

SCIENTIFIC PROGRAM SCHEDULE
(Oral Presentations: Ali'i Surf Ballroom)
(Poster Presentations: Paniolo Room)

SUNDAY, 2 April 2006

6:30-8:30 pm Welcome Reception (Paniolo Ocean Terrace)

MONDAY, 3 April 2006

MORNING SESSION (Chair: A. Acker)

- 8:50 - 9:00 Welcome Speeches
9:00 - 9:30 Quentin A. Parker, Milky Way and Magellanic Cloud Surveys for Planetary Nebulae
9:30 - 10:00 Laura Magrini, Local Group Surveys for Planetary Nebulae
10:00 - 10:25 Martin M. Roth, 3D Spectroscopy—a Powerful New Observational Tool for PN Research
10:25 - 11:15 Break
11:15 - 11:40 J. A. López, The SPM Kinematic Catalogue of Planetary Nebulae
11:40 - 12:10 Ortwin Gerhard, Surveys beyond the Local Group
12:10 - 12:40 John Feldmeier, Intracluster Planetary Nebulae
12:40 - 2:00 Lunch

AFTERNOON SESSION (Chair: S. Kwok)

- 2:00 - 2:30 Arsen R. Hajian, Distances to Planetary Nebulae
2:30 - 2:55 David J. Frew, Towards a New Distance Scale and Luminosity Function for Nearby Planetary Nebulae
2:55 - 3:25 Albert A. Zijlstra, AGB Stars
3:25 - 4:15 Break
4:15 - 4:45 Pedro Garcia-Lario, Properties of Post-AGB Objects
4:45 - 5:10 Carmen Sanchez Contreras, Probing Post-AGB Metamorphosis with NIR Adaptive Optics Imaging
5:10 - 5:35 Peter van Hoof, The Real-Time Stellar Evolution of Sakurai's Object
5:35 General Discussion

TUESDAY, 4 April 2006

MORNING SESSION (Chair: S. Torres-Peimbert)

- 9:00 - 9:30 M. Parthasarathy, Spectroscopic Properties of Post-AGB Stars
9:30 - 9:55 D. A. Garcia-Hernandez, Metallicity Effects in the Chemical Evolution from AGB Stars to PNe
9:55 - 10:25 Maurizio Busso (*TBA*)
10:25 - 11:15 Break
11:15 - 11:40 N. C. Sterling, The Abundances of Light Neutron-Capture Elements in Planetary Nebulae
11:40 - 12:10 Falk Herwig, Central Star Evolution
12:10 - 12:40 Orsola De Marco, Binary Central Stars
12:40 - 2:00 Lunch

AFTERNOON SESSION (Chair: Y.-H. Chu)

- 2:00 - 2:30 Rolf-Peter Kudritzki, Atmospheres and Winds of Central Stars
2:30 - 2:55 H. Todt, Revised Element Abundances for WC-type Central Stars
2:55 - 3:25 Thomas Rauch, High-Gravity Central Stars
3:25 - 4:15 Break
4:15 - 4:40 Ting-Hui Lee, The First Detection of a Magnetic Field in a Central Star via Zeeman Splitting:
The Hot Component of the He2-36 Central Star
4:40 - 5:10 Steven D. Kawaler, Asteroseismology of White Dwarfs, PN Central Stars and Post-AGB Stars
5:10 - 5:35 Deborah Mitchell, The Kinematics and Morphologies of Planetary Nebulae with Close-Binary Cores
5:35 General Discussion

WEDNESDAY, 5 April 2006

MORNING SESSION (Chair: M. Barlow)

- 9:00 - 9:30 Harriet L. Dinerstein, Absorption-Line Studies of the Gaseous Component
9:30 - 10:00 Martin A. Guerrero, Planetary Nebulae and Their Central Stars in the X-ray and EUV Regions
10:00 - 10:25 Detlef Schönberner, Modeling the X-ray Emission of Planetary Nebulae
10:25 - 11:05 Break
11:05 - 11:30 Motohide Kokubun, Suzaku Detection of a Highly Carbon Enriched Plasma in BD +30 3639
11:30 - 11:50 Joel Kastner, High-Resolution X-ray Spectroscopy of BD+303639
11:50 - 12:20 Joseph Hora, Infrared Imaging of Planetary Nebulae, Including Spitzer
12:20 - 12:50 Jeronimo Bernard-Salas, Infrared Spectroscopy of Planetary Nebulae, Including Spitzer

THURSDAY, 6 April 2006

MORNING SESSION (Chair: S. Deguchi)

- 9:00 - 9:25 E. Lagadec, Adaptive Optics and Optical Interferometry: The Inner Nebulae around Two Young
Planetary Nebulae with WR Central Stars
9:25 - 9:55 Valentin Bujarrabal, Submillimeter- and Millimeter-wave Molecular Data on Planetary Nebulae
and Post-AGB Objects
9:55 - 10:25 Manuel A. Bautista, Atomic Processes in Planetary Nebulae
10:25 - 11:15 Break
11:15 - 11:45 Xiaowei Liu, Optical Recombination Lines as Probes of Conditions in Planetary Nebulae
11:45 - 12:15 Manuel Peimbert, Temperature Fluctuations and Planetary Nebulae Abundances
12:15 - 12:40 M. Otsuka, High-Resolution Spectroscopic Study of the Halo PNe
12:40 - 2:00 Lunch

AFTERNOON SESSION (Chair: W. Maciel)

