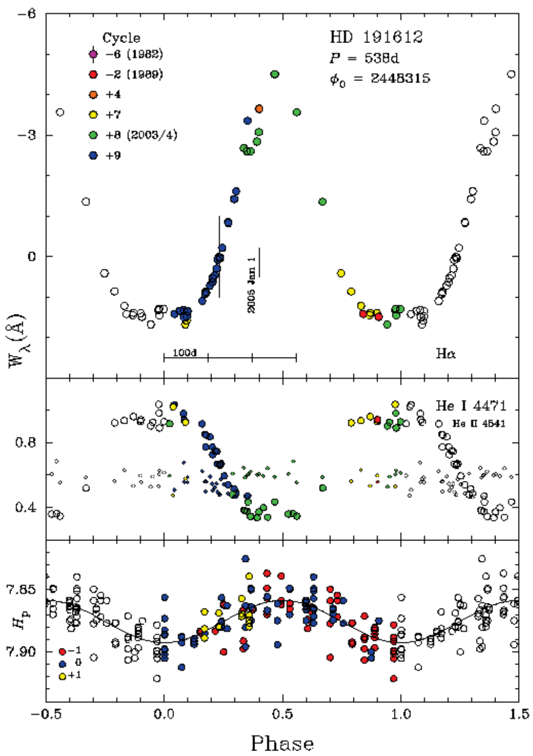

Figure.3 Illustration of spectral and photometric variability of HD191612. The upper panel shows how the Hα line switches from absorption (positive equivalent width) to emission (negative equivalent width). Note the good agreement between the data points covering 22 years, or 16 cycles. The central panel highlights the change in spectral type between the star's O8 type (large HeI equivalent width) to its O6 type (small HeI equivalent width). The bottom panel shows the light curve obtained from the Hipparcos data.

mechanisms linked to rotation or pulsation. Perhaps the most tempting explanation lies in the regime of binary evolution; a compact companion in an eccentric orbit and small periastron separation is one possible model. Unfortunately, while we can rule out radial velocity variations of HD191612 greater than 10–20 km/s this is not a strong constraint for this scenario, improved observations around a supposed periastron (Hα maximum) are clearly desirable and ongoing.

The relatively short period of HD191612 and wealth of spectroscopic material make it an ideal candidate for detailed study. In the coming year we will continue to monitor HD191612 and look forward to complementing the optical coverage with the acquisition of X-ray data using XMM-Newton (P. I. Nazé). The expectation is that we will obtain X-ray spectra at three phases representing typical O6, O8 and transition states of this star, along with contemporaneous optical spectroscopy.

We would like to thank the many observers and telescope groups who took part in this campaign (see Papers I and II), including Chris benn, Roy Østensen and Gloria Andreuzzi on La Palma. ¤

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The Search for the Companion Star of Tycho Brahe's 1572 Supernova

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In recent years, type Ia supernovae (SNe Ia) have been used successfully as cosmological probes of the Universe (Riess et al., 1998; Perlmutter et al., 1999). However, the nature of their progenitors has remained somewhat of a mystery. It is widely accepted that they represent the disruption of a degenerate object, but there are also numerous progenitor models (see for instance Ruiz-Lapuente, Canal, Isern, 1997a, for a review), but most of these have serious theoretical/observational problems or do not appear to produce sufficient numbers to explain the observed frequency of SNe Ia in our Galaxy (~3×10^{-3} yr^{-1}; Cappellaro & Turatto, 1997).

The Thermonuclear Runaway

Hoyle and Fowler (1960) described how a white dwarf, a common end-point in the evolution of low- and intermediate-mass stars, could become a powerful fusion bomb if its interior temperature rose from about 2×10^8 to 5×10^8 K. They anticipated that this type of explosion could well correspond to the class of objects identified by Minkowski (1941), called supernovae of type I and much later renamed type Ia. These supernovae are characterised by their spectral signatures and are the brightest observable stellar explosions.

But, how can such high temperatures (>10^8 K) be attained in the usually cold degenerate cores of white dwarfs? A natural way to heat white dwarfs up is by the accretion of material from a stellar companion. If the white dwarf grows in mass by taking material from a donor star, its central density and temperature rise, and it can achieve the critical condition near 1.4 solar masses, the so-called Chandrasekhar mass. The binary path is found to be the easiest physical way to give rise to bare white dwarfs exploding in large enough numbers to account for those supernovae. The single-star models were both physically and statistically unsuccessful. Recently, new momentum has been given to the study of possible evolutionary paths to explosion. Observational efforts with specific goals have been set up to clarify the issue by contrasting the models with empirical evidence.

Progenitor Models of Type Ia SNe

The progenitor models can roughly be divided into three classes: double-degenerate (DD) models, sub-Chandrasekhar models and single-degenerate (SD) Chandrasekhar models.

The DD alternative involves the progressive approach of two white dwarfs orbiting around the centre of mass of the system while they emit gravitational wave radiation (the material accreted by the white dwarf is neither H nor He but C+O from a disrupted CO white-dwarf companion) (Iben & Tutukov, 1984; Webbink, 1984). The less massive white dwarf is disrupted in the process, forming a torus of material around the most massive one. The accretion of this mass by the surviving white dwarf could cause its explosion if the combined mass is in excess of the Chandrasekhar mass (~1.4 solar masses). The lack of detection of any surviving companion could eventually confirm that it is destroyed in the course of the binary evolution, as expected in the merging of CO white dwarfs. Some objections have been raised, however: fine tuning in the accretion process might be required to avoid the burning of C into Ne and Mg, which would lead to a collapse event (i.e. undergoes accretion-induced collapse; AIC) instead of an thermonuclear explosion. There may be a small parameter range where AIC can be avoided, but it is unlikely to account for more than a small number of SNe Ia. This model nevertheless has the advantage of being in good agreement with the SN rate in our Galaxy (Nelemans et al., 2001).

A sub-Chandrasekhar-mass white dwarf could produce a SN Ia if helium is ignited violently in a shell surrounding the CO core and triggered a detonation wave that propagates inward and ignites the CO core (Woosley & Weaver, 1994; Livne & Arnett, 1995). Although they might not respond to the common type Ia phenomenon, they could correspond to very dim ones. A mixture of almost standard Chandrasekhar explosions with some very faint "peculiar" sub-Chandrasekhar explosions could exist. A few extremely faint type Ia explosions have been identified, in any case: The last supernova of type Ia that exploded in the Andromeda galaxy, in 1885, was of such a type. On the other hand, the evolutionary path toward explosion will not be directly reflected in the spectrum of the exploded white dwarf itself.

The arguably most favoured class of models at the present time involves single-degenerate scenarios, where the white dwarf accretes from a non-degenerate companion star (Whelan & Iben, 1973; Nomoto, 1982). In these models, the companion star can be a giant, a subgiant, a He star, or a main-sequence star, ie. it may either be a hydrogen-rich star or a helium star. One of the major problems with these models is that it is generally difficult to increase the mass of a white dwarf by accretion due to the occurrence of nova explosions and/or helium flashes (Nomoto, 1982) which may eject most of the accreted mass. There is a narrow parameter range where a white dwarf can accrete hydrogen-rich material and burn it in a stable manner. Burning of the accreted H into He and of the He into C can lead to the growth in mass and increase of the central temperature of the star, which would finally explode. Low accretion rates favours a much less violent explosion: A nova, which differs from a supernova in that the white dwarf remains intact, and there is opportunity for further recurrent outbursts. Whereas a nova is a skin-depth explosion, a type Ia supernova affects the whole star. A number of tests have been undertaken to reveal whether such a picture involving a H- or He-donor companion is correct (Ruiz-Lapuente, 1997b).

One promising channel that has been identified in recent years relates them to supersoft X-ray sources (Li & van den Heuvel, 1997). In this channel, the companion star is a somewhat evolved main-sequence star or subgiant of 2–3 solar masses, transferring mass on a thermal timescale to a white dwarf. As an example, calculations made by Podsiadlowski (2003) show that an initial system consisting of a 2.1 solar masses somewhat evolved main-sequence star and a 0.8 solar masses white dwarf can make the white dwarf grows very effectively. When it reaches the Chandrasekhar mass, it has parameters very similar to U Scorpii, a supersoft binary and recurrent nova where the white dwarf is already close to the Chandrasekhar mass and therefore one of the best SN Ia progenitors currently known (Thoroughgood et al., 2001).

While U Scorpii provides an excellent candidate for a SN Ia, consistent with theoretical expectations, it would be even better to have a more direct observational test for progenitor models (Ruiz-Lapuente, 1997b), in particular since it is quite possible, perhaps even likely, that there is more than one channel that leads to a SN Ia. Such direct tests could involve the detection of hydrogen or helium in the ejecta or the supernova environment, which could come from the outer layers of the exploding object, circumstellar material that was ejected from the progenitor system (e.g. Cumming et al., 1996), or matter that was stripped from the

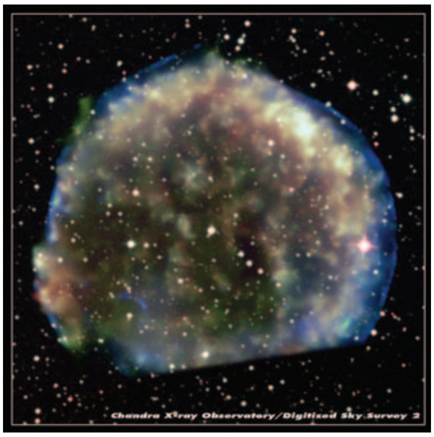


Figure 1. Chandra image of Tycho SNR. The colours in the Chandra X-Ray image of the hot bubble show different X-ray energies, with red, green, and blue representing low, medium, and high energies, respectively. (The image is cut off at the bottom because the southernmost region of the remnant fell outside the field of view of the Chandra camera). The bright star in the centre of the remnant is the same bright star in the centre of Figure 2 (star labelled 'Tycho A'). Credit: Chandra X-Ray Observatory/DSS2.

secondary by the supernova interaction and was mixed into the ejecta. A particularly conclusive test would be the detection of a companion star that has survived the supernova explosion in the supernova remnant. At present the detection of a surviving companion would only be feasible in our Galaxy. The supernova of the millennium, the Lupus supernova (also designated SN 1006 after the year of its appearance) was a supernova of this type. The supernova discovered by Tycho Brahe, SN 1572, was also of this type. Both are the only unambiguous type Ia supernovae observed in our Galaxy during the last thousand years.

Observable Consequences on the Companion Star

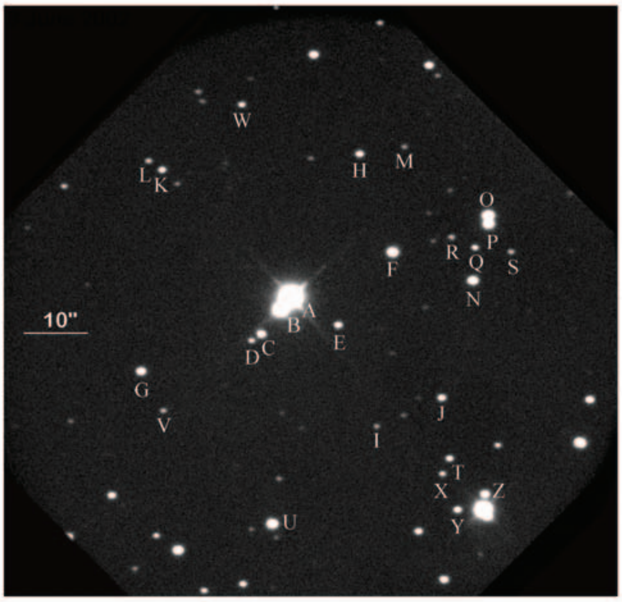
The predictions of how the companion star would look after the impact of the supernova ejecta, if there is any companion, were investigated by Canal, Méndez and Ruiz-Lapuente (2001), depending on the type of star it actually is. Among other features, the surviving companion star should have a peculiar velocity with respect to the average motion of the other stars at the same location in the Galaxy —mainly due to disruption of the binary— detectable through proper-motion and radial velocity measurements, and perhaps also signs of the impact of the supernova ejecta. The latter can be twofold. First, mass should have been stripped from the companion and thermal energy injected into it, possibly leading to the expansion of the stellar envelope that would make the star have a lower surface gravity. Second, depending on the interaction with the ejected material, the surface of the star could be contaminated by the slowest-moving ejecta made of Fe and Ni isotopes. If the companion's stellar envelope is radiative, such a contamination could be detectable through abundance measurements.

