

## Chapter 4

# IN-HOUSE RESEARCH

The in-house research effort at ING comprises 1 full-time equivalent (FTE) from its recurrent operational budget, plus an additional 2 FTEs contributed by PPARC. This effort is distributed amongst 9 members of the Astronomy Group which includes the Head of Astronomy, 6 support astronomers and 2 PPARC research fellows. In addition to these staff there are/were an additional 3 research-active staff (Dr Roy Østensen, Dr Sebastian Els and Dr Iona Söechting) funded by the European Community's Marie Curie Host Training scheme, while an additional research astronomer (Dr Chris Evans) joined us 2002 via a PPARC Postdoctoral research grant award to Dr Danny Lennon. One additional research-active astronomer (Dr Charo Villamariz Cid) joined us for a period of one year on secondment from the IAC.

During the years 2002 and 2003, ING staff's research productivity, as measured by publication rate was maintained at its previous high 2001 level. In this period they published approximately 200 papers in various scientific publications, approximately 45% of these appearing in refereed journals. A complete list of these papers is included in Appendix F.

An important aspect of the research effort is that ING staff continue to be closely involved with on-going research programmes which are heavily dependent on observations carried out on our telescopes. A typical example of this synergy between research and operations is the continuing lead ING staff provide for the "Local Group Census" Wide Field Survey programme plus their active participation in the successful bid to carry out an INT/WFC H $\alpha$  survey of the north Galactic plane (the IPHAS survey, PI: Prof Janet Drew). This latter survey is also noteworthy in that it represents a major collaboration between all three communities served by the ING; Spain, Britain and the Netherlands. ING astronomers continue to be successful applicants for time with key instruments on the WHT such as NAOMI and AF2. Further details on individuals' research interests and activities are summarised below.

The La Palma astronomy seminar programme continued to be run by ING, with Johan Knapen and Francisco Prada being the organisers. A total of 44 seminars were presented during the course of the last two years and this programme continues to be an important forum for local staff to discuss science and new developments, as well as a vital link with our visiting astronomers. The full seminar programme is presented in an Appendix G.

## INDIVIDUAL RESEARCH ACTIVITIES

Chris Benn completed his search for  $z \sim 4$  radio quasars, defining a sample which allowed measurement of the evolution with redshift of the space density of highly-luminous quasars (showing that the decline in space density beyond  $z \sim 2$  is slower for the most optically-luminous). A follow-up spectrum of one of the more unusual quasars is shown in Figure 1. Chris is involved

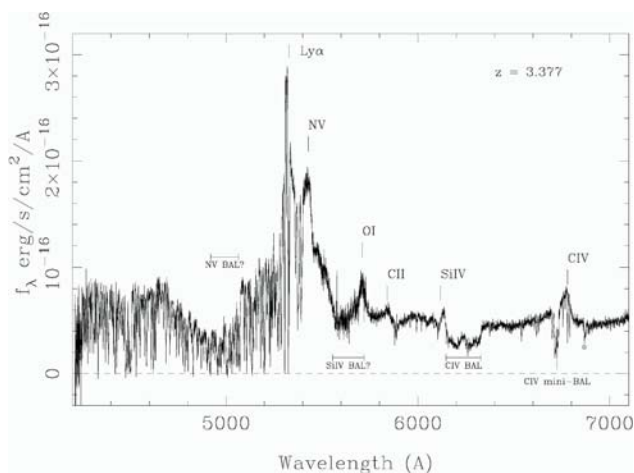


Figure 1. ISIS spectrum of an unusual Broad-Absorption-Line (BAL) quasar discovered during a search for high-redshift quasars (Benn et al.). The broad trough centred at 6230Å is due to CIV absorption by gas streaming out from the quasar at between 21,000 and 29,000 km s<sup>-1</sup> (i.e.  $\sim 0.1c$ ). The physics of the acceleration and confinement of the gas in BAL outflows is unknown. The unusual feature of this quasar is the CIV absorption near 6700Å. This shows velocity structure on a scale smaller than the CIV doublet separation (11Å at this redshift), allowing one to solve for both the fraction of the nuclear source covered by the gas ( $\sim 0.5$  in this case), and the true optical depth of the absorption, allowing estimation of column densities.

in several related investigations, of quasar host galaxies (using NAOMI), of the origin of red colours in quasars, and of the statistics of proximate DLAs (using SDSS). He was PI on a deep INT imaging search during 2003 for Ly- $\alpha$  emission from  $z \sim 4.5$  galaxies.