- 2:00 - 2:25 Yiannis G. Tsamis, Unravelling the Chemical Inhomogeneity of PNe with VLT FLAMES
Integral-Field Unit Spectroscopy
- 2:25 - 2:55 Roberto D. D. Costa, Planetary Nebulae as Probes for Galactic Chemical Evolution
- 2:55 - 3:25 Bengt Gustafsson, Abundances of Red Giants
- 3:25 - 4:15 Break
- 4:15 - 4:45 Barbara Ercolano, Advances in Nebular Photoionisation Modelling
- 4:45 - 5:10 Wouter H. T. Vlemmings, A Magnetically Collimated Jet from an Evolved Star
- 5:10 - 5:35 P. J. Huggins, The Formation of Globules in Planetary Nebulae
- 5:35 General Discussion

FRIDAY, 7 April 2006

MORNING SESSION (Chair: A. Manchado)

- 9:00 - 9:30 Romano L. M. Corradi, Macrostructures and Microstructures in Planetary Nebulae
- 9:30 - 10:00 Matthias Steffen, Hydrodynamical Interpretation of Basic Nebular Structures
- 10:00 - 10:25 Adam Frank, MHD Paradigms for Proto-PNe and PNe
- 10:25 - 11:15 Break
- 11:15 - 11:45 Guillermo Garcia-Segura, Dynamical PN Evolution with Magnetic Fields
- 11:45 - 12:15 Richard A. Shaw, Properties of the Magellanic Cloud Planetary Nebulae
- 12:15 - 12:40 Letizia Stanghellini, The IRS Spitzer Spectra of the Magellanic Cloud Planetary Nebulae:
Revealing the Dust and Gas Chemistry
- 12:40 - 2:00 Lunch

AFTERNOON SESSION (Chair: G. Jacoby)

- 2:00 - 2:30 Michael G. Richer, Properties of Planetary Nebulae in Other Galaxies
- 2:30 - 3:00 Robin Ciardullo, Planetary Nebulae as Probes of Stellar Populations
- 3:00 - 3:25 Eva Villaver, How PN Shells Interact with Their Local Environment
- 3:25 - 4:15 Break
- 4:15 - 4:40 Magda Arnaboldi, Kinematics Subcomponents in the Coma Cluster Core Traced by
Intracluster Planetary Nebulae
- 4:40 - 5:10 Aaron J. Romanowsky, Planetary Nebulae as Mass Tracers in Galaxies
- 5:10 - 5:35 R. H. Mendez, High-Quality Slitless Radial Velocities of Extragalactic Planetary Nebulae with
Subaru and FOCAS
- 5:35 General Discussion

INVITED AND CONTRIBUTED TALKS (in order of presentation)**Milky Way and Magellanic Cloud Surveys for Planetary Nebulae**

Quentin A. Parker, Macquarie University

I will review current major progress in PN surveys in our own Galaxy and the Magellanic clouds whilst giving relevant historical context and background. The recent on-line availability of large-scale wide-field surveys of the Galaxy in several optical and near/mid-infrared passbands has provided unprecedented opportunities to refine selection techniques and eliminate contaminants. This has been coupled with surveys offering improved sensitivity and resolution, permitting more extreme ends of the PN luminosity function to be explored while probing hitherto underrepresented evolutionary states. Known PN in our Galaxy and LMC have been significantly increased over the last few years due primarily to the advent of narrow-band imaging in important nebula lines such as H-alpha, [OIII] and [SIII]. These PNe are generally of lower surface brightness, larger angular extent, in more obscured regions and in later stages of evolution than those in most previous surveys. A more representative PN population for in-depth study is now available, particularly in the LMC where the known distance adds considerable utility for derived PN parameters. Future prospects for Galactic and LMC PN research are briefly highlighted.

Local Group Surveys for Planetary Nebulae

Laura Magrini, INAF, Osservatorio Astrofisico di Arcetri

The Local Group (LG) represents the best environment to study in detail the PN population in a large number of morphological types of galaxies. The closeness of the LG galaxies allows us to investigate the faintest side of the PN luminosity function and to detect PNe also in the less luminous galaxies, the dwarf galaxies, where a small number of them is expected.

A review of the results of the most recent imaging surveys in the LG is presented. The relationships between the number of PNe and several properties of the host galaxies, as for example the total luminosity, the star formation history, and the metallicity, are analyzed.

In addition, these new observational data are an invaluable resource for follow-up spectroscopy to derive the chemical properties of not only PNe, but also other important emission-line sources like HII regions. These are fundamental tools for the discussion of the chemical evolution of the host galaxies, mapping the history of their chemical enrichment at different epochs. The latest results on this subject are presented.

3D Spectroscopy—a Powerful New Observational Tool for PN Research

Martin M. Roth, Astrophysikalisches Institut Potsdam

Historically, technological progress with detectors and instrumentation has been essential for advances in any field of Astronomy. To mention just a few examples, the advent of CCDs was crucial for high dynamic range imaging and quantitative spectroscopy of galactic PNe, or faint object spectrophotometry of extragalactic PNe to distances as far as ~ 100 Mpc.

Unfortunately, the emerging technique of integral field (“3D”) spectroscopy, which has been applied very successfully for extragalactic problems, has been used so far very little for the study of PNe. However, 3D spectroscopy has an enormous potential for various observational problems, ranging from high spatial resolution emission line mapping in different wavelengths simultaneously, over extremely high sensitivity spectroscopy of low surface brightness objects like PN haloes, to accurate 3D spectrophotometry of extragalactic PNe, and many others.

As an attempt to encourage PN researchers to make better use of these new opportunities, I shall review the presently existing suite of 3D instruments (“IFUs”) on 4-8m class telescopes, highlight several examples of the successful use of these instruments for the study of PNe, and conclude with a discussion of powerful future 3D instrumentation, including MUSE-VLT and NIRSPEC-JWST, with special emphasis on adaptive optics assisted IFUs.