The Search for the Companion Star of SN 1572

Tycho Brahe's supernova (SN 1572) is one of the only two supernovae observed in our Galaxy that are thought to have been of type Ia as revealed by the light curve (Ruiz-Lapuente, 2004), radio emission (Baldwin et al., 1957) and X-ray spectra (Hughes et al., 1995).

The field that contained Tycho's supernova, relatively devoid of background stars, is favourable for searching for any surviving companion. With a Galactic latitude $b = +1.4°$, Tycho's supernova lies 59–78 pc above the Galactic plane. The stars in that direction show a consistent pattern of radial velocities with a mean value of -30 km s^{-1} at 3 kpc. The star most likely to have been the mass donor of SN 1572 has to show a multiple coincidence: being at the distance of SN 1572, showing an unusual motion in comparison to the stars at the same location, having stellar parameters consistent with being struck by the supernova explosion and lying near the remnant centre.

The distance to SN 1572 inferred from the expansion of the radio shell and by other methods lies around 3 kpc. Such a distance, and the light-curve shape



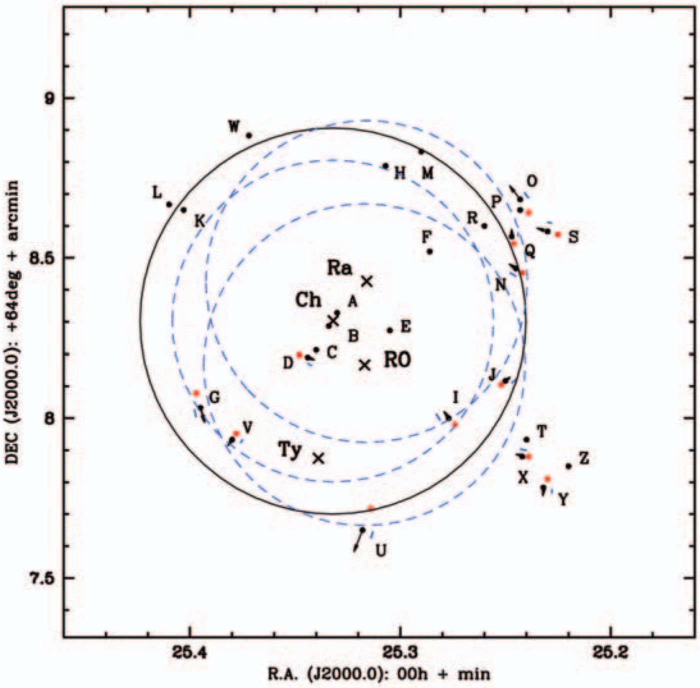


Figure 2 (left). B-band image of the centre of Tycho SNR from the Auxiliary Port camera at the William Herschel Telescope. The emptiness of the field is remarkable. We carried out repeated photometric and spectroscopic observations of the included stars in the surveyed area (see solid circle in Figure 3) at various epochs to check for variability and exclude binarity.

Figure 3 (right). Positions and proper motions of stars. Positions are compared with three centres: the Chandra (Ch) and ROSAT (RO) geometrical centres of the X-ray emission, and that of the radio emission (Ra). Dashed lines indicate circles of 0.5 arcmin around those centres and the solid line is a circle with a radius of 0.65 arcmin around the Chandra centre. The supernova position reconstructed from Tycho Brahe's measurements (Ty) is also shown, though merely for its historical interest. The proper motions of the stars measured from HST WFPC2 images are represented by arrows, their lengths indicating the total displacements from 1572 to 2004. Error bars are shown by parallel segments. Red circles are the extrapolated positions of the stars back to 1572.

of SN 1572, are consistent with it being a normal type Ia supernova in luminosity, like those commonly found in cosmological searches (Ruiz-Lapuente, 2004).

Given the age of Tycho SNR and the lower limit to its distance (2.83±0.79 kpc), any possible companion, even if it moved at a speed of 300 km s^{-1}, could not be farther than 0.15 arcmin from its position at the time of the explosion. However, the search radius significantly expands owing to the uncertainty in the derived centre of the SNR. The radius of the remnant is 4.325±0.025 arcmin (Ruiz-Lapuente, 2004) and the SNR is quite spherically symmetric (see Figure 1). Nevertheless, there is a 0.56 arcmin displacement along the east-west axis between the radio emission and the high-energy continuum in the 4.5–5.8 keV band observed by XMM-Newton in the position of the western rim. Such asymmetry amounts to a 14% offset along the east–west axis. Evidence that the ejecta encountered a dense H-cloud at the eastern edge giving rise to brighter emission and lower ejecta velocity, while finding a lower-density medium in the western rim, might account for the asymmetry (Decourchelle et al., 2001). In SNRs from core-collapse supernovae (type II), up to a 15% discrepancy between the location of the compact object and the geometric centre is found in the most symmetric cases.

On the basis of the above considerations we decided to cover 15% of the innermost radius (0.65 arcmin) centred on RA=00 25 19.9, Dec=64 08 18.2 (J2000), the Chandra Observatory coordinates for the geometrical centre of the X-ray emission of the SNR (Figures 2 and 3). And as deep as V=22 so sampling main-sequence with spectral types earlier than K6 (for later types the total mass available for transfer excludes them as viable candidates to type Ia SN companions), subgiant and red giant candidates at the distance of the remnant (Canal, Méndez, Ruiz-Lapuente, 2001). For a description of our survey strategy see Ruiz-Lapuente et al. (2003a).

We obtained spectra of most of the stars in the surveyed area using Keck I, II+ESI, LRIS, WHT+UES, ISIS and NOT+ALFOSC, and photometric data using the INT+PFC, WFC and WHT+Aux Port Camera. All but one of the observed stars are either main-sequence stars (luminosity class V) with spectral types A4-K3 or giant stars (luminosity class III) with spectral types G0–K3.

Red-giant stars are possible companions of type Ia supernovae. Masses in the range 0.9-1.5 solar masses are the most favourable cases (Hachisu et al., 1996). Red-giants have envelopes loosely bound gravitationally, and upon collision with the SN ejecta it should be either completely stripped or just a small fraction of it remains bound to the core. In the former case, the remaining

He core would appear as a hot He pre-white dwarf, not as a red giant. In the latter case, the H-burning shell would remain active and the residual envelope would expand to red-giant size. None of the detected red-giant stars lie in one of these possibilities and they are all at distances incompatible with that of SN 1572.

Main-sequence stars are also viable companions of type Ia supernovae. Close binaries with 2 to 3.5 solar masses main-sequence or subgiant companions have indeed been suggested as one class of systems able to produce type Ia supernovae (Li et al., 1997). Among systems containing a main-sequence star, recurrent novae have been pointed out as possible progenitors (Livio & Truran, 1992). Stripping of mass from the impact of the ejecta on this type of companion is also expected and as a consequence the companion star increases its volume and luminosity, to later return to the equilibrium values of a star with the new (decreased) mass (Canal et al., 2001; Marietta et al., 2000; Podsiadlowski, 2003). Main-sequence companions should experience the highest increase in peculiar velocity (peculiar velocities up to 200 to 300 km s^{-1} after the explosion) as the orbital separation of the binary system is shorter than in other possible progenitor models. However, the detected main-sequence stars in the sample have low peculiar velocities, the surface abundances are compatible with solar values and no odd combinations of log g and T_{eff} are found.

The Case of Tycho G

Tycho G is a subgiant G2IV star located at 0.49 arcmin from the Chandra centre of Tycho SNR. From low resolution spectroscopy, and after dereddening by $E(B–V)$=0.60±0.05 mag, we derive a temperature of T_{eff}=5750 K, a surface gravity log g=4.0–3.0, and solar metallicity from high-resolution spectroscopy. For the spectral type found and being a slightly evolved star (surface gravity not much below the main-sequence value), the mass should be about solar and thus the radius, for the range of surface gravities above,

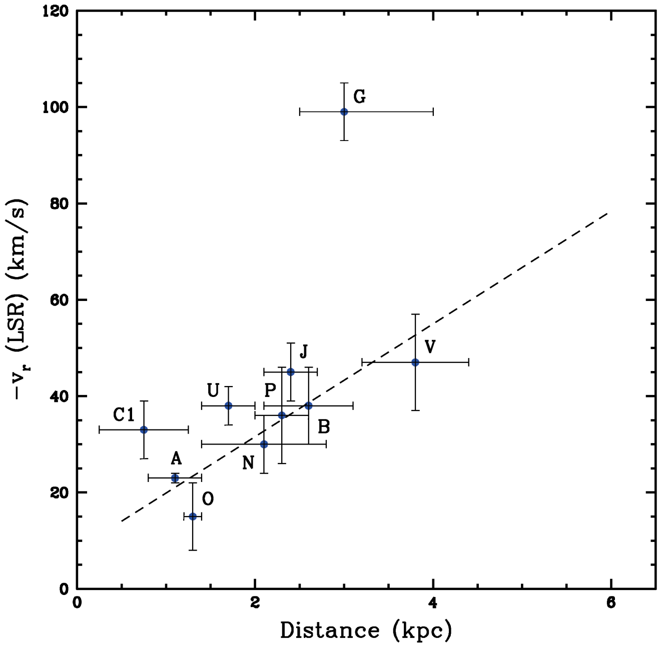


Figure 4. Radial velocity in the Local Standard of Rest (LSR), versus distance for the subsample of stars closer than 6.5 kpc. The dashed line shows the approximate relationship for the stars in the direction of Tycho given by the expression v_r=–v_{solar} cos(l–l_{solar})+A r sin(2l), where l and l_{solar} are the respective Galactic longitudes of Tycho SNR and the solar apex, v_{solar} is the Sun's velocity in the LSR, A is the Oort's constant and r is the distance in kpc. We include two field stars (stars Tycho O and U) that are slightly away from the search area but at distances in the range 2–4 kpc.

should be R≈1–3 solar radii, which translates via our photometric data (Tycho G's apparent V magnitude is 18.71±0.04) into a distance d≈2.5–4.0 kpc.

Tycho G could have been a main-sequence star or a subgiant before the explosion. Main-sequence stars no longer look like ordinary main-sequence stars after the explosion of the supernova, but subgiants with envelopes expanded. Subgiants remain subgiants of lower surface gravity (Marietta et al., 2000; Podsiadlowski, 2003).

Stars at distances d≈2.0–4.0 kpc in the direction of Tycho SNR move at average radial velocity v_r≈–20 to –40 km s^{-1} (in the Local Standard of Rest) with a ~20 km s^{-1} velocity dispersion (Binney & Merrifield, 1998; Dehnen & Binney, 1998). Tycho G moves at –108±6 km s^{-1} (heliocentric) in the radial direction. In contrast, all other stars with distances compatible with that of SN 1572 have radial velocitites within the velocity dispersion as compared with the average of all stars at the same location in the Galaxy (see Figure 4).

From detailed proper motion measurements on Hubble Space Telescope WFPC2 images (Ruiz-Lapuente et al., 2003b) it is found that Tycho G has tangential velocitites μ_b=–6.11±1.34 mas yr^{-1} and μ_l= –2.60±1.34 mas yr^{-1} resulting in a total tangential velocity of 94±27 km s^{-1} (a 24 km s^{-1} systematic error was added due to uncertainty in the reference frame solution of the images). This proper motion programme continues in HST Cycle 13 where measurements with smaller error bars will be obtained using both WFPC2 and ACS. The other stars of our sample do not show such coincidence in distance and high tangential velocity. Putting together radial and tangential velocities, we derive a value of 136 km s^{-1} for the modulus of the velocity vector of Tycho G, being a factor of 3 larger than the mean velocity value at 3 kpc.