Romano Corradi continued his study of the dynamical evolution of Galactic planetary nebulae. During 2002, the research was mainly focussed on the formation of collimated large-scale and small-scale morphological components, and on the search and study of giant ionised haloes around the main bodies of the nebulae. In parallel, the search for planetary nebulae in external galaxies continued, mainly in the framework of the Local Group Census, our INT survey programme of emission-line imagery of the Local Group. The observations of the survey are now complete, and their analysis has increased significantly the number of planetary nebulae known in irregular and elliptical dwarf galaxies. Spectroscopic follow-ups are in progress. In 2002, a rare and spectacular event caught the attention of the astronomical community, the light echo around the mysterious erupting star V838 Monocerotis (see Figure 2). The WHT and the INT played an important role in following the evolution of the light echo, and subsequent HST observations led to a publication in *Nature*. In 2003, his work on Galactic planetary Nebulae was mainly focused on the study of their haloes, which are the last observable signature of the mass loss occurred during the red giant phase prior to the final envelope ejection from solar-like stars. A comprehensive observational search and study of such haloes was published on *MNRAS*. The systems of rings found in the inner regions of a number of haloes were also investigated, showing that mass loss modulation is a rather common (and thus important) characteristic of the last ten thousand years of the asymptotic giant branch phase. Together with Almudena Zurita and ING student, Dimitris Mislis, analysis has begun of the extragalactic HII regions using the data from the Local Group Census. He is also involved in the H $\alpha$  survey of the Milky Way (IPHAS).

Sebastian Els is a Marie Curie Fellow and has been carrying out high contrast Adaptive Optics (AO) observations of extrasolar planetary systems in order to search for additional low mass companions. If such substellar companions exist in wide orbits they are undetectable using stellar radial velocities, hence the need for high spatial resolution observations. He is also involved in extending the radial velocity method towards young active stars, and has completed an

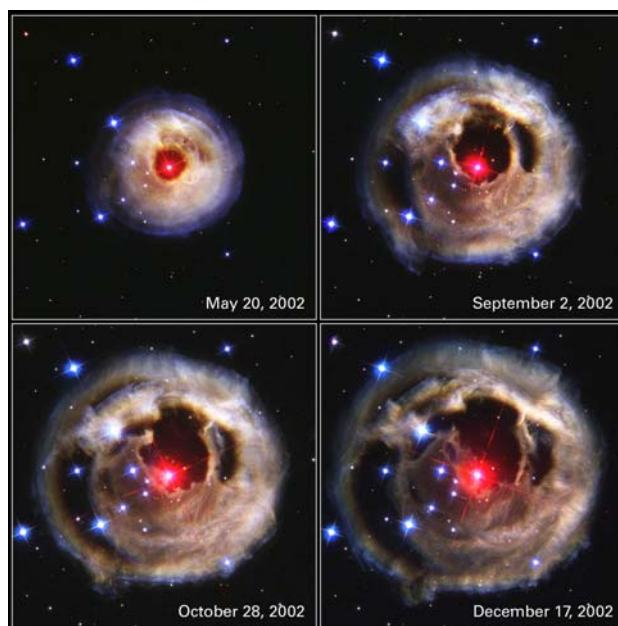


Figure 2. Images obtained by Hubble Space Telescope of erupting star V838 Monocerotis on 20 May, 2 September, 28 October and 17 December, 2002.

observational programme related to this programme. Finally he has begun an investigation to search for planets forming inside protoplanetary accretion disks.