The SPM Kinematic Catalogue of Planetary Nebulae

J. A. López, M. Richer, & H. Riesgo, IA-UNAM, et al.

The San Pedro Martir Kinematic Catalogue of Planetary Nebulae currently provides spatially resolved, long-slit, high resolution echelle spectra for 300 galactic PNe. The catalogue also includes observations of 200 extragalactic PNe from the nearest Local Group galaxies. For the resolved galactic PNe usually several slit positions have been obtained. The total number of single slit observations runs currently into a few thousands for the entire sample. Most of the observations have been obtained with the Manchester Echelle Spectrometer at SPM. The catalogue covers all stellar populations (disk, bulge and halo). Including extragalactic objects, the sample covers a factor of ten in metallicities and ages of the progenitor populations. The Catalogue allows for the first time to classify emission line spectra into well defined groups and analyse their relation to morphology, evolutionary stage and physical parameters of the progenitor star. We present in this contribution the Catalogue and the first results derived from it.

Surveys beyond the Local Group

Ortwin Gerhard, Max-Planck-Institut für Ex. Physik, Garching

In this talk I plan to review the photometric and spectroscopic survey techniques that have been used to detect planetary nebulae beyond the Local Group, out to the Coma galaxy cluster at 100 Mpc distance. Difficulties and contaminations by other sources, and ways to overcome them, will be discussed as well as discovery highlights, science results, and perspectives for the future.

Intracluster Planetary Nebulae

John Feldmeier, YSU

I review the progress on research of intracluster planetary nebulae (IPNe), planetaries outside the galaxies in clusters or groups. There has been significant progress in detecting large numbers of IPNe in nearby galaxy clusters, and searches of multiple galaxy groups for IPNe have been undertaken. Results to date show that IPNe are common in galaxy clusters (up to 15% of the total stellar luminosity), and are ideal kinematical test particles for studying the history of galaxy interactions. Other important developments, such as the detection of distant IPNe candidates in the Coma Cluster and the first hydrodynamical simulations of IPNe will also be discussed.

Distances to Planetary Nebulae

Arsen R. Hajian, US Naval Observatory

I will be reviewing the state of distance estimation to planetary nebulae, including statistical and direct methods. I will also be discussing the results from a moderately large survey of expansion distances from PNe using the Hubble Space Telescope combined with ground-based, long-slit spectroscopy. Geometric and astrophysical modifications to the expansion distance method will also be reviewed, as well as some of the astrophysical implications of the resulting distance scale.

Towards a New Distance Scale and Luminosity Function for Nearby Planetary Nebulae

David J. Frew, Physics Dept., Macquarie University; Quentin Parker, Macquarie University/AAO

The local planetary nebula (PN) census is dominated by extremely evolved examples, and until recently, was incomplete. New discoveries from the AAO/UKST H-alpha Survey and SHASSA in particular, have partially remedied this problem. In addition, we find that some currently accepted nearby PNe are not bona fide PNe at all. New data from WHAM (Madsen et al., this conference) suggests that ~ 10 percent are in fact Stromgren spheres in the ISM. Consequently we are able to generate for the first time a statistically significant 'clean' sample of local PNe. Distance estimates for a robust sample of calibrating PNe from the literature, plus new distances for a number of highly evolved PNe, have allowed a new optical H-alpha surface brightness – radius relationship to be devised as a useful distance indicator. It covers > 8 dex in H-alpha surface brightness, and while the spread is ~ 1 dex in SB at a given radius, bipolar and bipolar-core PNe tend to populate the upper envelope of the trend, while round high-excitation PNe appear to form a sharp lower bound to the relation. As a result, distances can be estimated for almost all remaining nearby PNe to ± 30 percent, which has allowed a first look at the faint end of the PNLF in [OIII], H-alpha, and H-beta. Our new volume-limited 'solar neighborhood' PN sample also allows new estimates of the total number ($\sim 30,000$), space density, scale height(s) and birth rate (in agreement with the WD birthrate) of Galactic PNe.

AGB Stars

Albert A. Zijlstra, University of Manchester

The shells of planetary nebulae reflect the mass loss process on the AGB, where they were ejected. PNe can therefore be used as tracers of the AGB mass loss process. This talk will give a review of AGB mass loss. The wind structures will be discussed, contrasting the highly developed PNe morphologies with the far more symmetric structures on the AGB. Mass loss fluctuations will be discussed, as will be the dependence of the mass loss on metallicity. Evidence for a change in the mass loss below a metallicity of $[\text{Fe}/\text{H}] = -1$ will be reviewed.

Properties of Post-AGB Objects

Pedro Garcia-Lario, ESAC/ESA

A review is presented of the most recent surveys performed in our Galaxy to search for new candidate post-AGB stars and of the main new results obtained in the last years on this rare class of astronomical sources.

Multi-wavelength analysis of an increasing number of post-AGB stars is now available, extending our detailed knowledge to the infrared for the first time, where crucial information is contained on the chemical composition of the gas and dust in their circumstellar shells. The discovery of many new solid state features is just an example of the new findings, which are now being interpreted in the framework of stellar evolution. In addition, a new population of heavily obscured post-AGB stars was discovered, which may represent the missing link between massive AGB stars and type I PNe, not previously considered in previous analysis, showing interesting chemical properties.

The overall infrared properties derived from ISO and Spitzer data can be used to trace the mass loss history and the chemical evolution of the ejected material. The results impose severe observational constraints to the current nucleosynthesis models and suggest that the evolution is mainly determined not only by the initial mass but also by the metallicity of the progenitor star.