This derived velocity lies in the range of expected peculiar velocities of the companion star from the disruption of a white dwarf plus subgiant/main-sequence system. The system would have resembled the recurrent nova U Scorpii, ie. a system made of a white dwarf close to the Chandrasekhar mass

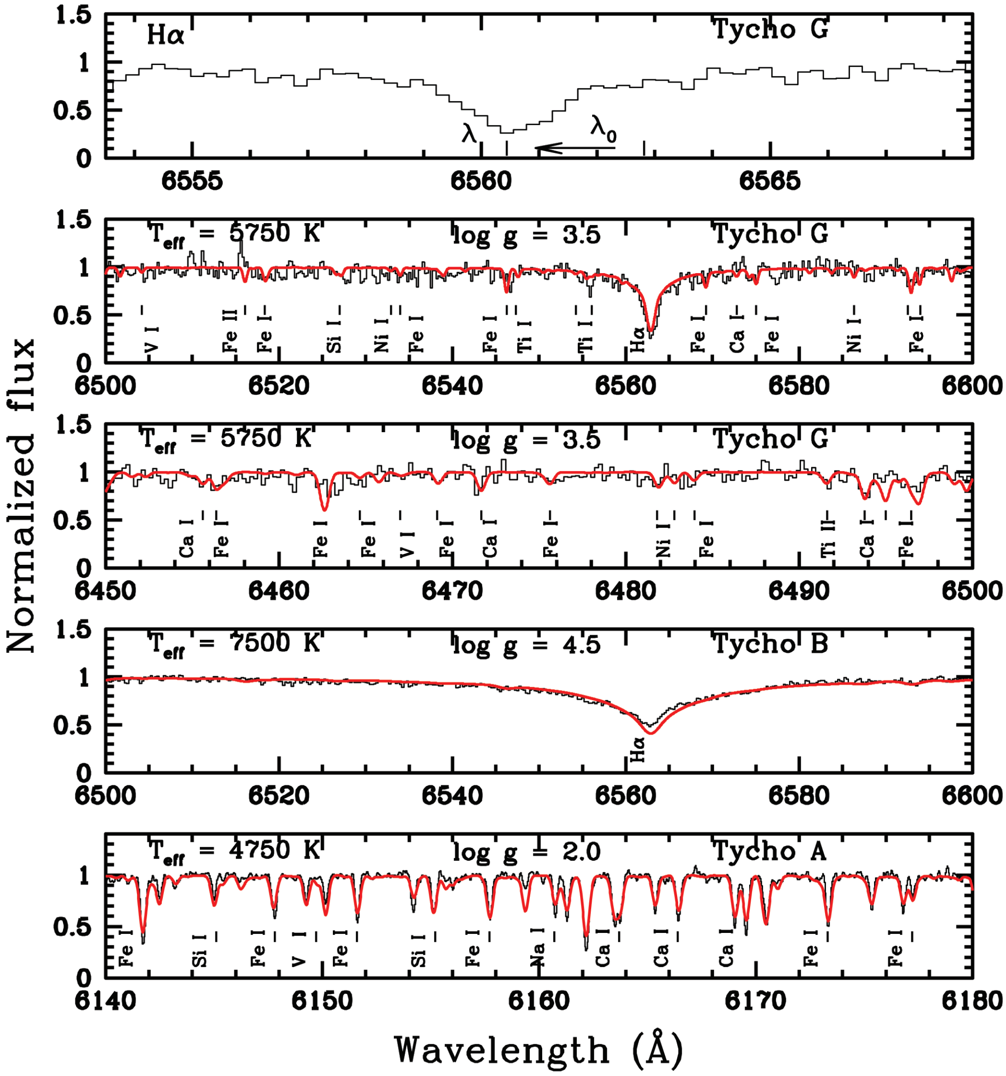


Figure 5. Model fits to observed spectra of the subgiant star Tycho G, the red giant star Tycho A and the main-sequence star Tycho B. Identification of the most significant metal lines are given. We have not detected significant spectroscopic anomalies, either here or in the whole sample, and most spectra are well reproduced assuming solar abundances. Thin lines correspond to the observations and thicker lines to the synthetic spectra. Spectra were obtained at the WHT with UES and ISIS. Tycho A (bottom panel) is the closest red giant in the sample. It is a K0 III star, and its mas should be 3 solar masses approximately. Tycho A is ruled out as the companion star of SN 1572 on the basis of its short distance: 1.1±0.3 kpc. All the other red giants are located well beyond Tycho´s remnant, and therefore are also ruled out. The A8/A9 star Tycho B (second panel from bottom) has 1.5 solar masses, which would fall within the appropriate range for main-sequence type Ia supernova companions, as it would have been massive enough to transfer the required amount of mass to the white dwarf. The entirely normal atmospheric parameters, however, strongly argue against any such event in the star's recent past. The second and third spectra from the top show computed spectra compared with observed spectra for Tycho G. The upper panel shows the observed spectrum near Hα. This line is blueshifted, implying a peculiar radial velocity exceeding about 3 times the velocity dispersion for its stellar type.

(initial mass of the white dwarf 0.8 solar masses) plus a companion of roughly a solar mass (initial mass of the evolved companion 2.0–2.5 solar masses filling its Roche lobe) at the moment of the explosion. The excess velocity corresponds to a period of about 2–7 days (a period of 6 days correspond to an orbital velocity of 90 km s^{-1} approximately). The effective radius of the Roche lobe of the companion just before the explosion would have been 7 solar radii.Given the effective temperature and luminosity of Tycho G, the radius is less than 3 times the solar radius. This smaller radius would be a consequence of mass stripping and shock heating by the supernova impact, plus subsequent fast cooling of the outer layers up to the present time.

Such a high velocity, however, could be explained if Tycho G belongs to the Galactic halo population. The lower limit to the metallicity obtained from the spectral fits [M/H]>–0.5, however, excludes this possibility (see Figures 5 and 6). Spectra taken at five different epochs also exclude Tycho G is a single-lined spectroscopic binary.

Conclusions

Our search for the binary companion of Tycho's supernova has excluded giant stars. It has also shown the absence of blue or highly luminous objects as post-explosion companion stars. One of the stars, Tycho G of our sample, show a high peculiar velocity (both radial and tangential velocities), lies within the distance range for the explosion of SN 1572, and its type, G2IV, fits the post-explosion profile of a type Ia supernova companion whose position in the Hertzsprung-Russell diagram is untypical for a standard subgiant.

If Tycho G is the companion star of SN 1572, its overall characteristics imply that the supernova explosion affected the companion mainly through the kinematics. Therefore, a star very similar to the our Sun but of a slightly more evolved type would have been the mass donor that triggered the explosion of type Ia SN 1572, connecting the supernova explosion to the family of cataclysmic variables.

The results of this research, led by Pilar Ruiz-Lapuente of the University of Barcelona, was published in the October 28 issue of *Nature*. The co-authors are Fernando Comeron (ESO), Javier Méndez (University of Barcelona and ING), Ramón Canal (University of Barcelona), Stephen Smartt (IoA, Cambridge), Alex Filippenko (University of California, Berkeley), Robert Kurucz (Harvard-Smithsonian Centre for Astrophysics), Ryan Chornock and Ryan Foley (University of California, Berkeley), Vallery Stanishev (Stockholm University), and Rodrigo Ibata (Observatory of Strasbourg). ¤

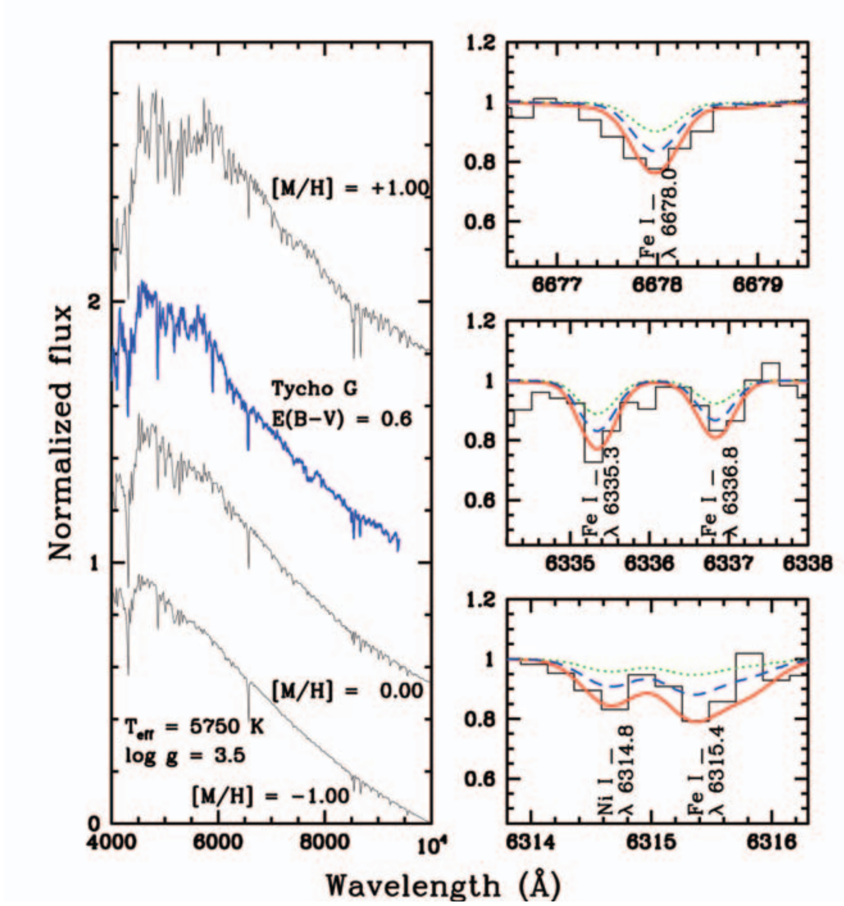


Figure 6. Left: A low-resolution spectrum over a wide wavelength range was obtained with LRIS at the Keck Observatory (second from top) and it is compared with template model spectra of the same spectral class and various metallicities. Right: Several fits to Fe and Ni lines in Tycho G for solar abundances (bold line), [Fe/H]=–0.5 (dashed line) and [Fe/H]=–1 (dotted line). The high content of nickel and iron in the gas of Tycho G clearly identifies it as a star born in the Galactic Plane. The data was obtained with ISIS at the WHT.

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TELESCOPES AND INSTRUMENTATION

PlanetPol: A High Sensitivity Polarimetre for the Direct Detection and Characterisation of Scattered Light from Extra-solar Planets

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After commissioning on the University of Hawaii 88-inch telescope, PlanetPol has been used successfully on the WHT in April and October 2004. The instrument, funded by PPARC, was designed and built at the University of Hertfordshire.

PlanetPol is a stellar polarimetre designed to measure fractional polarisations of 10^{-6} or less. With this sensitivity PlanetPol should be capable of detecting the polarisation signature of so-called hot-Jupiters. These are extra-solar planets (EXP) whose size is approximately that of Jupiter but with orbits that are 0.1 AU or less (orbital periods of a few days). The linear polarisation should vary with phase angle from zero at full phase to a maximum whose amplitude and position depends on the nature of the scattering particles in the planetary atmosphere. Measuring the polarisation signature not only gives a direct detection of the EXP, in contrast to the more usual indirect detections by which most EXPs are discovered, but can provide information about the planet's albedo and radius, and on the nature of the scatterers. Further, from the position angle of polarisation the inclination of the planet's orbit (i) can be determined thereby enabling the planet's mass to be determined. In contrast, techniques such as the RV method only measure $M \sin i$.

Polarimetry is a technique that is capable of very high sensitivity as it is a differential technique that in principle is not affected by the Earth's atmosphere, and hence is limited only by photon noise. However, fractional polarisations of a few parts in a million are lower than most astronomical polarimetres can achieve, although comparable sensitivities have been obtained before, albeit under somewhat idealised conditions. Kemp et al. (1987, *Nature*, **326**, 270) measured the integrated light from the sun and gave an upper limit for the fractional linear polarisation of 2×10^{-7}. However, Kemp et al. used a polarimetre that directly viewed the sun, rather than using an intermediate telescope, and hence avoided the potential problem of telescope polarisation.

PlanetPol has a classical design and takes advantage of some of the techniques pioneered by Kemp. It was designed for use on a range of telescopes, mounted at the unfolded Cassegrain so as to minimise telescope polarisation.

All high sensitivity polarisation measurements to date have made use of photoelastic modulators (PEM) in which a slab of non-birefringent material is stressed using a piezo at the resonant frequency of the slab, f_0, thereby reducing the power needed to sustain a standing wave in the PEM. Such devices are ideal as polarisation modulators as they operate at frequencies of tens of kHz, well above seeing or scintillation fluctuations produced by turbulence in the Earth's atmosphere and they do not involve any rotating parts and so do not produce any periodic motion of the image on the detector, nor any periodic light

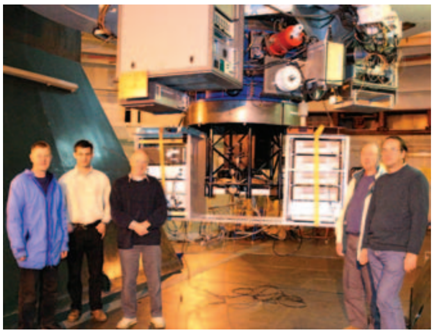


Figure 1. Top: Picture shows PlanetPol on the WHT, with left to right: Edwin Hirst, Phil Lucas, Jim Hough, Dave Harrison and Jeremy Bailey. Bottom: PlanetPol instrument.

modulation produced by dust on the modulator. The PEMs in PlanetPol are type I/FS20 made from fused silica, with a PEM90 Controller, all manufactured by Hinds Instruments.

