

Chapter 4

IN-HOUSE RESEARCH

During 2006 and 2007, the research productivity of the ING Astronomy Group, as measured by publication rate, was maintained at its previous high level, was approximately 100 papers in refereed journals. A complete list of these papers is included in Appendix F. Appendix G shows the research seminars given at ING by visiting astronomers or staff members.

As in previous years, an important aspect of the research effort is that ING staff continue to be closely involved with on-going research programs which rely on observations carried out on our telescopes. One example is the ING's very active role in the INT/WFC H alpha survey of the north Galactic plane (the IPHAS survey), which involves five ING staff astronomers (Corradi, Greimel, Lennon, Leisy and Skillen) and several ING students.

An outstanding example of the synergy of telescopes of the Observatorio del Roque de los Muchachos is the search for extrasolar planets driven by the SuperWASP facility, in which Skillen is deeply involved. This project started in 2004 and it is discovering a number of new extrasolar planets, many of which have been confirmed by follow-up imaging and spectroscopy with the ING telescopes.

Moreover, Benn is P.I. of the project "The nature of quasar outflows" which was awarded the International Time Programme for 2007.

Further enhancement of the international visibility of the ING was provided by two major international conferences organised in 2006 and 2007.

More of these and other activities are described below.

INDIVIDUAL RESEARCH ACTIVITIES

In a search for rare white dwarf populations using SDSS Stripe 82 repeat imaging, Bramich and collaborators have discovered 8 new candidate ultracool white dwarfs, which probe the earliest star formation in the Galactic disk. From the same data, they have also discovered 10 new candidate halo white dwarfs, useful as probes of the

earliest star formation in the proto-Galaxy and for testing of the age of the oldest stars. Bramich's interest in extra-solar planet research has led to the discovery of a pre-main sequence eclipsing binary in the Orion nebula cluster with two sub-solar-mass components. These are rare systems that can be used to help constrain theories of star formation and stellar evolution. Bramich is currently developing a new method for difference image analysis, which promises to be more powerful and robust than the standard method, and with many fewer input parameters.

Benn used WHT/ISIS to investigate the physics of the absorbers in broad-absorption-line (BAL) quasars. By deriving true column densities (eliminating the effect of covering factor) for different ions, it was possible to estimate the ionisation parameter at different absorbers. This constrains the distance of the absorbers from the nucleus, which is currently uncertain by several orders of magnitude, limiting our understanding of the impact of the outflow on the quasar and its environment.

Benn was awarded most of the La Palma international time (2007-8) on the WHT, TNG, INT, NOT and Mercator telescopes, to carry out a more ambitious campaign aimed at understanding the physics of BAL quasars. This work is in collaboration with Arav (Virginia), Barker (Sheffield), Carballo, González and Jiménez (Santander), Ellison (Victoria, Canada), Holt (Leiden), Mack and Montenegro (Bologna) and others. The team has also obtained Keck and VLT time for this project.

Corradi studied several aspects of Galactic and extragalactic planetary nebulae (PNe). In the Galaxy, significant progress has been achieved in the search for new PNe in the Galactic Plane. Preliminary results in the area from 18 to 20 hours in right ascension show that the IPHAS survey will likely triple the number of known PNe. This will allow us to build a magnitude-limited sample of objects, and to discuss fundamental properties such as the stellar death rate in the Galaxy. In addition, the increased sample will allow us to study in more detail, critical phases such as the fast transition between red giants and PNe, which is short and therefore quite rarely observed. Together with his former PhD student Santander, now a

support astronomer at the ING, the role of binary interactions in the late stages of stellar evolution has been investigated by means of high quality (e.g. HST and VLT) observations of nebulae around symbiotic Miras. They illustrate the complex mass loss history and physics from these stars. Outside the Galaxy, PNe are nowadays used as reliable tracers of the luminosity, dynamics, and distances of any stellar system. Corradi contributed to the calibration of the use of PNe as luminosity indicators in all type of galaxies, through a comprehensive study of PNe in the Local Group, and a thorough comparison with population synthesis models.