Post-AGB samples are likely to grow in the near future with the release of the future ASTRO-F catalogues. Studies on post-AGB stars will probably need to extend the analysis to extragalactic samples, which will certainly improve our knowledge on the evolutionary connections between AGB stars and PNe.

Probing Post-AGB Metamorphosis with NIR Adaptive Optics Imaging

Carmen Sanchez Contreras, Instituto de Estructura de la Materia, CSIC; D. Le Mignant, Keck; S. Raghvendra, JPL, Caltech, et al.

Astronomers have long been puzzled by the morphological variety and bizarre shapes of planetary and protoplanetary nebulae (PNe and PPNe). We have recently obtained high angular resolution 1.6-4.7micron images of a sample of PPNe and young PNe using the Keck Adaptive Optics (AO) system (see poster by Le Mignant et al.). These observations provide higher angular resolution and probe deeper into the dusty envelopes of PPNe and PNe than HST images and, therefore, have revealed with unprecedented detail the morphology of these nebulae. Some objects show limb-brightened lobes displaying a remarkable point-like symmetry, which suggests the presence of underlying precessing jets that may be carving out the nebular lobes. Our images have also revealed a very rich structure at the very small scale of $\sim 0.1''$, including jet-like features, filaments, etc. Here we present detailed analysis of the NIR colors and spectral energy distributions (SEDs) in a sub-sample of post-AGB objects in different evolutionary stages observed with AO. In some cases, part of the NIR flux is due to warm ($\sim 300-700\text{K}$) dust thermal emission. The combined study of the spatial distribution and temperature of this dust component enables characterization of the central source(s).

The Real-Time Stellar Evolution of Sakurai's Object

Peter van Hoof, Royal Observatory of Belgium; Albert Zijlstra, University of Manchester; Falk Herwig, Los Alamos National Laboratory, et al.

When intermediate mass stars reach the final stages of their evolution, they all experience thermal pulses. These are semi-periodic helium shell flashes that cause material from the helium-burning layer to be mixed to the surface of the star. As a result, the chemical composition of the surface is altered dramatically. When this material is subsequently ejected, it will enrich the interstellar medium with new elements. After the star has experienced a number of these thermal pulses, it will start to heat up, become a planetary nebula, and eventually evolve onto the cooling track to become a white dwarf. It is theorized that about 25% of all objects will experience one final (very) late thermal pulse when they are on the cooling track. Despite this high percentage, this process is only very rarely observed. The discovery of Sakurai's star in 1996 provided the first opportunity in modern times to observe a very late thermal pulse. This object has baffled the scientific community with its very fast evolution. To reproduce this evolution we have proposed a new theoretical model which suppresses convective mixing under the influence of flash burning. A strong prediction of this model is that the star will evolve back to a temperature of 80,000 K within the next 5 to 10 years. Recent observations with the VLA confirm the onset of ionization in the recent ejecta and show that the predicted fast evolution has begun.

Spectroscopic Properties of Post-AGB Stars

M. Parthasarathy, Indian Institute of Astrophysics, Koramangala, Bangalore - 34, India

From an analysis of IRAS data several post-AGB stars with K, G, F, A supergiant type spectra to OB supergiant type spectra were discovered. They form an evolutionary sequence between the tip of the AGB and early stages planetary nebulae. Spectroscopic properties, abundance patterns, abundance peculiarities, evidence for third dredge-up and s-process nucleosynthesis, binarity, and spectral variability, of these stars are reviewed. Spectroscopic properties of hot post-AGB stars which form an evolutionary link between the cooler (K, G, F) post-AGB stars and young planetary nebulae are discussed. Observational evidence for rapid evolution of some of the hot post-AGB stars (Hen 1357, SAO 85766 etc) is reviewed.

Metallicity Effects in the Chemical Evolution from AGB Stars to PNe

D. A. Garcia-Hernandez & P. Garcia-Lario, ESAC/ESA; B. Plez, Université de Montpellier II; A. Manchado, IAC; F. D'Antona, INAF-Osservatorio Astronomico di Roma; J. Lub & H. Habing, Sterrewacht Leiden

We present the main results derived from a chemical abundance analysis carried out on a large sample of massive galactic O-rich AGB stars ($M > 3M_{\odot}$). Combining these results with previous studies made on a similar sample of luminous AGB stars belonging to the Magellanic Clouds we conclude that there are strong observational evidences that metallicity is playing a more important role than generally assumed in chemical evolution models. This concerns not only the onset of the so-called 'Hot Bottom Burning' and the efficiency of the third dredge-up, as derived from our optical observations, but also the dust production efficiency and the chemical properties of the dust grains in the shell, as inferred from the available infrared data. We find Li overabundances in the galactic stars studied, indicating that they are actually 'Hot Bottom Burning' AGB stars. Similar Li overabundances are also observed in the most luminous Magellanic Cloud AGB stars. However, the AGB stars in our galactic sample are not enriched in s-process elements, in contrast to what it is observed in the Magellanic Clouds. In addition, many stars in the galactic sample appear heavily obscured in the optical, suggesting a much more efficient dust production and/or stronger mass loss rates which eventually can be translated into shorter AGB lifetimes. A comparison of our results with the observational data available on post-AGB stars and PNe is presented. This multi-wavelength analysis is used to impose observational constraints on the evolutionary connections between the different populations of AGB/post-AGB stars/PNe identified in various metallicity environments.