A 3-wedge Wollaston is used as the analyser, giving better image quality than the more usual 2-wedge device. Following the analyser are wheels with colour filters and neutral density filters. Two-element Fabry lenses image the primary mirror onto single element detectors, sufficient for a stellar polarimetre, and these also eliminate any problems with flat-fielding. The very high modulation rates of the PEMs (20 kHz for PlanetPol) are, in any case, incompatible with the readout rates for CCDs, although the solar ZIMPOL Polarimetre, see `http://www.noao.edu/noao/staff/keller/` uses the charge shifting and storage capabilities of CCDs to act as a synchronous demodulator, thus largely overcoming the readout limitations.

PlanetPol uses Avalanche Photodiodes (APD), which have higher quantum efficiency than photocathodes and less noise than the external amplifier of a photodiode, providing the best signal to noise for the photon rates achieved with PlanetPol. The APDs were specially designed by Hamamatsu (type C4777-SPL-S2383-70K), operating with a gain of 100, a spectral response covering 400–1000 nm, a frequency response of 0–70 kHz (3 dB) and employ a 2-stage thermoelectric cooler (TEC), giving a detector temperature of –20°C. They have a nominal size of 1 mm with an active area of 0.70 mm. Their NEP is < 2 fWHz$^{-½}$.

PlanetPol has 2 channels, the star channel, on the telescope axis, and a sky channel, offset by 95 mm. As only one PEM is used in each channel, the instrument has to be rotated through 45 degrees to measure the second Stokes parameter for linear polarisation. The analyser, together with the filters, and detector assemblies, can be rotated through 90 degrees so as to change the phase of the modulated signal by 180 degrees, and hence eliminate any offsets in the signal detection train.

Each of 4 signal channels uses a Stanford Research SR830DSP lock-in amplifier to extract the linear polarisation signal modulated at 40 kHz (twice the modulation frequency of the PEM). The DC signal from the detectors is fed to a 16-bit ADC. An ARCOM Industrial PC, running Agilent Vee Pro 6 is used to control all the mechanical functions of the instrument, the settings of the lock-in amplifiers and ADCs, and also acquires and displays the data. Communication with the ARCOM computer is via an Adderlink KVM Extender, using a dedicated ethernet line to a remote monitor and keyboard in the observatory's control room. Data reduction is carried out using a laptop running IDL, which shares files with the ARCOM over the LAN.

Figure 2. Schematic of PlanetPol.

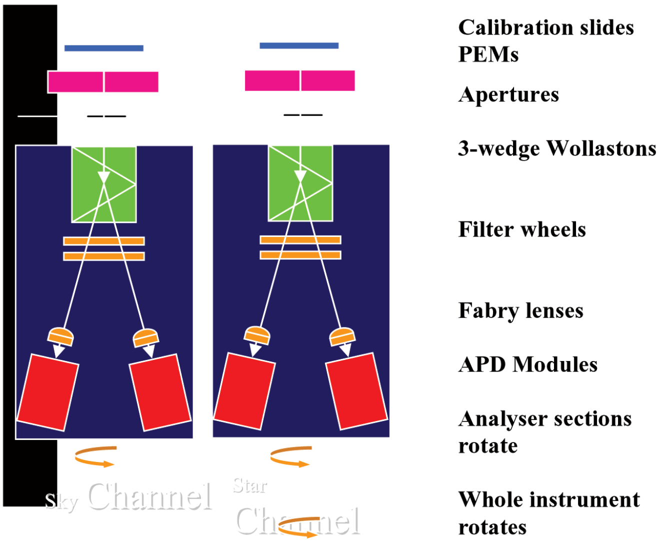
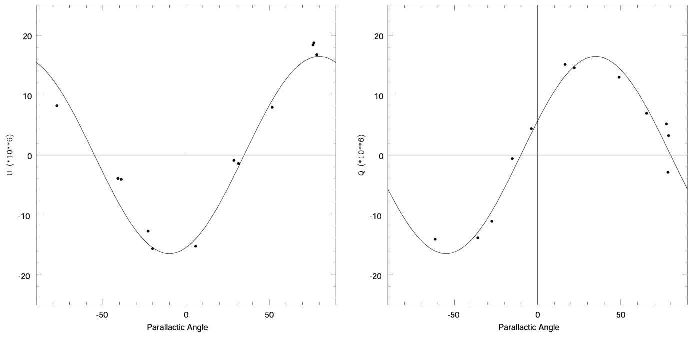


Figure 3. U and Q polarisations for nearby stars at different parallactic angles. U and Q are not shown in the equatorial coordinate system. Fractional polarisations are in units of 10^{-6}.



In order to measure fractional polarisations of 10^{-6} or less, it is essential to determine the telescope polarisation (TP) so that the absolute error in TP is much lower than 10^{-6}. This was achieved by observing nearby stars (typically within ~20 pc) with the telescope de-rotator on, causing the TP to rotate while any other contributions to the polarisation are fixed. Measuring the polarisation of these nearby stars as a function of parallactic angle should produce, in the absence of any intrinsic stellar polarisation, interstellar polarisation, and instrument polarisation, a sinusoidal curve in U and in Q with an amplitude equal to the telescope polarisation, and phase shifted by 45°. Figure 3 shows the measured U and Q polarisations as a function of parallactic angle. In practice, even for very nearby stars, there will be some interstellar polarisation and a curve was fitted to the data set taking this into account. The best fit curves give a fractional polarisation for the TP of $(16.45\pm0.20)\times10^{-6}$. This very low TP makes the WHT an ideal telescope for making very high sensitivity polarisation measurements.

In the two observing runs to date observations were made of τ Boo and υ And, although poor weather has meant that we have only limited data. Nonetheless, the very good performance of PlanetPol gives us confidence that we can determine the polarisation signature of the hot-Jupiter EXPs.

There are also several other observational programmes that will be possible with PlanetPol, with its very high sensitivity. Of course, very high sensitivities require large numbers of photons with a fractional polarisation of 1×10^{-6}, requiring 2×10^{12} detected photons.

Some possible programmes are:

– the distribution of dust in the local ISM,
– oblateness of rapidly rotating stars,
– star spots on active stars,
– debris discs around young main sequence stars. ¤

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An Updated View of the Light Pollution at the Roque de Los Muchachos Observatory

M. Pedani (Fundación Galileo Galilei)

The Sources of Light Pollution at La Palma

The Observatorio del Roque de Los Muchachos (ORM), located at La Palma in the Canary Islands is actually the largest European Observatory in the northern hemisphere. The site benefits from good sky transparency, high fractions of clear (~70%) and photometric nights (~60%) and a mean seeing of 0.76" (Muñoz-Tuñón et al., 1997). An inversion layer in the 1300–1700 m height range, guarantees (though with many exceptions in winter) stable observing conditions during 3/4 of the year. About 85,000 people live in La Palma, mainly concentrated in 8 small towns within 15 km of the ORM. Given the altitude of the ORM, the line-of-sight over the sea has a radius of ~180 km, enough to intercept the lighting of the major Canary island Tenerife (800,000 people and 120 km distant) whose coast is visible to the naked eye on very clear nights. Nevertheless, its contribution to the sky brightness, as well as that of two small islands, (El Hierro and La Gomera, 29,000 people and 40 km distant) is negligible. In many cases, the presence of the so called "sea of clouds" below the thermal inversion layer, greatly reduces outdoor lighting, especially during the coldest months.

The Canary Sky Law, introduced in 1992 (McNally, 1994) put strict limits on the type of lamps which can be used for outdoor lighting, on their power, and on orientation with respect to the ground and implied that, after local midnight, most of the high-pressure sodium (HPS) and mercury lamps must be extinguished, as well as all the discharge-tube illumination. In general, low-pressure sodium (LPS) lamps should be used except in the urban areas where HPS lamps are admitted and a non-negligible fraction of mercury and incandescent lamps still exist.

LPS lamps are the best choice for astronomy because their emission is almost exclusively concentrated in the NaD $\lambda\lambda$ 5890–6 doublet, which simply adds to the natural sky glow at these wavelength. No continuum emission arises from these lamps. Other emission lines are Na I $\lambda\lambda$ 5683–8 and Na I $\lambda\lambda$ 6154–61, the latter about 4 times weaker than the former. Detecting the above lines in the sky spectra permits the contributions to the NaD 5890–6 emission from light pollution and the natural sky glow to be disentangled. Up to now, the only way to measure the natural NaD skyglow at ORM was during an artificial 1 hour blackout on the night 24–25 June 1995 to celebrate the 10th anniversary of the inauguration of the ORM (see Benn & Ellison, 1998 for details).

The HPS lamps are the second contributor in terms of light output on La Palma. Their emission is characterised by a smooth continuum in the ~5500 to 7000 Å range. The NaD $\lambda\lambda$ 5890–6 line, is now replaced by a deep void. Other narrow emission lines are: NaI $\lambda\lambda$ 4665–9, NaI $\lambda\lambda$ 4979–83, NaI $\lambda\lambda$ 5149–53, NaI $\lambda\lambda$ 5683–8 and NaI $\lambda\lambda$ 6154–61.

Mercury lamps, though they contribute with a mere 9% to the total luminous flux of the island are another important source of light-polluting lines, especially in the violet/blue region of the spectrum. There is also a weak continuum emission in the 3200–7800 Å range. The most important lines observed in our spectra are: HgI λ 4046, HgI λ 4358, HgI λ 5461, HgI λ 5769 and HgI λ 5790.

Incandescent lamps are a significant source of light pollution before midnight, though their solely continuum emission is not considered in the present work. Nevertheless, BE98 estimated their contribution to zenith sky brightness at *V*-band to be 0.01 mag.

At La Palma, light pollution originates from 17,166 street lamps (end of year 2000, 23% more than reported in BE98) emitting a total of 1.56×10^5 klumens before midnight, reduced to 1.0×10^5 klumens after that hour. If we consider that about 50% of the light is emitted by the fixtures and the ground reflectivity is assumed 10%, we calculate that the amount of power emitted upward by the outdoor lighting is ~16 W/km^2 before midnight and ~11 W/km^2 after. It is noteworthy that the typical sky background of $V = 21.9$ mag/arcsec^2 corresponds to ~9.2 W/km^2.

Observational Data

Our sky spectra were obtained from archival science frames taken in the period August-December 2003 with the 3.58 m Telescopio Nazionale Galileo at La Palma using DoLoRes (Device Optimised for Low Resolution), equipped with a 2048×2048 pixel thinned back-illuminated CCD with 15 μm pixels. Only spectra taken with the LR-B Grism were considered, with a final wavelength coverage of ~3800–8000 Å. The slit widths used were 1.0" and 1.3", yielding a resolution of 2.8 Å/pix and 3.6 Å/pix respectively. Wavelength comparison lines were obtained with a Helium lamp at the beginning of each night. For the present study, only deep exposures taken with airmass < 1.3 during photometric, moonless nights with low extinction were selected. After a careful visual inspection, those spectra showing very similar content of light

Line	Group1	Group 2	Group 3	Group 4	Group 5	Group 6
Hg I λ4046	3.4	5.2	9.5	6.1	10.2	6.3
Hg I λ4358	5.6	7.9	22.0	17.6	14.2	4.5
N I λ5199	1.5	15.4	3.2	11.2	5.1	3.1
Hg I λ5461	4.4	5.5	25.7	10.9	8.6	4.7
O I λ5577	310	256	303	234	447	504
Na I λ5683–8	3.5	6.3	30.6	9.5	11.4	3.6
Hg I λ5769	*n.d.*	*n.d.*	7.2	*n.d.*	1.9	1.4
Hg I λ5790	*n.d.*	*n.d.*	4.7	*n.d.*	1.7	0.7
NaD λλ5890–6	189(156)	148(89)	658(431)	284(134)	251(162)	270(161)
Na I λλ6154–61	*n.a.*	*n.d.*	9.5	*n.a.*	9.6	*n.a.*

Table 1. Fluxes of the most important emission lines as measured in our spectra. Values are in R (rayleigh, see BE98 for some useful conversion formulas). When not detected, a line is labeled with "n.d."; if the line was too noisy/faint or either blended with another line, it is labeled with "n.a.". Contribution to NaD λλ5890–6 from light pollution is shown in parentheses.

pollution lines were aligned and co-added to build six template spectra (hereinafter groups). These groups span a wide range in azimuth, epoch of the year and observing conditions, crucial to disentangle environmental and seasonal effects. As reported by BE98, we also found noticeable night-to-night variations in the intensity of the light pollution lines; this could be due to the presence of clouds below the ORM, blocking most of the outdoor lighting. To reduce the errors on the final line fluxes, we decided to include in the same group only those spectra whose NaD λ5892 line fluxes differed by no more than 30%. In particular, the spectra with the highest Na line fluxes (less cloud cover) were considered.