An ING visiting scientist, Klaus Fuhrmann, continued spectroscopic analyses of all stars within 25 pc, north of the declination -15 deg, and down to absolute visual magnitude $M_V=6.0$, which corresponds to approximate spectral type K2 V. Since the defined sample of $N\sim 350$ stars is volume complete, it allows for an unbiased investigation of the local stellar populations, the extremely old ($\tau > 12$ Gyr) thick disc and the much younger thin disc ($\tau < 8$ Gyr). The local normalisation of the former population turns out to be 20%, which, along with its considerable chemical enrichment level, implies that the thick disc must be a massive component of the Milky Way Galaxy, a major source of baryonic dark matter. Its star-burst like formation history particularly challenges the hierarchical cold-dark-matter-dominated formation picture for spiral galaxies. Another focus of Fuhrmann's research is on model atmosphere analyses of exoplanet host stars. Comparison with the above volume-complete nearby star sample suggests that the usual claim that exoplanet host stars are metal-rich, is only a weak effect, if any, restricted to the 0.1 dex level.

Leisy participated in the IPHAS survey group, searching and studying ionised nebulae in the Galactic disc. In addition, together with Corradi he has been studying the physics and chemistry of extragalactic planetary nebulae. Most of them were discovered through an INT narrow-band survey of the Local Group. Follow up spectroscopy at several 8m telescopes allowed to accurate determination of their chemical abundances. These are used both for studying stellar evolution and chemical yields in stellar populations with metallicity different from the Galaxy, and for determining the chemical history of the parent stellar populations.

As a member of the Supernova Cosmology Project and The Physics of Type Ia Supernova Explosions (RTN) collaboration, Méndez participated in observations for both projects on the telescopes at the Observatorio del Roque

de los Muchachos Observatory, and also collaborated with the SDSSII Supernova Survey. Méndez became a member of the teaching panel of a master degree on science journalism and science, technology and environmental communication organised by University Carlos III, Madrid, and started a research network on science communication called "Red Elipsis".

Skillen, in collaboration with Pollacco (QUB), commissioned a major upgrade to the SuperWASP computing infrastructure. A sophisticated weather station and environment monitoring system allows the facility to now operate robotically under computer control. The inaugural season of SuperWASP observing yielded light-curves for some 6.7 million stars with V magnitudes in the range $\sim 8-15$, comprising ~ 1.3 billion photometric data points in total. Although these light-curves encompass a wide range of interesting variable star phenomena, the main focus of SuperWASP is to uncover the small, $\sim 1\%$ periodic dips typical of 'hot Jupiter' exoplanets as they transit the discs of their host stars.

Computer analysis by the WASP Consortium of the well-sampled light curves of roughly one million of these stars brighter than 13th magnitude identified some 100 high-priority candidates. In an increasingly productive collaboration of the WASP Consortium with teams from Geneva, Marseille and Paris, the discovery of three exoplanets, WASP-1b, 2b (see accompanying figure) and 3b was subsequently confirmed in follow-up spectroscopy

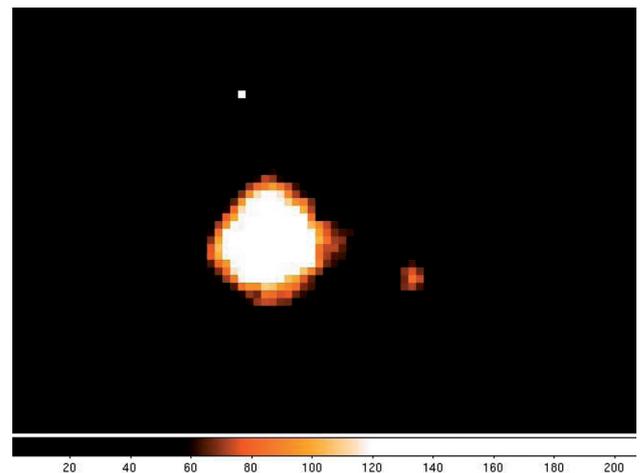


Figure 60. The host star of WASP-2b has a stellar companion 2.7 magnitudes fainter at H, located 0.7 arcsecs away. A deep eclipse of a faint companion could mimic an exoplanet transit in photometry, in which the two are not spatially resolved. In-transit and out-of-transit photometry on AO corrected images taken with NAOMI/INGRID show that the faint companion does not undergo deep eclipses, and therefore it is not the origin of the observed transits.

using the stabilised spectrograph SOPHIE on the OHP-1.9m telescope, France.

Skillen initiated a project on the WHT and NOT, in collaboration with Benn (ING) and Pollacco (QUB), for monitoring the transits of known exoplanets. Their aim was to detect other, low-mass planets in these systems from their gravitational perturbation on the times of transit by the known exoplanet.