Nucleosynthesis in AGB Stars

Maurizio Busso

I shall review our knowledge on the main nucleosynthesis processes occurring in Asymptotic Giant Branch stars during the advanced evolutionary stages in which the strongly mass-losing star is powered by H-shell burning periodically interrupted by episodes of explosive He-shell ignition (the thermal pulses). All nucleosynthesis products from AGB stars are controlled by capture of light particles: protons, neutrons and α s. The main products are ^{12}C , s-elements, and intermediate p-capture nuclei (^{13}C , ^{14}N , ^{17}O , ^{26}Al). I shall discuss the conditions for their synthesis, which require the activation of different mixing mechanisms. Convective mixing, under the form of envelope penetration into the He-rich layers, commonly known as third dredge-up, is necessary for the appearance of new elements at the surface; on the other hand, the activation of neutron captures requires diffusive processes for mixing protons into the He layers and driving the formation of the neutron source ^{13}C . Similarly, production of intermediate elements from proton captures above the H-burning shell requires non-convective circulation phenomena (cool bottom processes). A discussion will be presented of the ensuing element yields, as observed in their photospheres, in unevolved stars of subsequent generations, in Early Solar System materials, and in presolar grains of AGB origin recovered in meteorites.

The Abundances of Light Neutron-Capture Elements in Planetary Nebulae

N. C. Sterling, University of Texas; H. L. Dinerstein, University of Texas

We present results of the first large-scale survey of neutron(n)-capture element abundances in planetary nebulae (PNe). It is expected that some PNe will be enriched in these elements (atomic number $Z > 30$), due to the operation of s -process nucleosynthesis and convective dredge-up in their progenitor stars. We have observed near-infrared emission lines from the n -capture elements Se and Kr in over 100 PNe, using the CoolSpec spectrometer on the 2.7-m telescope at McDonald Observatory. [Kr III] 2.199 and [Se IV] 2.287 μm have been detected in 65 of 114 PNe, for a detection rate of nearly 60%. We have incorporated these elements into the atomic databases of the photoionization codes CLOUDY and XSTAR, which we have used to derive corrections for unseen ionization stages and thereby determine elemental abundances. Our analysis shows that Se and Kr are enriched relative to solar in about 40% of the PNe exhibiting these emission lines, with enhancements ranging from 1–10 times solar. Kr tends to be more enriched than Se, in agreement with current models of s -process nucleosynthesis. We also find that Se and Kr are generally more strongly enhanced in PNe with hydrogen-deficient Wolf-Rayet type central stars, as well as objects with lower mass progenitors ($M < 4 M_{\odot}$). These results constitute the first broad characterization of s -process enrichments in PNe as a population, and reveal the impact of low- and intermediate-mass stars on the chemical evolution of trans-iron elements in the Galaxy.

Central Star Evolution

Falk Herwig, LANL

I will review stellar evolution models of central stars of planetary nebulae, and more generally of post-AGB stars. Recent years have added some progress in understanding the different post-AGB evolution channels, including those with born-again evolution. Special emphasis will be on the connection of post-AGB model properties and the AGB progenitor evolution. For example, the exact position of the post-AGB track depends on how AGB evolution properties, like mass loss, hot-bottom burning and dredge-up were modeled. Recent work has shown that CSPN can be a powerful tool to constrain nucleosynthesis in AGB stars. I will summarize recent work in pulsation analysis of CSPN (GW Vir stars). New work has also been done in the area of hydrodynamic simulations of convection of the He-shell flash, which is relevant for post-AGB thermal pulse events.

Binary Central Stars

Orsola De Marco, American Museum of Natural History

Most discussions regarding planetary nebulae implicitly assume that only a minority of these objects have evolved via a binary evolutionary channel. Recent observational evidence points to this fraction being a lot larger than previously believed. This is likely to add new fuel to the debate of how PN got their shape.

In this review I will present what we know and what we do not about binary central stars. I will in particular concentrate on new evidence for binarity and on binary central star detection techniques. One of the most effective methods to determine whether central stars have companions is to survey them for periodic radial velocity variation of their spectral lines. This method is effective but alas not efficient as it requires large allocations of 4-m class telescope time. Additional techniques might include X-ray and near-IR spectroscopy with 10-m class telescopes, large area photometric surveys, and polarimetry. From this it will be apparent that only a multi-sided observational approach can resolve the issue of how many central stars have (or had) a binary companion.

Finally I will review and compare PN, WD, and other related object's estimated birthrates and suggest that stellar evolutionary theory is consistent with a much larger binary fraction for PN central stars than currently acknowledged.

Atmospheres and Winds of Central Stars

Rolf-Peter Kudritzki, Institute for Astronomy, Univ. of Hawai'i

The progress over the last years in modelling the atmospheres and winds of Central Stars will be reviewed. We will discuss the effects of the inclusion of the blanketing by millions of metal lines in NLTE on the diagnostics of photospheric and stellar wind lines, which are usually used to determine the stellar parameters such as effective temperature, gravity, radius, mass-loss rates and distance. Moreover, we will refer to recent work on the winds of O-stars, which indicates that these winds are possibly inhomogeneous and clumped. We will investigate implications from this work on the spectral diagnostics of Central Stars.

Revised Element Abundances for WC-type Central Stars

H. Todt, G. Gräfener, & W.-R. Hamann, Institut für Physik und Astrophysik, Universität Potsdam

Previous spectral analyses of Wolf-Rayet type central stars with the most advanced Potsdam Wolf-Rayet (PoWR) model atmospheres, which account for line-blanketing and clumping, seemed to approve lower carbon abundances for early subtypes ([WCE]) than for the late ones ([WCL]). This would imply that late and early subtypes are not evolutionary connected. We checked these results for possible systematic errors, and found that the additional inclusion of very high ions of C and O in the model atoms has an unexpected indirect influence on the diagnostic lines. Therefore the carbon abundances in [WCE] subtypes have been underestimated in previous work. We investigate if the revised abundance pattern is consistent with an evolutionary connection between [WCL] and [WCE] type central stars.