NaI Lines – Natural and Artificial Contributions

Given the population of lamps at La Palma, the Na I lines are by far the most important sources of light pollution at ORM. BE98 reported a median equivalent width of NaD λ5892 of ~100 Å (~100 R, 1 R ≡ 10^{10}/(4π) photons s^{-1} m^{-2} $ster^{-1}$) during summer, of which ~70 R due to outdoor lighting and ~30 R due to the natural skyglow. The natural NaD skyglow is known to have a strong seasonal variation, going from ~30 R in summer to ~200 R in winter (Schubert & Walterscheid, 2000). A noticeable effect we found in our spectra is the decrease of the Na and Hg lines in the spectra taken after local midnight, when most of the HPS and mercury lamps are switched off, according to the Canary Sky Law.

To disentangle the natural and artificial contributions to the NaD λλ5892–6 emission we used our Group 5 and 6 spectra taken respectively before and after midnight. Note that no seasonal effect is present since both of them were taken at the end of September 2003. We assumed that all the Na λλ5683–8 flux of Group 6 is due to LPS lamps while that of Group 5 is the sum of LPS and HPS contributions. Thus the fractional contribution of LPS to NaI λλ5683–8 emission of Group 5 is 3.6/11.4=0.32 and that of HPS is 0.68. From the Philips catalogue of lamps we derived the ratio NaD λλ5892–6/NaI λλ5683–8=44.6 for the SOX LPS 35W lamps mostly used at La Palma. For Group 6 we calculate that light pollution from LPS lamps contributes ~3.6×44.6=161 R to the NaD λλ5890–6 flux; Group 5 has an identical value since LPS lamps are never switched off during the night. We deduce that at the end of September 2003 the natural NaD λλ5892–6 skyglow at ORM was ~90–100 R.

We also tried another approach to verify our assumptions about the fluxes of Na I λλ5683–8 for Groups 5 and 6. The ratio of the illumination contribution of HPS vs. LPS lighting in La Palma is ~0.48. From the Philips catalogue of lamps, as most of the HPS lamps at La Palma are SON-T 70W, we calculate that the flux of NaI λλ5683–8 emitted by a LPS lamp is 0.38 times that emitted by a HPS lamp. Thus, for Na I λλ5683–8 of Group 5 we obtain that 3.4 R are from LPS lamps and 8.0 R are from HPS lamps. These values are in very good agreement with those obtained above by simply assuming that all the flux of NaI λλ5683–8 in Group 6 (3.6 R) comes from LPS lamps.

Group 1 (see Figure 1) is our longest exposure spectrum and well represents the average observing conditions at ORM after midnight when looking at ±5 hrs from the meridian. The first important difference from BE98 is that we now clearly detect NaI λλ5683–8 emission, while Na I λλ6154–61 is still undetected. Moreover, the Group 1 spectrum shows that the average contribution of light pollution to the NaD λλ5892–8 flux in the southern regions of sky after midnight is ~150 R, about twice the value measured in 1998.

Group 2 (see Figure 1) is interesting because it was taken towards the NW, a zone with relatively low light pollution as confirmed by the lowest contribution of artificial NaD λλ5892–8 detected in our spectra (89 R). With respect to Group 1, the higher flux of NaI λλ5683–8 is due to the fact that Group 2 was taken before local midnight.

Group 3 has light pollution lines with abnormally high fluxes (see Figure 1). It was taken looking in the direction of the most polluting towns of the island, before midnight and with thin clouds above the ORM (no data are available for the atmospheric extinction). A direct estimate with the above explained procedure of the artificial contribution to the NaD λλ5892–8 gives 431 R, which would result in a natural NaD background of 227 R, somewhat higher than expected at the end of October. In this case, the presence of high clouds could have played a role in reflecting back light pollution to the observatory.

Group 4 is a typical spectrum taken looking toward a moderately polluted

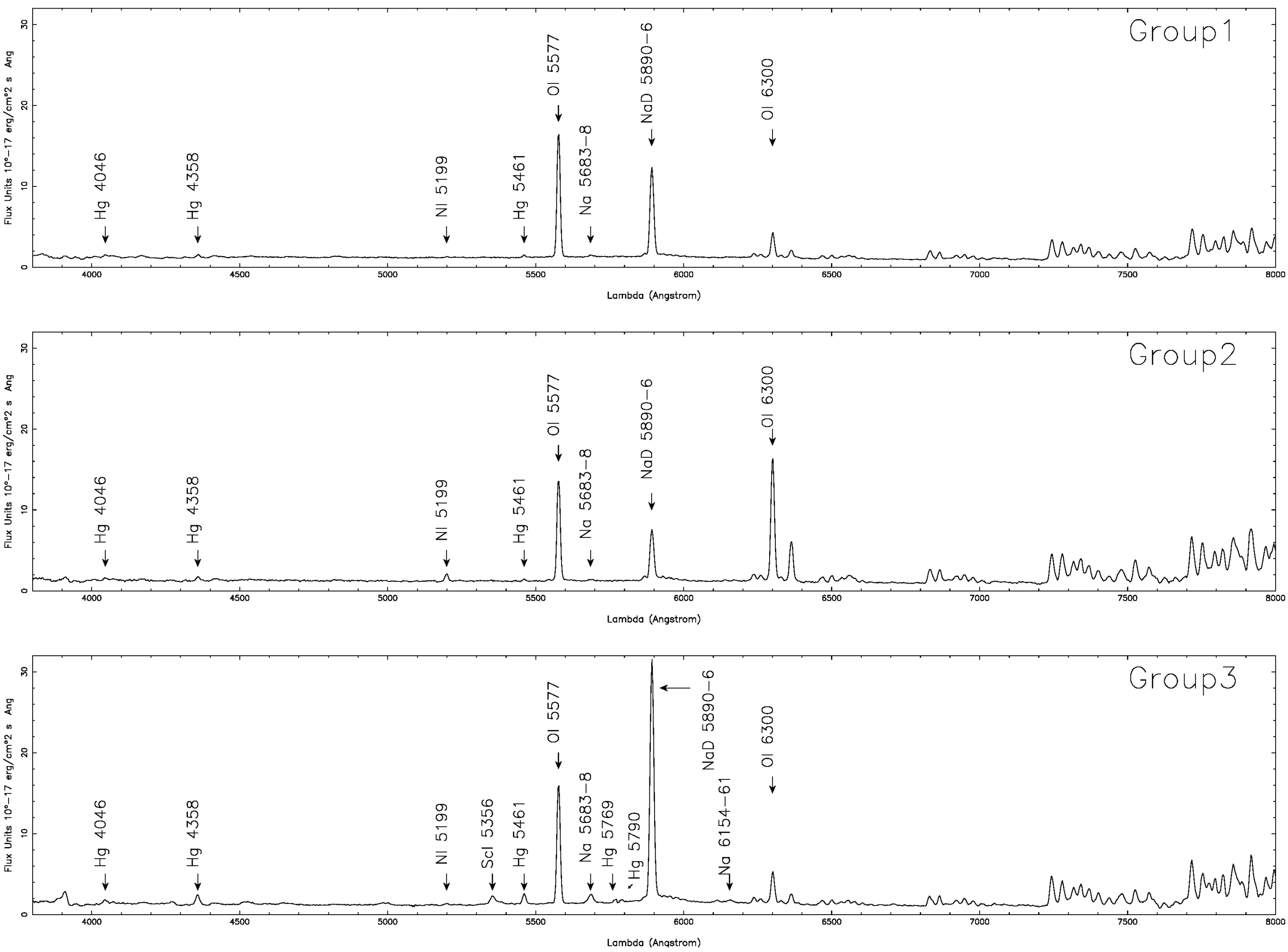

Figure 1. The night-sky spectra. The Group 1 (4 hrs total exposure) is the average of 8 spectra and best represents the average observing conditions at ORM. The Group 2 spectrum was taken towards the NW, the least light-polluted zone at ORM. The Group 3 spectrum was taken towards the most light-polluted region of sky at ORM, before midnight. The presence of thin clouds could explain the abnormally high fluxes of the light polluting lines.

region of sky, ~2 hrs before meridian. Here, the effects of the two urban areas of Breña Alta/Breña Baja and partly of Santa Cruz de La Palma are evident. The higher-than-average levels of the Na lines (note the NaI λλ 5683–8 flux of 9.5 R) are also due to the fact that it was taken before midnight. We estimate the contribution of light pollution to the NaD λλ 5892–8 to be 134 R.

The above discussed Group 5 and Group 6 are typical spectra taken at the meridian where the line of sight intercepts the town of El Paso. The decrease of the Na lines fluxes is evident in Group 6, taken after midnight. The contribution of light pollution to the NaD λλ 5892–8 is ~160 R, similar to that of Group 4 and Group 1. In all our spectra, the fluxes of the NaD λλ 5892–6 line are always 1.5–2.5 times higher than those of BE98. In principle this indicates that light pollution due to LPS and HPS lamps considerably increased in the last 5 years at La Palma, despite the efforts made to control it.

HgI Lines

If we consider Group 1, the emission of the lines HgI λ 4358 and HgI λ 5461 is about half that reported in BE98 but our spectrum also shows the line HgI λ 4046 detected for the first time at ORM and with intensity comparable to HgI λ 5461.

Although the Group2 spectrum was taken in a less polluted region of sky, it has ~40% more Hg emission than Group 1 and half the Hg emission of Groups 4 and 5 taken toward two towns before midnight. This demonstrates the benefits of the Canary Sky Law; observations made in the less polluted region of sky before midnight imply higher fluxes of Hg lines than those made toward a more polluted region but after midnight.

The most striking feature in our spectra is the line detected in Group 3 (see Figure 1) at 5355.5 Å which we identified as Sc I (tabulated λ is 5356.09 Å, see Table 6 of Slanger et al., 2003). Sc is used as an additive to high-pressure metal halide lamps. Since on La Palma these are used only in the soccer stadiums (to be extinguished after 23:00), our detection could have coincided with some nocturnal sporting activity. The line at 5351.1 Å detected in Group 4 (see Figure 2) can also be identified as ScI emission (tabulated λ at 5349.71 Å). The Group 3 shows other two lines never detected before at ORM: HgI λ 5769 and HgI λ 5790, only observed