RR Lyrae stars, as metal poor, evolved standard candles, can be used to trace the primordial stellar population of the galactic halo, if their kinematical properties are known. In collaboration with Barnes, Jeffery and Montemayor (University of Texas), Skillen completed a study to determine high-precision centre-of-mass radial velocities of a sample of field RR Lyrae stars, using echelle spectroscopy at the McDonald Observatory.

Rix has published an ApJ paper in collaboration with Pettini (IoA), Steidel (Caltech) and others on the recently discovered, proximate damped, Lyman alpha system (PDLA) towards the quasar Q2343-BX415.

Interest in this relatively neglected population of absorbers has been revived in recent years by the realisation that the environmental differences between PDLAs and the better studied 'normal' (intervening) DLAs, can give insight into galaxy formation in a quasar environment. What made this particular object so interesting was the coincidence in redshift (to within a few hundred km/s) between the absorbing gas and the background quasar.

Rix and her collaborators performed a detailed study of the chemical and physical properties of Q2343-BX415's PDLA, finding a metal enrichment comparable to normal DLAs and in stark contrast to the supersolar metallicity determinations previously reported for some proximate high ionisation systems. Their study of the kinematics showed that high ionisation gas is not only situated close to the quasar but is also infalling. Meanwhile the neutral gas was found to be receding from the quasar at ~ 160 km/s which, combined with a distance estimate based upon the ionisation and excitation state of the gas, presented the intriguing possibility that we are witnessing a shell of gas outflowing from the quasar host galaxy. Such outflows are routinely observed in star-forming galaxies at comparable redshifts and are thought to play a crucial role in galaxy feedback.

Rix and Pettini have now initiated a project to search for a subset of PDLAs for which the absorbing gas is exactly coincident in redshift with that of the quasar, as seen for

Q2343-BX415, and therefore likely to be associated with either the quasar's host galaxy, or a nearby galaxy forming in the same group.

In her role as 'XOasis package support' for the ING's OASIS instrument, Rix was also involved in a research project with Lennon and Parker (1-year ING student) to study the circumstellar properties of the Luminous Blue Variable (LBV) P Cygni. This project exploited adaptive-optics 3D spectroscopic observations from the WHT's OASIS+NAOMI instrumentation suite.

ORGANISATION OF SCIENTIFIC MEETINGS

Corradi, with assistance from ING's Astronomy and Administration groups, organised, on the island of La Palma, two international conferences: "The nature of V838 Monocerotis and its light echo", held from May 16 to 19, 2006, and "Asymmetrical Planetary nebulae IV", held from June 18 to 22, 2007.

The 2002 outburst of V838 Monocerotis, and its highly peculiar, fast evolution toward a very low photospheric



Figure 61. Poster for the conference "The Nature of V838 Mon and Its Light Echo".

temperature and a hypergiant size, was one of the most puzzling events in stellar astrophysics in recent years. With the goal of shedding light on this phenomenon, 50 astrophysicists from all over the world met on La Palma in 2006. They contributed to a lively conference, in which the nature of the outbursting source (a thermonuclear runaway in a massive star? merging of two low-mass stars? capture of one or several planets?), and the cause of the spectacular light echo observed around it, was debated. The conference was also an excellent opportunity to foster cooperation and coordination of future observational and modelling efforts, which are needed to shed further light on this rare object.

The conference organised in 2007 was the fourth meeting of the "Asymmetrical Planetary Nebulae" series devoted to understanding the variety of shapes displayed by planetary nebulae, and their implications to stellar evolution.

The importance of the phenomenon was highlighted by extensive CCD imaging surveys taken more than 20 years ago, but a satisfactory understanding of the cause of the sudden switch to an anisotropic mass loss mode at the end of stellar evolution is still missing.

120 astronomers met on La Palma to present the latest observational data and theoretical models. As an overall result of the conference, the role of binary systems in producing the observed mass loss geometries was further strengthened, and, following ample discussion sessions, a wide international collaboration aimed at producing a robust observational effort to demonstrate it, has been set up.

Finally, a users' meeting at NAM 2006 "Astronomy from La Palma: Developments and Future Directions" was organised, including 8 poster presentations by astronomy staff members.



Figure 62. Poster for the conference "Asymmetrical Planetary Nebulae IV".