High-Gravity Central Stars

Thomas Rauch, Institut für Astronomie und Astrophysik, Universität Tübingen, Germany

Central stars of Planetary Nebulae (PNe) represent the hottest stage of stellar post-AGB (asymptotic giant branch) evolution for medium-mass stars. Close to the end of nuclear burning, gravity starts to dominate their evolution and determines their surface composition. The high-gravity central stars are (pre)-white dwarfs just entering the white-dwarf cooling sequence.

We review the investigations and developments since the last IAU Symposium on PNe in 2001.

Asteroseismology of White Dwarfs, PN Central Stars and Post-AGB Stars

Steven D. Kawaler, Iowa State University

The field of white dwarf pulsation was born over 35 years ago, and the first pulsating central star was discovered over 20 years ago. It was soon realized that these nonradially pulsating stars provided a window to the interior structure and evolutionary time scales of these fascinating stars. A flurry of activity from the mid 1980s to the mid 1990s, both observational and theoretical, began to realize this potential. A new generation of stellar models, coupled with reanalysis of seismological data and discovery of a large number of faint pulsators, has recently revitalized this field and promises to provide firm answers to some of the outstanding problems of post-AGB evolution. In this review talk, I will remind us of the early days of white dwarf and pre-white dwarf seismology to provide a context for the more recent work on these stars. With this background, the remarkable recent progress in leukonoseismology, including work on the excitation of pulsations in hot pre-white dwarfs and the structure and evolution of cooler white dwarfs can be fully appreciated.

The Kinematics and Morphologies of Planetary Nebulae with Close-Binary Cores

Deborah Mitchell, Jodrell Bank Observatory, The University of Manchester

The aim of our programme is to investigate the role of close-binary central stars on the shaping of planetary nebulae and in particular, the formation of bipolar planetary nebulae.

Long-slit echelle observations and deep images were taken of several planetary nebulae with confirmed close-binary cores. Northern sky targets were observed using the Manchester Echelle Spectrometer combined with the 2.1-m San Pedro Martir telescope in Mexico; Southern sky targets were observed using UCLES combined with the 3.9-m Anglo-Australian telescope and EMMI combined with the 3.58-m New Technology telescope in Chile.

A long-slit was placed at several positions across each nebula in order to deduce the overall velocity structure. The program Novacart (Tim O'Brien, private communication) was then used to produce a model of the nebula and synthetic position-velocity arrays, which could then be compared with kinematic observations.

Abell 63 is an especially important test case in the programme as its central binary system is almost totally eclipsing, which means its physical parameters can be determined in a model-independent way. The Novacart model suggests that Abell 63 has a hollow tube-like structure with a slightly pinched waist. It appears that two jets have blown diametrically opposed cavities in a pre-existing dusty envelope.

This model will also be tested for Abell 46, which has a partially eclipsing binary core and Sp 1, which we predict is a bipolar nebula viewed pole-on.

The properties of the models will be used as tests of stellar evolutionary theory.

Absorption-Line Studies of the Gaseous Component

Harriet L. Dinerstein, University of Texas at Austin

The physical and abundance properties of the gaseous component of planetary nebulae have traditionally been studied using their rich, pan-chromatic emission line spectra. However, absorption lines produced within the column of nebular gas in front of the central star can provide complementary information, giving access to ions and energy levels that cannot be studied via emission lines, and yielding new evidence regarding the presence and nature of internal inhomogeneities. The far-ultraviolet spectral region, as studied with HST and FUSE, is particularly useful for probing species in the photodissociation region (PDR), such as molecular hydrogen (H_2) and neutral oxygen (O I). Comparison of absorption-line results to emission lines in the same nebulae demonstrates that there is strong spatial segregation of the molecular material—and, possibly, of the dust as well—globally and/or on small scales. Measurements of UV absorption lines from fine-structure levels of O I reveal that non-thermal processes (specifically, fluorescence) can have an important influence on the excitation equilibrium of this species, affecting interpretations of the important infrared cooling lines at 63 and 145 microns. UV absorption lines can also be seen from some rarer ionized species, such as the neutron-capture element Ge, while absorption lines in other spectral regions, including the optical and radio, provide additional valuable tracers of neutral and molecular material.

Planetary Nebulae and Their Central Stars in the X-ray and EUV Regions

Martin A. Guerrero, IAA-CISC

Einstein, EXOSAT, ROSAT, and ASCA X-ray observations of planetary nebulae (PNe) detected soft photospheric X-ray emission from their central stars, but the diffuse X-ray emission from the shocked fast stellar wind in their interiors could not be unambiguously resolved. The new generation of X-ray observatories, Chandra and XMM-Newton, have finally resolved the diffuse X-ray emission from shocked fast winds in PN interiors. These observations have produced exquisite X-ray images and invaluable X-ray spectra of PNe that allows us to examine the spatial distribution and physical properties of hot gas in PNe. Furthermore, these observatories have detected diffuse X-ray emission from bow-shocks of fast collimated outflows impinging on the nebular envelopes, and unexpected hard X-ray point-sources associated to the central stars of PNe. In this talk, I will review the results of these new X-ray observations of PNe, describe the theoretical progress motivated by these results, and discuss the promising results of future observations.