Robert Greimel, our Data Pipeline Scientist and WFC specialist, has worked with Thomas Augusteijn and Paul Groot (Nijmegen) on Cataclysmic Variables in a follow up from the Wide Field Camera Survey “Faint Star Variability” programme. He has also collaborated on the “Local Group Census” survey and is involved in the H $\alpha$  survey of the Milky Way (IPHAS).

Danny Lennon, together with Chris Evans (postdoc) and Carrie Trundle (PhD student) worked on a number of projects concerning hot massive stars. In the course of 2002–03 a strong collaborative relationship was developed with the hot star group at the IAC (led by Prof Artemio Herrero). As part of this process Charo Villamariz Cid spent one year at ING on secondment from the IAC, while there have been frequent exchange visits between ING and IAC staff. Highlights from this group’s activities include the discovery of extremely weak stellar winds for O-type dwarfs in the SMC; compelling evidence of the important role of rotation on the evolution of massive single stars; strong disagreement between theoretical predictions and observations of the mass-loss rates of B-type supergiants in the SMC, but confirmation of the predictions of radiation theory for the terminal velocities of massive supergiants. The group is also an

important participant in an international collaboration which was awarded VLT Large Programme status for “A FLAMES survey of Massive Stars in the Magellanic Clouds”. In addition to these joint activities, Lennon collaborated on further investigations of the chemical composition of massive stars in nearby resolved galaxies, which included the first stellar abundances for the dIrr galaxy WLM, and a new look at the stellar abundance gradients in M31 (with Trundle). He was also involved in showing that the surface abundances of Sher 25, a B-type supergiant with a bipolar nebula similar to that of SN1987A, are not the product of dredge-up during the red supergiant phase of evolution. This result contradicts previous thinking on the evolutionary history of this supergiant. Evans continued working on his definitive 2dF survey of massive stars in the SMC, was involved in the revision of the temperature scale for massive stars, and played a key role in the planning and preparation of the VLT/FLAMES observational programme.

Pierre Leisy has been looking for new extragalactic Planetary Nebulae in Local Group galaxies and beyond with wide field imaging facilities at ING and ESO, with follow-up spectroscopy planned using multi-object spectrographs on the WHT, TNG and VLT. The objective is to determine accurate HII region and PNe abundances for comparison with local PNe in our Galaxy and with the LMC and SMC. The main goal is to better understand the dredge-up and enrichments into the low-intermediate mass stars and constrain the evolution of galactic metallicities over their entire lifetimes (since PNe are abundance tracers over 200 million to 10 billion years). Pierre is also a leading participant in the H $\alpha$  survey of the North Galactic Plane with a major allocation of INT time allocated to this project. He has also completed a major study of 180 PNe in the Magellanic Clouds.

Javier Licandro carried out an extensive observational programme focused on understanding the solar system ‘zoo’, acquiring spectra in the near infrared of 7 Trans-Neptunian Objects, 8 Centaurs, 2 cometary nuclei; spectrophotometry in the visible and near-IR of approximately 60 Near Earth Objects; visible and near-IR spectroscopy of approximately 50 Near Earth Asteroids and asteroids in cometary orbits. This extensive body of work included the first published infrared spectra of a cometary bare nucleus and a detailed analysis of the behaviour of Comet 21P/Giacobini-Zinner during its 1998 perihelion (illustrated in Figure 3).