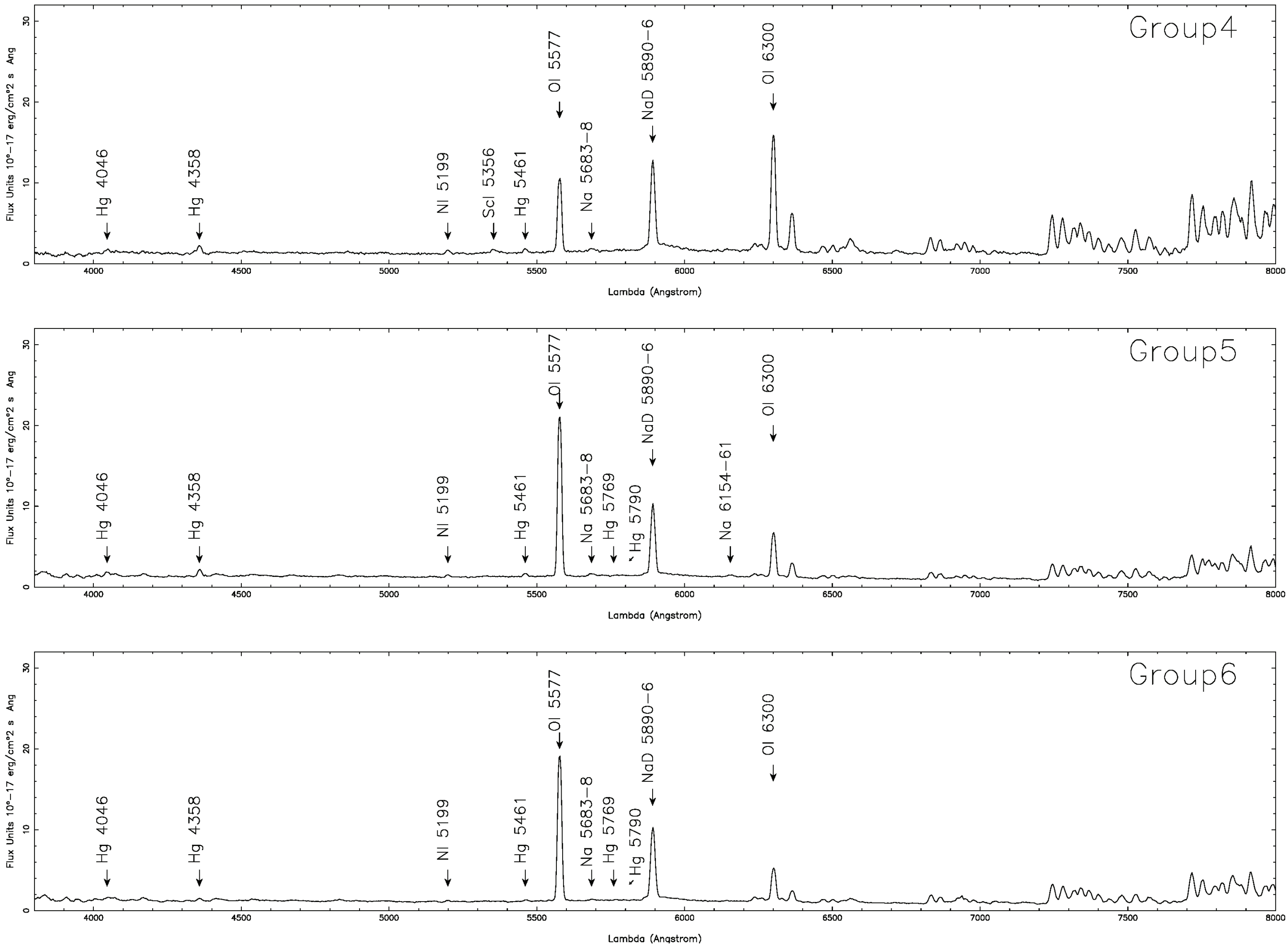

Figure 2. The night-sky spectra. The Group 4 spectrum was taken toward a moderately polluted region before midnight. The Group 5 spectrum was taken toward the meridian before midnight. The Group 6 spectrum was taken toward the meridian after midnight.

at Mount Hamilton (Slanger et al., 2003) and Kitt Peak (Massey et al., 1990). Though very faint, these lines also appear in our Groups 5 and 6, with a clear dimming after midnight evident in the latter spectrum.

To conclude, the average fluxes of the Hg lines detected in our spectra are ~50% fainter than those reported in BE98. When observing toward a town, the Hg lines have about the same intensities as in 1998. Our directional spectra show for the first time the effect of the application of the Sky Law after midnight but it is evident that Hg lamps are never completely extinguished after that hour, since Hg lines are present in all our spectra. For a typical town like El Paso (see Groups 5 and 6), we infer that only half of the mercury lamps are extinguished after midnight. At La Palma, the average intensity of the NaD λλ5892–8 line emitted by LPS lamps increased by a factor of 1.5–2 over the last 5 years and its contribution to the sky background is 0.05–0.10 mag at *V*-band and 0.07–0.12 mag at *R*-band, depending on the region of sky and the time when observations are made. The IAU's recommendation that NaD λλ5892–8 emission should not exceed in intensity the natural background, is definitely no longer met. Na lines such as NaI λλ5683–8 and NaI λλ6154–61 were also detected in our spectra for the first time. Light pollution from Hg lamps is ~50% lower than in 1998, except when observations are made looking toward the towns, before midnight; in this case we found very similar levels. Though in non-optimal atmospheric conditions, we detected in Group 3 one strong line which was identified as ScI. This element is used as an additive in high-pressure metal halide lamps which, to our knowledge, are only used in the soccer stadiums on La Palma. The presence of this type of lamp on La Palma is confirmed by another line at 5351.1 Å detected in the Group 4 spectrum which can also be identified as Sc I emission. ¤

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OTHER NEWS FROM ING

Joint ING and NOT Conference: Second Meeting on Hot Subdwarf Stars and Related Objects

Together with the Nordic Optical Telescope, the ING is organising a meeting with the title "Hot Subdwarf Stars and Related Objects", to be held on La Palma from the 6 to 10 of June this summer. The conference venue is the Real Club Náutico of Santa Cruz de La Palma, and it will be the first major astronomy conference to be held in the home town of the ING's sea-level offices.

Financial support has been given by the organisers, the Excmo. Cabildo Insular de La Palma (local government) and the Patronato de Turismo de La Palma (tourist board). Additionally the Real Club Náutico has been extremely helpful by making their facilities available to us at no cost.

This conference is the second meeting on hot subdwarf stars, a new biennial series that was started at Keele University in 2003. It is an offspring of the long running White Dwarf meetings, which counted their 14th meeting last year. The intention is that the Subdwarf meetings will also run every second year, in the odd years between the WD meetings. The aim of the workshop series is to disseminate recent results on the properties, formation, and evolution of the hot subdwarf stars and related objects, and to assess the impact of these results on other areas of astrophysics.

Hot subdwarf stars are extreme horizontal branch (EHB) stars and pre-white dwarf stars. The EHB stars are core helium-burning stars with extremely thin hydrogen envelopes, and form the majority of bright stars in surveys for extremely blue objects, where they are classified as subdwarf-B (sdB) stars. They also appear in the colour-magnitude diagrams of some globular clusters as an extension of the blue tail formed by classical horizontal branch stars, though it is not clear why some clusters show this feature and others do not. The pre-white dwarf stars are related to the sdBs, but have exhausted their capacity to burn helium in the core. Many of the brightest hot subdwarfs in the field are of this class, and they are classified as sdO stars.

Topics for the meeting includes: Evolutionary models and the UV-upturn phenomenon; hot subdwarfs and hot HB stars in the field, clusters and galaxies; hot subdwarfs in binary systems; atmospheric properties of hot subdwarf stars; asteroseismology of sdB stars, and progenitors and progeny of sdB stars.

The capacity of the conferences is limited by the size of the available facilities to about 90 people. More information can be found on the ING web-pages, at http://www.ing.iac.es/conferences/subdwarf/. The registration is open until April 1. ¤

Roy H. Østensen on behalf of the Local Organising Committe (subdwarf@ing.iac.es)

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The Travelogue of an Astronomer*

S. Hameed (Astronomy Department, University of Massachusetts)

*: Article published in the Pakistan newspaper 'Dawn' on 17 October 2004.

Roughly 3 million years back, a series of volcanic eruptions raised a huge mass of land to a height of over 3000 meters. The primary volcano lost its fight to gravity and eventually collapsed 500,000 years ago to form a huge caldera. Today this is the most dominant feature on the island of La Palma in the Spanish Canary Islands, located in the Atlantic Ocean off the coast of Morocco. The rim of the caldera is now populated with instruments designed to answer some of humanity's most profound questions about our place in the universe. Three million years of landscaping has provided astronomers an ideal place to gaze at the heavens.

I was awarded 4 nights to use the 2.5 meter Isaac Newton Telescope, one of the ten telescopes located at La Palma. The size denotes the diameter of the main mirror of the telescope; the bigger the mirror the more powerful is the telescope. The 10 meter Keck telescope is the largest in the world and is located in Hawaii.

My journey started from Amherst, Massachusetts. I packed my observing notebook in the backpack along with other travel essentials, and just like my passport and my toothbrush, I was not going to let it separate from me at any cost. In order to get to La Palma, I had to fly first from Boston to Madrid, then from Madrid to the island of Tenerife, and finally on a small propeller plane to La Palma. Observatories are usually located in such remote and exotic locations because astronomers seek places that have little or no light pollution, are high-up on the mountain and are close to the ocean. The tall peaks of the mountains provide the necessary dry conditions and the ocean smooths the air that, as a result, improves the quality of the pictures taken through the telescope. Thus, volcanic islands, like La Palma and Hawaii, are some of the world's best locations for astronomy and provide astronomers an excuse to visit these visually stunning places.

Before getting to La Palma, I spent a night in Tenerife. I was expecting Tenerife to be a small sleepy island geared solely for entertaining tourists from western Europe. While tourism is indeed one of its main industries, Tenerife turned out to be a busy port with a population of over half a million. I stayed in a small university town, La Laguna, located roughly 6 km from the capital city of Santa Cruz. It was in Santa Cruz I learnt that, despite its remote location, Tenerife has played its role in history. The legendary British naval officer, Lord Nelson (1758-1805) or better known as Horatio Nelson, lost his arm in the battle for Tenerife in 1797. The guilty cannon has been preserved and is now one of the tourist attractions on the island. Horatio Nelson survived the cannon shot, but died at the hands of a French sniper in the battle of Trafalgar in 1805. I don't know what happened to the rifle of the sniper, but the Trafalgar Square in London can be seen as a memorial to the war achievements of Lord Nelson.

Tenerife also has a footnote in relatively recent Spanish history. General Franco, who was in exile on the island, flew from Tenerife to take control of Spanish troops in Morocco, an event that started the bloody Spanish civil war in 1936, leading ultimately to the Fascist victory in 1939.

After staying overnight in Tenerife, I flew to La Palma on a small plane that braved the winds of the Atlantic ocean. Even though the flight lasted only 20 minutes, the turbulence made it seemed much longer. Perhaps this is the only occasion when I not only paid attention to the instructions given by the air-hostess regarding life-jackets, but also read additional material on plane safety and escape routes. At La Palma airport I was relieved to see a smiling taxi driver holding a sign of the telescope with my name on it.

La Palma is a small island with a population of roughly 80,000. This volcanic island is the youngest amongst the Canary Islands and is still geologically active. I don't think I felt completely reassured to know that the last major volcanic eruption on the island occurred in 1971. The landscape of the island is dominated by the Caldera of Taburiente, formed by the collapse of the primary volcano. The rim of the caldera, roughly 10,000 feet above sea level, was my destination. The road up the mountain had endless twists and turns and the landscape changed dramatically in the hour long drive from the airport to the observatory. The sight and sound of waves crashing on the beach gave way to our passage through a forest of dense pine trees leading up to an almost barren top. Reflection of sunlight from one of the telescope domes provided the first greeting from the observatory and the secrets of the night sky seemed safely hidden in the stunningly beautiful dark-blue sky.

The taxi dropped me at the residential area for astronomers which is like a small hostel with a cafeteria. My telescope was located a few kilometres away but I could see its dome from the window of my room. I was given keys to a car and my first afternoon was spent checking instruments at the telescope. Everything was ready now. All I had to do was wait for the Sun to go down.

Meal times at observatories are dictated by the Sun. Dinner is usually served 2 hours before the sunset. Fish was on the menu for the first night. I got my plate and looked for a table with English conversation; this is usually the table of astronomers. It is exciting to meet astronomers from all over the world and to learn about their research. The astronomer sitting next to me had flown from England and was working on galaxies that formed when our universe was "only" a billion years old. A Dutch astronomer was searching for exploding stars in nearby galaxies, while giant eruptions from stars was the interest of another. The conversation at dinner ranged from the latest science results to politics and local culture. Now we were all ready to go to our respective telescopes.

After dinner I waited outside for the sky to get dark. My mind wandered off thinking about the indigenous people that lived here several centuries ago and how they would have looked up and interpreted the sky. La Palma (and the other Canary Islands) were first settled by native Canarians, called Guanches, whose origin is still controversial. Guanches are now extinct, but are thought to be an offshoot of the race of Berbers from northern Africa. The Spanish conquest of the Canary Islands began in 1402 and went on until 1496. Despite having enormous technological advantage, the Spanish Conquistadors faced stiff resistance from the natives, in particular from legendary Tanausú, who ruled the Kingdom of Aceró on the island of La Palma. Tanausú fought from the base of the Caldera and was finally defeated with treachery in 1493. The sight of a majestic sunset brought me back to the present. Earth's rotation was taking the rays of the Sun away from the Earth. A layer of clouds could be seen covering the ocean below us. Like the eyes of a giant but curious beast, I could see the slits of the neighbouring telescope domes open up.

I pointed my telescope first at a galaxy named NGC 210, the two hundred and tenth object in the New General Catalogue of galaxies. Apart from a few nearby galaxies, most galaxies have numerical numbers assigned to them. Still, that does not take away the majesty of an individual galaxy containing roughly a hundred billion stars. I am searching for new born stars in some of these galaxies. My journey to the Canary Islands took only two days from Massachusetts, but the light photons hitting the mirror of the telescope, in the case of NGC 210, started their journey 60 million years ago. The light has taken so long to get to us that some of the stars are probably already dead but we are just getting the news of their birth. After taking several images of NGC 210, I turned my attention to NGC 660 followed by other galaxies.