Modeling the X-ray Emission of Planetary Nebulae

Detlef Schönberner and Matthias Steffen, Astrophys. Institut Potsdam

Recent observations using the Chandra X-ray Observatory and XMM Newton revealed without doubt diffuse X-ray emission from the shock-heated wind gas in planetary nebula interiors. Hydrodynamical models of the interaction of the fast stellar wind with the dense AGB wind show that the shocked gas becomes too hot and too tenuous to produce the observed X-ray emission. Considering heat conduction across the contact discontinuity changes the structure of the shock-heated gas as predicted by similarity solutions (cf. Zhekov & Perinotto, A&A 309, 648, 1996): nearly the whole bubble becomes cooler and denser, with electron density and temperature ranging from 10 to 100 cm⁻³ and 10⁶ to 10⁷ K, respectively, well suited to explain the observed X-ray emission.

We included heat conduction in our hydrodynamical modeling of planetary nebulae and were able to follow the changes of the X-ray emission from the hot bubble while the model PN evolves across the H-R diagram. We computed the X-ray properties for different model parameters and found good agreement with the existing observations. The UV emission from highly ionized species in the conduction front is a natural byproduct of our modeling, and we present also the first results for the [O VI] line at 1032 Angstrom observed by FUSE.

Suzaku Detection of a Highly Carbon Enriched Plasma in BD +30 3639

Motohide Kokubun, Mio Murashima, and Kazuo Makishima, University of Tokyo, et al.

In some planetary nebulae, X-ray emission arises from an extended region inside the optical nebular shell. We have started X-ray investigations of planetary nebulae, based on a belief that their X-rays serve as a new probe to investigate chemical abundances of the materials which the progenitor lost in the final stage of its evolution. We observed the brightest X-ray emitting planetary nebula BD +30 3639 with the Suzaku satellite which is the newest X-ray observatory launched on 2005 July 10 based on a Japan-US collaboration. Thanks to the excellent low-energy performance of Suzaku, we for the first time succeeded in resolving a strong hydrogen-like carbon line at 0.37 keV, from other lines such as OVII, OVIII, and NeIX. The implied abundance ratios among C, N, O and Ne are highly non-solar, with an extremely high (nearly 100 times solar) C/O ratio. These results indicate that the X-ray emitting material in this object represents the helium burning products in a very pure form.

High-Resolution X-ray Spectroscopy of BD+303639

Joel Kastner and Young Sam Yu, Rochester Inst. of Technology; John Houck, MIT, et al.

The many recent discoveries of diffuse X-ray emission from PNe by the Chandra and XMM-Newton X-ray Observatories have raised fundamental questions concerning the origin of very hot ($> 10^6$ K) plasma in PNe, and the relationship of this superheated plasma to PN shaping processes. To make further progress, we require detailed information concerning the physical conditions of the X-ray-emitting gas as a function of position within X-ray emitting PN “hot bubbles.” Such information can be obtained only from X-ray observations combining high spectral and spatial resolution. In 2006 February and 2007 January we will obtain two such observations of the well-studied planetary nebula BD +303639 – the brightest diffuse X-ray source among PNe – using Chandra’s Low Energy Transmission Gratings spectrometer in combination with its Advanced CCD Imaging Spectrometer (LETG/ACIS-S). These two 40-hour LETG/ACIS-S exposures will yield the first-ever high resolution X-ray spectra of a PN. We expect to resolve high ionization state lines that are diagnostic of plasma temperature and composition. Preliminary results concerning the brightest emission lines (e.g., O VII, O VIII, Ne IX, Ne X) will be presented for the first time at this meeting.

Infrared Imaging of Planetary Nebulae

Joseph L. Hora, Harvard-Smithsonian Center for Astrophysics

I will review recent infrared imaging of planetary nebulae. New ground-based telescopes and instruments, and the recent launch of the Spitzer Space Telescope and the return of the NICMOS instrument on HST have provided new tools that are being utilized in the study of planetary nebula.

Infrared Spectroscopy of Planetary Nebulae, Including Spitzer

Jeronimo Bernard-Salas, Cornell University

By the ejection of the outer parts of the envelope, the planetary nebula contributes to the enrichment of the interstellar medium. This offers a way to reliably check the nuclear processes that have taken place in the interior of the star. The end phase of a star's life, is therefore crucial to the understanding of the chemical evolution of our Galaxy. For this, accurate abundances of the ejected material in the planetary nebula phase are essential.

Infrared spectra avoid/reduce many problems usually encountered when determining abundances: In the infrared, emission lines due to many ionization stages are seen, greatly reducing the need for ionization correction factors. The infrared lines originate from levels so close to the ground level that they are not sensitive to the temperature. Infrared lines are weakly affected by extinction, avoiding significant errors when correcting the observed lines fluxes.

In addition, the emission of dust occurs in the infrared and therefore features such as PAHs and silicates can only be studied in this part of the spectrum. This is important to study how the dust evolves and especially the excitation conditions of the photo-dissociation regions from which these features arise.

This talk will review the main infrared spectroscopic advances in the area during the last years. This will include recent results from the Spitzer Space Telescope which has enabled us to extend the infrared study of planetary nebulae outside the Milky Way.