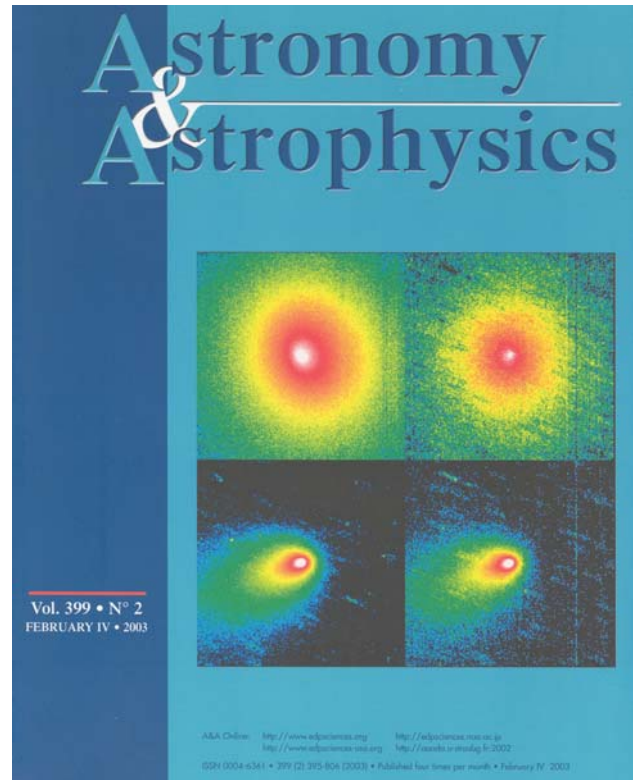


Figure 3. Front cover of *Astronomy and Astrophysics*, Vol. 399, No. 2, February 2003.

Roy Østensen’s Marie Curie Fellowship at the ING ended in April 2003, but continued as a PPARC postdoctoral research fellow in June of the same year. He is continuing his work with the ING AO, where his work has focused on characterisation of AO performance. In his research he has continued his ongoing work on pulsations in subdwarf B-type stars, discovering several new examples of this interesting type of short period pulsating star, as well as two interesting short period binary sdB+dM systems. He has also undertaken a survey of spectroscopic subdwarf B binaries with NAOMI in order to put the different evolutionary scenarios proposed for these stars to a test. Collaborations in this field have been extended to include Pierre Maxted (on the AO studies of sdB binaries), John Telting from the Nordic Optical Telescope (on time resolved spectroscopic studies of pulsating sdB stars) and a Spanish group including Ana Ulla, Raquel Oreiro and Christina Rodríguez López of the IAC and the University of Vigo. As a byproduct of the candidate selection work underlying the pulsation survey, Østensen has developed a complete database system for hot subdwarf stars, bringing together results from the numerous blue star surveys into one searchable databank. He is also working on mining the Sloan Digital Sky Survey for spectroscopic and photometric data on new and known subdwarf stars.



Ian Skillen continued his work on the distance scale but during 2003 his main research effort went into the SuperWASP project. This project is an ultra-wide angle photometric survey of bright stars primarily aimed at searching for planets (Wide Angle Search for Planets) and aims to photometrically survey large numbers of stars in the magnitude range 7 to 13 to better than 1% precision over a wide area of sky. It plans to obtain very well sampled lightcurves for all the stars in each field which will be used to detect planetary transits and track Near-Earth Objects and optical transients. The resulting database will be useful for a variety of science goals. Ian assisted Don Pollacco (QUB) in achieving first light with SuperWASP during the course of 2003.

Almudena Zurita has continued her research on the population of HII regions and the Diffuse Ionised Gas (DIG) of spiral galaxies. She and her collaborators are working on the development of a new photoionisation model for HII regions. It offers the advantage of taking the ISM as non-homogeneous (clumpy), and this provides more realistic models than the ones normally used. The first results obtained, although the code is still under development, are encouraging, reproducing very well the observed radial brightness profiles of HII regions in nearby galaxies. One of the aims of the use of this photoionisation model is to calculate the fraction of photons escaping from the HII regions and that ionise the DIG in a galaxy. Also, she has been working on H $\alpha$  Fabry-Perot TAURUS data cubes of spirals with the aim of improving our understanding of both the global dynamics of disc galaxies, and of the relation between kinematics and massive star formation. Among these results, one in particular deserves special mention; the strongly barred spiral NGC 1530 reveals a clear anti-correlation between star forming zones and zones of high velocity shear, as well as evidence that the latter coincide precisely with the dust lanes mapped via broad band images. She has also continued with the programme to calibrate the change in slope or glitch observed in the H $\alpha$  luminosity functions of the HII regions of spirals and irregulars, for measuring extragalactic distances. Finally, Almudena has been collaborating with Carrie Trundle to use the Local Group Census data to select both blue supergiant stars and associated HII regions M31 for a comparative study of their respective chemical compositions.