The first night goes smoothly, and my work is interrupted only by the increasing brightness of the sky due to dawn. I close off the telescope dome and walk outside to look at the caldera. Inside the caldera stands the monolith Idafe, an altar for the original indigenous people to worship their god Abora. I could not help but wonder if, in our quest to understand our origins, the telescopes are the new altars for humanity. ¤

News from the Roque

At the time of writing, the 10-m GTC telescope, the flagship project at the Roque de Los Muchachos Observatory, continues to make very good progress. As can be seen from the web cameras on the GTC's web page (`http://www.gtc.iac.es/webcam_s.asp`) the main telescope structure is essentially complete and many of the mirror segments have already been received. The year 2005 will be an important one for the GTC project, as the telescope will be prepared to receive the first photons.

The GTC project will also have a base at sea level in a brand new building, the Centro Astronómico de La Palma (CALP), which is nearing completion at the time of writing. The GTC offices are located in Breña Baja, only a few kilometres from the main town of Santa Cruz. We hope that the short distance between the Mayantigo building and CALP will help foster close collaboration between the various observatory groups.

Left: Progress on GTC Telescope, picture grabbed from internal webcam on 25 February. Right: Picture of CALP base.

The Liverpool telescope has had its first robotic observations last year. Following an upgrade to the hydraulic system for the enclosure, the telescope will be fully ready for regular operation.

A long-standing item on the wish-list of the observatory has been the construction of a visitor's centre where the public can receive information about the functioning of the observatory, amongst other things. The growth in tourism and the resulting increase in numbers of visitors to the observatory has made this even more important in recent years. Latest progress is that land a little down-hill from the observatory has been made available for the construction of a visitor's centre. This important step may well mean that such a centre will become reality not too long from now.

The fact that the Canary Islands are not always blessed with sunny skies is indicated by the adjacent pictures, taken during one of the severe snowy periods that this winter has produced. We're contemplating adding skis to the standard observatory outfit. ¤

René Rutten (rgmr@ing.iac.es)

Views of the snown observatory. From top to bottom: An ING´s car almost covered by snow (credit Juan Carlos Pérez); View of Fuente Nueva site from JKT´s internal live camera; Panoramic view from nitrogen plant (credit Jürg Rey).

WINT: Observing Time Awarded to High School Students from The Netherlands

N. Douglas (Kapteyn Institute, University of Groningen)

Students at the INT control room during WINT observations.

As well as extending the borders of our knowledge of the universe, one of the tasks of Astronomy is to communicate these efforts to the public and to encourage the emergence of the next generation of astronomers. The Dutch graduate school "NOVA" recently organised "WINT", a competition amongst high school students throughout the Netherlands. At stake for the forty or so contestants, from which four winners had to be selected, was a trip to La Palma and share in two nights of observing time with the Wide Field Camera at the 2.5m INT (the name of the project means "winning" in Dutch, as well as being the acronym for "observing time at the INT").

The proposals were diverse, ranging from popular targets such as planetary nebulae to challenging observations such as the smaller moons of Saturn and minor planets. The main selection criteria were that the proposals should be well researched and that the observing parameters had been checked, as well as that data would be obtained which could be used for exercises in the classroom later.

The winners were Caroline Straatman who was interested in the stellar colours arising from galaxy collisions, Max Verhagen who wanted to obtain images and colours of the stars and nebulosity in the Pleiades, Evelien Dam who wanted to recover the smaller moons of Saturn, and Suyan Zhang who wrote the best case for the Owl Nebula, a popular target. We also allocated secondary programs for each of the school students, to be done if time allowed and, in the case of Evelien's project, to allow for the evident difficulty of her prime target. The winners were all (near) school leavers of age 16–18. Accompanying them were two students of Astronomy from the University of Groningen, Else Starkenburg and Jakob van Bethlehem, myself, and a science reporter. Prof Peter Barthel and Jacques Visser provided organisation and logistical support in the Netherlands.

The prize included a guided tour of the island, visits to some of the observatory facilities, and observing on February 24 and 25. By chance, the first night coincided with an occultation of a star by a minor planet, the narrow footprint of which passed through the Canary Islands! A webcam was set up to allow the "folks back home" to follow the action and to contribute suggestions via an interactive forum.

The weather on arrival at La Palma was poor, and this hindered the sightseeing trip somewhat, the the extent of the problem only becoming apparent when we were denied access to the mountain for the first night of observing (immediately ruling out the occultation). This type of decision is not taken lightly, as was confirmed the next day when we drove up to the observatory in a convoy of (unusually slow) taxis. We were confronted with scenes of chin-high snow dunes, heavy clearance machines, bitingly cold winds, and a generally pessimistic feeling about the prospects of observing on this, our second and last night. ING, sensing this also, had started to open the door to partial use of a third night.

In the end, and to everyone's relief, we did in fact observe throughout the entire second night, despite the imminent danger of the wind forcing the dome to close. Data was obtained for all projects and we were even able to put some preliminary results on the website, which was designed by another student in Groningen, Christiaan Boersma. A victim of our own success, the webcam could not handle the number of hits and failed at the moment supreme, but we continued to receive messages of support and excitement from home base. The data is bound to keep a large number of Dutch school children busy in the coming weeks.

After a few hours sleep in the Residencia we learned that the weather had again taken a turn for the worse and were further impressed when we spotted what appeared to be a royal decree referring to the danger of high winds. Due to fly back to the Netherlands early the next day, we decided that risk of becoming stuck on the mountain was too much to ignore, despite the enticement of further observing. Thus, we returned to sea level by way of a two-and-a-half hour taxi ride in poor conditions, only to hear rumours that many flights from La Palma had been cancelled. I will spare the account of chaos at the overstretched airport at La Palma, but in the end we arrived back in Amsterdam nearly two days later than planned. The first newspaper articles had begun appearing, and the WINT project, we learned, would feature the coming weekend in a national newspaper, as well as in a radio program to be compiled from audio material gathered by the reporter who had accompanied us on the trip.

Despite the weather-related setbacks and delays, our little group continued throughout to bask in the satisfaction of having visited the observatory and having used the powerful Isaac Newton Telescope for a whole night, under circumstances which came very close to us not even being able to leave sea level during the entire trip. We enjoyed each other's company, and I was moved by the first new message to appear on the website following our return, written by Max, one of the participants: "I miss La Palma already..." Truly, we did our share to guarantee the emergence of the next generation of astronomers! ¤

Nigel Douglas (ndouglas@astro.rug.nl)

Visits to ING

A total of 860 visitors split in 42 tours were shown round the WHT and occasionally the INT from September 2004 to January 2005. In total 203 official tours were organised and 5656 visitors shown around in 2004, including Open Days. Visitors included the general secretary of the Swedish Royal Academy of Sciences and Ireland's embassador in Spain. The television programme 'Redes' of Spanish TVE and the series 'Schrödingers Katt' of the Norwegian NRK TV were filmed, and the programme series 'Un Programa Estelar' comprising six chapters filmed in 2003 was shown on the Spanish TVE2 channel twice. From 8 to 14 November the Spanish Education and Science Ministry and the IAC celebrated the European Science Week on La Palma. As part of the activities, an excursion to the observatory was organised in collaboration with the Public Outreach group of OPTICON (accompanying photos). ¤

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Amateur Awards

In 2004 two people working or collaborating with ING were awarded with important amateur distinctions. Mischa Schirmer, ING support astronomer, was awarded a special mention (telescope category) for his photographs of NGC 2246, M33 and NGC 7023 at the first national astrophotography competition "Fotocósmica 2004"organised by the IAC. All the awarded photographs were taken at sea level a bit south of Santa Cruz de La Palma. The telescope was a 20 cm f/3.8 (760 mm focal length) Flat Field Camera ("FFC") from Lichtenknecker Optics. More information on the individual photographs can be found at `http://www.astro.uni-bonn.de/~mischa/mbo/gallery_ccd/`.

Nik Szymanek, an amateur astronomer in the United Kingdom who collaborates with ING in public outreach activities (see, for instance, *ING Newsl.*, **6**, 29), was the 2004 recipient of the Astronomical Society of the Pacific's Amateur Achievement Award. Given annually since 1979, the Amateur Achievement Award is designed to recognise significant contributions to astronomy or amateur astronomy by those not employed in the field of astronomy in a professional capacity. The Society's Board of Directors noted Szymanek's leadership in state-of-the-art imaging and image processing —especially his true-colour, deep-sky images produced from the data obtained by observers at ING— and his ongoing contributions to education and public outreach. ¤

Javier Méndez (jma@ing.iac.es)

Seminars Given at ING

Visiting observers are politely invited to give a seminar at ING. Talks usually take place in the sea level office in the afternoon and last for about 30 minutes plus time for questions afterwards. Astronomers from ING and other institutions on site are invited to assist. Please contact Danny Lennon at `djl@ing.iac.es` and visit this URL: `http://www.ing.iac.es/Astronomy/science/seminars.html`, for more details. These were the seminars to 1st of March:

Feb 18. Hugo Schwarz (CTIO/NOAO/AURA), "The SOAR telescope is nigh!".

Dec 1. Santi Cassisi (Osservatorio Astronomico di Collurania in Teramo), "Hot Stellar Populations in Galactic Globular Clusters: The population(s) puzzle goes deeper".

Nov 22. Sonia Fornasier (Astronomy Dep. of Padova University), "Physical Studies of Minor Bodies".

Aug 10. Angelo Antonelli (INAF-Osservatorio Astronomico di Roma, Italy), "Gamma Ray Bursts in the SWIFT Era".


Left: Awarded photograph of NGC 2246, the Rosette Nebula by Mischa Schirmer. The image was obtained through an Hα filter on a 2×2 mosaic of 21 images totalising an exposure time of 3 hours and 30 minutes. Right: Picture of the WHT taken by Nik Szymanek with a digital camera.

TELESCOPE TIME

Applying for Time

Danny Lennon (Head of Astronomy, ING)

Over the years the instrument suite at the WHT has changed many times. One constant in all these changes is that our intermediate dispersion spectrograph ISIS continues to win the largest share of the observing time across all our three TACs. It's therefore good to see some improvements coming to this venerable instrument. The past 6 months have seen the commissioning of a new dichroic beam splitter, and initial tests indicate that the infamous ripples which plagued the old dichroic set are substantially reduced. Throughput in both blue and red arms is improved, while the response of the new blue fold mirror is also substantially better than before (details may be found on the ISIS web pages). This is the only dichroic which will be offered in service mode, and will be the default dichroic offered to visiting observers unless an alternative is specified. It is expected that the older dichroics will be phased out of use pending feedback from users.

We have also commissioned the new ISIS TV slit viewing camera, discussed in the article by Simon Tulloch in *ING Newsletter*, **8**, 20. This camera is based on a Peltier cooled frame transfer CCD, and can be controlled in much the same way as any other CCD at the ING. Besides offering better image quality and improved ease of acquisition for ISIS it offers the additional advantage that one can now take an acquisition image of the slit during a science exposure. Finally during the coming year we expect to see the image slicer commissioned on ISIS, this will have a 2 arcsec entrance aperture and a 0.5 arcsec sliced output image, nicely matched to the optimum resolution of the ISIS CCDs.

The digital media storage landscape continues to change very rapidly, which is just as well given the increasing rate of data acquisition in astronomy. A number of survey programmes using the WFC on the INT have highlighted this issue recently due to their extremely high data rates (and short exposure times), and the ING now has a provision to allow users to copy their data to external firewire discs. If users can demonstrate a clear need for this facility on the INT and wish to avail themselves of the service they should contact Robert Greimel (greimel@ing.iac.es).

Despite some minor teething problems during 2004B, LIRIS continues to perform very well at Cassegrain. We will therefore continue with our policy of only offering LIRIS for use at this focal station for IR imaging (and spectroscopy), INGRID will continue to be used with NAOMI, our natural guide star AO system. OASIS is performing as expected, however it should be noted that with OASIS there is the choice of using the instrument with or without AO correction. Furthermore, during 2005A, we expect to finish commissioning a mode of operation in which only tip-tilt correction is applied, somewhat relaxing the constraint on the magnitude of the guide star while still providing attractive performance in the I-band.

The Director's Message has already referred to the questionnaire which has been released by ING in order to gauge the views of the astronomical community on the future of the observatory. While individual responses are confidential, the overall results will be fed into the ING review process later this year and will have an influence on the future development of ING and its instrumentation suite. For example, the default situation on the future for the WHT is essentially the continuation of the existing suite of instruments, which now comprises optical and IR imaging and spectroscopic capability, multi-object spectroscopy, and adaptive optics (AO) at optical and IR wavelengths. Our ongoing development currently focuses on extending the use of the AO suite through the use of a Rayleigh laser beacon which will dramatically increase the sky coverage and hence the scientific potential of the existing AO system. The INT is currently a single instrument telescope, utilising the Wide Field Camera, and no change in this status is as yet decided upon. It is very important therefore that our users complete and submit the questionnaire if they wish to have their say on the future of ING. ¤

Danny Lennon (djl@ing.iac.es)

IMPORTANT

APPLYING FOR OBSERVING TIME
http://www.ing.iac.es/Astronomy/observing/INGinfo_home.html

DEADLINES FOR SUBMITTING APPLICATIONS

UK PATT
15 March, 15 September

NL NFRA PC
15 March, 15 September
(31 March for 2005B)

SP CAT
1 April, 1 October

ITP
http://www.iac.es/gabinete/cci/

SEMESTERS
A: 1 February – 31 July
B: 1 August – 31 January

OTHER IMPORTANT LINKS

SUBMITTING A SERVICE PROPOSAL
http://www.ing.iac.es/Astronomy/observing/service/service.html

SUBMITTING AN OVERRIDE REQUEST
http://www.ing.iac.es/Astronomy/observing/overrides.html

APPLYING TO USE A NEW VISITOR INSTRUMENT
http://www.ing.iac.es/Astronomy/observing/NewVisitorInstruments.html

APPLYING FOR OPTICON EU FUNDING
http://www.otri.iac.es/eno/

Telescope Time Awards Semester 2005A

The principal investigator, institution or university, title of the programme, and programme reference for every telescope and allocation are listed below. Service programmes are not included. For observing schedules please visit this web page: `http://www.ing.iac.es/ds/sched/`.

ITP Programmes on the ING Telescopes

- Gänsicke (Warwick). Towards a global understanding of close binary evolution. **ITP7**.

William Herschel Telescope

UK PATT

- Ahmad (Armagh Observatory). Parameters of hot subdwarfs of the double-lined spectroscopic binary — PG 1544+488. **W/2005A/46**.
- Bailey (Anglo–Australian Observatory). A high precision polarization survey of bright stars. **W/2005A/10**.
- Blundell (Oxford). A complete spatial and dynamical study of the microquasar SS433. **W/2005A/52**.
- Bower (Durham). The Lyman-α haloes of SCUBA galaxies: exploring super-winds and feedback at z=3. **W/2005A/21**.
- Christian (Queen's University, Belfast). ISIS characterisation of variable stars from the SuperWASP survey. **W/2005A/36**.
- Dobbie (Leicester). A rigorous examination of the evolutionary status of SDSS hot DB white dwarfs within the DO/DB gap. **W/2005A/5**.
- Gänsicke (Warwick). SW, Sextantis stars — totally normal? **W/2005A/31**.
- Hewett (IoA, Cambridge). Imaging of spectroscopically selected gravitational lenses from the SDSS. **W/2005A/19**.
- Hough (Hertfordshire). Circular spectropolarimetry of DIBs. **W/2005A/7**.
- Jarvis (Oxford). Spectroscopic redshifts for the first radio galaxy sample selected at 74 MHz. **W/2005A/8**.
- Keenan (Queen's University, Belfast). The space density of B-type stars in the Galactic halo. **W/2005A/6**.
- Knigge (Southampton). Spectroscopic reconnaissance of candidate emission line stars discovered by IPHAS. **W/2005A/39**.
- Kosroshah (Birmingham). A membership study of the nearest fossil group. **W/2005A/17**.
- Kurosawa (Exeter). The clumpy nature of O supergiant stellar winds. **W/2005A/42**.
- Levan (Leicester). Probing the high redshift universe with GRBs. **W/2005A/53**.
- Lucas (Hertfordshire). PLANETPOL polarimetry of Tau Boo Ab. **W/2005A/20**.
- Magrini (Firenze, Italy). The chemical content of nearby galaxies: GR 8. **W/2005A/29**.
- Merrifield (School of Physics and Astronomy, Nottingham). Determining the dynamics of round elliptical galaxies using the Planetary Nebula Spectrograph. **W/2005A/37**.
- Pettini (IoA, Cambridge). The nature of DLA galaxies traced through spin temperatures: the optical survey. **W/2005A/3**.
- Pozzo (ICL). Late-time study of the very nearby Type IIP SN 2004dj. **W/2005A/13**.
- Tadhunter (Sheffield). Ultraluminous infrared galaxies: quasars and radio galaxies in the making? **W/2005A/1**.
- Tanvir (Hertfordshire). The physics of short bursts and relativistic blast waves. **W/2004B/51 LT**.
- Wilkinson (IoA, Cambridge). Dark matter at the edge of the Sextans dwarf spheroidal. **W/2005A/35**.

NL PATT

- Cappellari (Leiden Observatory). Dark matter in early-type galaxies: stellar line-of-sight velocity-distribution at 5Re using SAURON. **w05an005**.
- Douglas (Kapteyn Institute). Determining the dynamics of round elliptical galaxies using the Planetary Nebula Spectrograph (PN.S). **w05an014**.
- Franx (Leiden Observatory). Infrared spectroscopy of restframe optically red galaxies at high redshift. **w05an006**.
- Groot (Nijmegen). High-resolution eclipse mapping of accretion disks in cataclysmic variables. **w05an004**.
- Helmi (Kapteyn Institute). Building up the Milky Way halo via accretion of small satellites. **w05an017**.
- McDermid (Leiden Observatory). The central black hole in NGC 4486A: measuring the mass and environment with OASIS+NAOMI. **w05an023**.
- Roelofs (Nijmegen). Measuring directly the anticipated tidal deformation of the accretion disk of AM CVn. **w05an012**.
- Wijers (Astronomical Institute, Amsterdam). The physics of short bursts and relativistics blast waves. **w05an013**.
- Wijers (Astronomical Institute, Amsterdam). Probing the high redshift universe with GRBs. **w05an020**.

SP CAT

- Beckman (IAC). Basic properties of the nuclear bars in galaxies with double bar. **W39/2005A**.
- Cairós (IAC). Near infrared mapping of blue compact dwarf galaxies: disentangling the starburst and the old stars. **W33/2005A**.
- Casares (IAC). Determining system parameters of a Soft X-ray transient in outburst. **W1/2005A**.
- Eiroa (Autónoma de Madrid). IMF to the subestellar limit in extremely young pre-main sequence clusters: Serpens. **W14/2005A**.
- González (IAA). Finding an evolutionary link between radio galaxies and very luminous infrared galaxies. **W8/2005A**.
- Gorgas (Complutense de Madrid). The star formation history of elliptical galaxies in different environments. **W52/2005A**.
- Licandro (IAC/ING). The Deep Impact experiment. **W19/2005A**.
- López (IAC). Studying the dynamics and origin of nuclear bars. **W38/2005A**.
- López-Martín (IAC). Identifying and characterising the counterparts to ULXs. **W30/2005A**.
- López-Sánchez (IAC). Star formation zones in starburst galaxies with tidal streams. **W51/2005A**.
- Mediavilla (IAC). Photometric and spectroscopic variability of gravitational lenses. **WL2/2005A**.

– Mollá (CIEMAT, Madrid). Stellar populations in cooling flow cluster galaxies. **W22/2005A**.
– Pérez (Autónoma de Madrid). Propagation of star formation in apparently compact blue galaxies. **W29/2005A**.
– Rodríguez (Vigo). Physical parameters and chemical abundances in hot type O subdwarfs. **W26/2005A**.
– Shahbaz (IAC). The origin of the optical variability in the black hole X-ray transient V404 Cyg. **W50/2005A**.
– Zapatero (LAEFF-INTA). Brown dwarfs around poor metallicity stars. **W21/2005A**.
– Zeilinger (Institute for Astronomy, Viena). Ram-pressure stripping in Virgo cluster galaxies and their extraplanar ionised gas. **W56/2005A**.

Spanish Additional Time

– Balcells (IAC). GOYA deep infrared survey. **W41/2005A**.
– Hammersley (IAC). Visible spectroscopy of the GTC standards. **W31/2005A**.
– Herrero (IAC). Detecting the population of blue massive stars to 5 Mpc for OSIRIS. **W40/2005A**.
– Martín (IAC). A search for brown dwarf candidates in three young open clusters for GTC follow-up. **W3/2005A**.

WHT-TNG Time Share

– Jeffers (Observatoire Midi-Pyrenees, France). Starspot tracking on the W Ursae Majoris system 44 Boo. **W/2005A/24** [on the TNG].
– Quirrenbach (Leiden Observatory). Line bisector variations for K giant stars with possible planetary companions. **w05an001** [on the TNG].
– Trevese (Roma). Investigating the nature of Low Luminosity Active Galactic Nuclei (LLAGN). **T15** [on the WHT].

Instrument Builders' Guaranteed Time

– Bacon (CRAL-Observatoire, Lyon). **GT Type A**.
– Bacon (CRAL-Observatoire, Lyon). **GT Type B**.
– Manchado (IAC). **LIRIS GT**.

Isaac Newton Telescope

UK PATT

– Burleigh (Leicester). Faint planetary nebulae around hot white dwarfs. **I/2005A/8**.
– Coates (Mullard Space Science Laboratory). Wide-field imaging of Comet 9P/Tempel during the Deep Impact collision. **I/2005A/11**.
– Drew (ICL). IPHAS — the INT/WFC photometric Hα survey of the northern galactic plane. **I/2005A/7**.
– James (Liverpool John Moores). Star formation history of dwarf galaxies in the Virgo cluster. **I/2005A/6**.
– Jarvis (Oxford). A wide-field search for Lyman-α haloes: A pre-requisite for massive galaxy formation? **I/2005A/2**.
– Mackey (IoA, Cambridge). A survey for dwarf galaxy remnants around outer halo globular clusters. **I/2005A/1**.
– Ramsay (Mullard Space Science Laboratory). RApid Time Survey - Exploring a new temporal parameter space. **I/2005A/3**.
– Zeilinger (Institute for Astronomy, Viena). Ages and metallicities of dwarf ellipticals in clusters at z=0.04. **I/2005A/5**.

NL PATT

– Aragon (Kapteyn Institute). Measuring galaxy spin alignments along a void-intersection filament near AWM3. **i05an007**.
– Franx (Leiden Observatory). Practical astronomy for 2nd year students. **i05an005**.
– Groot (Nijmegen). IPHAS — the INT/WFC photometric Hα survey of the northern galactic plane. **i05an001**.
– Kovac (Kapteyn Institute). The optical counterparts of the smallest gas-rich galaxies. **i05an006**.
– Röttgering (Sterrewacht Leiden). Lyα emission line halos and the properties of z>2 proto-clusters. **i05an002**.

SP CAT

– Beckman (IAC). The links between bars and star formation: An advanced survey. **I9/2005A**.
– Castro-Tirado (IAA-CSIC). Physical characterisation of Gamma-ray bursts (GRBs) in the SWIFT era. **W25/2005A** [*sic*].
– Deeg (IAC). Sample definition for exoplanet detection by the COROT spacecraft. **I11/2005A**.
– Hatziminaoglou (IAC). Deep imaging in SWIRE ELAIS N1 and N2 fields. **I1/2005A**.
– Iglesias (Laboratoire d'Astrophysique de Marseille). The impact of starbursts in the halos of dwarf galaxies. **I6/2005A**.
– Leisy (IAC/ING). IPHAS — the INT/WFC photometric Hα survey of the northern galactic plane. **I3/2005A**.
– López (IAC). The luminosity function of galaxies in Hercules supercluster. **I10/2005A**.
– Martínez (Valencia). Dwarf galaxy population around isolated galaxies and in small groups. **I4/2005A**.
– Martínez-Delgado (Max-Planck-Institut fur Astronomie, Heidelberg). Two new ultra-faint Milky Way companions. **I13/2005A**.
– Zurita (Granada). Global morphology of star formation: Local calibration. **I7/2005A**.

Spanish Additional Time Allocations

– Rebolo (IAC/CSIC). Subestellar populations in young clusters and stellar associations: I. Orion Belt and Praesepe. **I8/2005A**.
– Vílchez (IAA). Deep Hα imaging of clusters of galaxies in the WINGS Survey. **I12/2005A**.

Abbreviations:

CAT	Comité para la Asignación de Tiempo
ITP	International Time Programme
LT	Long term
NFRA	Netherlands Foundation for Research in Astronomy
NL	The Netherlands
PATT	Panel for the Allocation of Telescope Time
PC	Programme Committee
SP	Spain
TAC	Time Allocation Committee
TNG	Telescopio Nazionale Galileo
UK	The United Kingdom

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ISAAC NEWTON GROUP OF TELESCOPES

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