Other research active staff no longer in ING employment are: Thomas Augsteijn who worked on cataclysmic variables and X-ray binaries; Begoña García Lorenzo working on starburst galaxies, blue

compact galaxies and extinction at intermediate redshifts; Francisco Prada, a support astronomer at ING for a period of 1 year who worked on tidal streams, dark matter and galaxy evolution; Ilona Söechting who held a 1-year Marie Curie Fellowship and worked on quasars and large-scale structure; Johan Knapen who held a PPARC fellowship until late-2002 and worked on the dynamics and morphology of disk galaxies. While these staff left ING employment during the course of 2002/03 their publications during the relevant periods are included in the staff bibliography (Appendix F).

In addition to the above, a number of ING scientific and technical staff in zero research time posts contribute to the research environment at ING through their own interests. Javier Méndez (Librarian and Public Relations Officer) completed a spectroscopic, photometric and radial velocity survey of the centre of Tycho supernova remnant aimed at identifying the companion star of Tycho SN. Additional observations are scheduled with HST during Cycle 12 and Javier has observed for the Supernova Cosmology Project, The Physics of Type Ia Supernova Explosions (RTN) and the European Supernova Consortium (ESC) collaborations. Marco Azzaro (Telescope Operator) worked closely with Francisco Prada on galaxy evolution and mergers, Saskia Prins (Astronomy Administration) continued her investigation into supernova remnants in M31.

## SCIENTIFIC CONFERENCES

Hosting an astronomy conference is fast becoming an annual event at ING with conferences being organised in both 2002 and 2003. During May 27–31, 2002, a Euroconference named “Symbiotic Stars Probing Stellar Evolution” was organised by Romano Corradi (Co-Chair of SOC, Chair of LOC) and held in Los Cancajos near Santa Cruz de La Palma. In addition to the financial support from the ING, the conference took advantage of substantial support awarded to Dr Corradi by the European Commission “High-Level Scientific Conferences” programme. This helped many people to attend this Euroconference, but above all attracted and supported a large number of young researchers (almost a half of the participants), both PhD students and post-docs from basically all the European states.

The Euroconference was attended by one hundred astronomers (from almost thirty different countries) working in various disciplines that are directly or indirectly related to the study of symbiotic stars. This

led to a very productive exchange of ideas, allowing the participants not only to discuss the most recent results in the field of symbiotic stars and debate on the still many open questions, but also to strengthen the links with specific related fields like planetary nebulae and novae, or even suggest fascinating physical relationship with objects at the other end of the energy scale in the Universe, like quasars.

Among the most important scientific achievements of the conference was the confrontation of high quality multifrequency observations, both from modern ground-based telescopes and from space, with the theoretical models and evolutionary scenarios. In particular, the role of chemical composition remains a bit of mystery, and should be certainly addressed in future studies. It seems to be now well-established that the hot component of most, if not all symbiotic systems, is a white dwarf accreting material from its giant companion. There is strong evidence from rotational velocity measurements that the symbiotic giants do not fill their Roche lobes and the symbiotic binary components interact via stellar wind. However, some of

these systems with low Roche lobe-filling factor show evident ellipsoidal changes. Related to this is the important problem of the possible formation of an accretion disk. While there is no direct evidence for the accretion disk presence in any system, disks would help to understand the Z And-type activity, the formation of

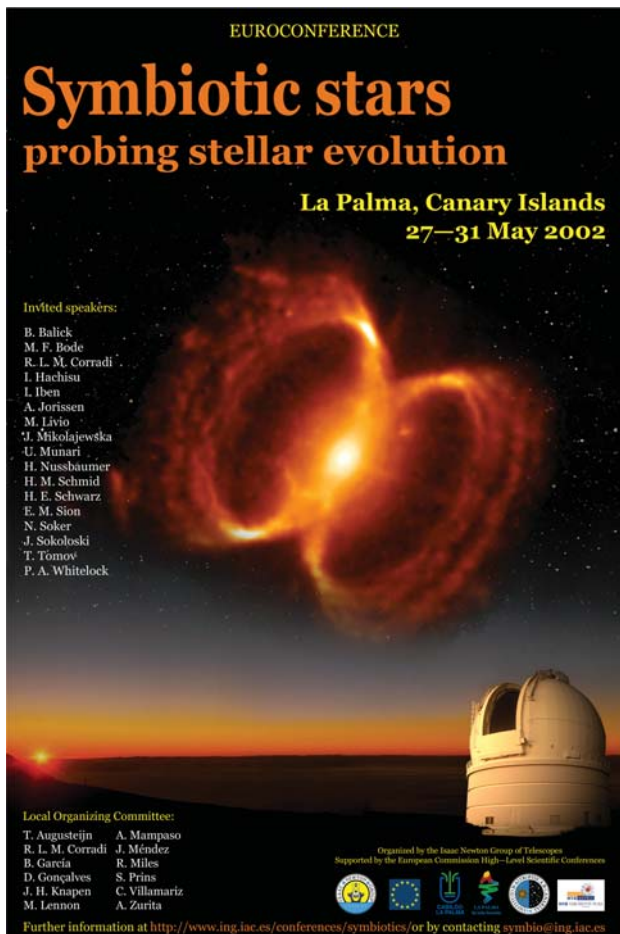


Figure 4. Poster of the Euroconference “Symbiotic Stars Probing Stellar Evolution”.

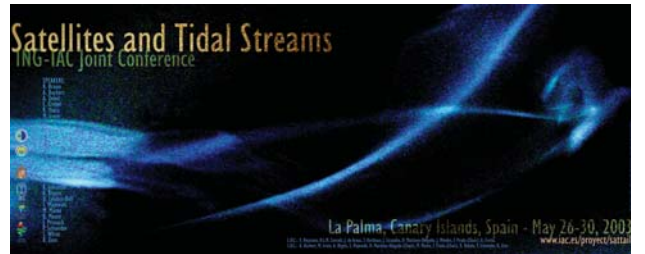


Figure 5. Poster of the ING-IAC joint conference “Satellites and Tidal Streams”.

jets in active systems and the bipolar structure of many symbiotic nebulae. The capability by HST and ground-based imaging of resolving these circumstellar nebulae is also a fascinating result of the research in the field of symbiotic stars in the last years. Their morphological and dynamical similarities with planetary and pre-planetary nebulae attracted a number of researchers working in the latter fields, and great discussion resulted during the conference from the mutual comparison, both observational and theoretical.

On May 26–30, 2003, the first joint ING-IAC conference was organised by Francisco Prada (Co-Chair SOC, Chair of LOC) on “Satellites and Tidal Streams”. Current cosmological models predict that galaxies form through the merging of smaller substructures. Satellites and tidal streams might then represent the visible remains of the building blocks of giant galaxies. They therefore provide important information on the merging history and galaxy formation in the Universe. In this conference the observational evidence for substructures, their internal structure and their dynamical evolution and disruption within the tidal field of the host galaxy were discussed and confronted with theoretical cosmological predictions of hierarchical merging and galaxy formation. Important topics included; dark matter in galaxies, galactic halo substructure and the formation of the Milky Way, satellites and CDM Models, the dark matter content of dwarf spheroidals, mass substructure from gravitational lensing, tidal streams and the disruption of satellite galaxies, galaxy formation and the faint end of the luminosity function. This conference also highlighted the important contribution which the telescopes on La Palma have made to this cutting edge field of research.