Adaptive Optics and Optical Interferometry: The Inner Nebulae around Two Young Planetary Nebulae with WR Central Stars

O. Chesneau, Observatoire de la Cote d'azur, France; E. Lagadec, Observatoire de la Cote d'azur, France, University of Manchester, UK; O. De Marco, AMNH, NY, USA

Talk will be given by E. Lagadec

We present interferometry (VLTI) and adaptive optics (NACO) imaging of the dust emission from two Wolf-Rayet-type planetary nebulae, Hen 2-113 and CPD-56 8032. They are located at the same distance and have the same stellar class ([WC10]), making the detection of any differences in their close environment of great interest. Hen 2-113 reveals the presence of a diabolo-shaped structure, tilted with respect to the surrounding bipolar nebula observed in the optical with the HST. Ten-micron interferometry did not detect a clear core. The dusty environment of CPD-568032 is much more compact. It is dominated by a bright, barely resolved, core embedded in a larger nebula with complex structure. From MIDI 8.7micron acquisition images (dominated by PAHs emission), the extension and geometry of the core have been estimated and compared to the STIS/HST observations (De Marco et al., 1997 and 2002). Moreover, high SNR fringes at low level have been detected with projected baselines between 40 and 45 meters. This clear signal is interpreted in terms of the bright inner rim of a dusty disk exposed to the flux from the Wolf-Rayet star. The geometrical parameters of the N band flux distribution are well constrained by means of simple geometrical models and a simple radiative transfer model has been developed to extract the physical parameters of the disk.

Submillimeter- and Millimeter-wave Molecular Data on Planetary Nebulae and Post-AGB Objects

Valentin Bujarrabal, Observatorio Astronomico Nacional, Spain

Molecular line emission is an important tool to study young planetary nebulae (PNe). Molecular lines are weak in evolved PNe because the relatively hot star and diffuse nebula yield strong photodissociation. In young PNe, however, the molecular emission, particularly of CO, probes a large amount of mass; sometimes, about one solar mass of cool gas is detected. CO lines are on the other hand very easy to interpret, because of their simple excitation. These lines are probably the best tool to study the spatial distribution and kinematics of the bulk of the gas in young PNe. The various shapes and dynamics of young PNe and the implications of these data on our knowledge of PN formation are discussed.

Atomic Processes in Planetary Nebulae

Manuel A. Bautista, IVIC

Historically Planetary Nebular (PNe) research has been a ground for much development in atomic physics. In the last five years the combination of a generation of powerful observatories, the development of ever more sophisticated spectral modeling codes, and important efforts on mass production of high quality atomic data has led to important progress in our understanding of the atomic spectra of PNe. In this paper I review such progress, including identification of heavy species (beyond the iron peak elements), observations of hyperfine emission lines and analysis of isotopic abundances, fluorescent and multi-photon atomic processes, and new techniques for diagnostics of physical conditions based on recombination spectra. I also present an overview of the current stage of available atomic data in terms of how it leads to reliable spectral diagnostics and ion abundances. Finally I discuss the new trends on the research of atomic processes in PNe.

Optical Recombination Lines as Probes of Conditions in Planetary Nebulae

Xiaowei Liu, Department of Astronomy, Peking University

Several deep optical spectrophotometric surveys, allowing detail nebular plasma diagnostics and abundance analyses using weak hydrogen and helium recombination continua and heavy element optical recombination lines (ORLs), have been carried out and published for several dozen Galactic disk and bulge planetary nebulae (PNe), as well as for a small number of Galactic, Magellanic and other extragalactic H II regions. The results invariably show that electron temperatures deduced from recombination line (continuum) diagnostics, typified by electron temperatures deduced from the ratio of hydrogen Balmer discontinuity to H 12, $T_e(\text{BJ})$, are systematically lower than values derived from collisionally excited lines (CELs), typified by those derived from the [O III] nebular to auroral forbidden line ratio, $T_e([\text{O III}])$. In companion, ionic abundances of heavy elements relative to hydrogen derived from intensities of heavy element ORLs relative to $H\beta$, such as O^{2+}/H^+ deduced from O II ORLs, are systematically higher than those derived from CELs, such as O^{2+}/H^+ deduced from [O III] forbidden lines. The two phenomena are found to be correlated with each other and the magnitude of discrepancy varies from object to object. The abundance discrepancy factor, adf, defined as the ratio of ionic abundance derived from ORLs to that deduced from CELs, ranges from unity, i.e. near agreement, up to a factor of 70, with a median value of about 2. For a given nebula, the adf's for individual heavy elements studied so far, including C, N, O, Ne and Mg, are found to be comparable, yielding relative heavy elemental abundance ratio, such as C/O, in general agreement with those deduced from CEL analysis. It is found that adf is anti-correlated with nebular surface brightness, i.e. being higher in old, low surface brightness PNe. For a given nebula, adf is also found to increase towards the nebular centre.

The accuracy of spectrophotometry of the surveys, combined with the new atomic data, such as effective recombination coefficients calculated down to temperatures as low as a few hundred Kelvin, have made it possible to determine the physical conditions under which the lines originate. It is now realized that the bulk emission of heavy element ORLs, at least in PNe exhibiting particularly large adf's, arises from another previously unknown component of plasma which, presumably as a result of its much enhanced metallicity and consequently much enhanced cooling efficiency by heavy element infrared fine-structure lines, has an electron temperature of only a few hundred Kelvin, and thus emits essentially none in ultraviolet or optical CELs (and therefore invisible in those lines). The two aforementioned types of dichotomy arise simply because CELs and ORLs probe two separate spatially co-existing components of plasma, yet of completely different physical conditions – one of $T_e \sim 10,000$ K and with approximately solar metallicity and another of T_e of a few hundred Kelvin and with a metallicity hundreds times higher. The fact that adf's vary from nebula to nebula and are highest for low surface brightness PNe, may reflect an evolutionary effect, i.e. as the nebula expands and its surface brightness decreases, the cool component becomes more and more dominant in contributing the observed total flux of an ORL. For a given multiplet, the relative intensities of O II ORLs are found to deviate from values derived assuming the ground states of recombining O^{2+} ions, $2p^2\ 3P_{0,1,2}$, are thermalized. This potentially provides a powerful diagnostic tool to determine the electron density under which the lines are emitted, and consequently the total mass of ionized gas required to reproduce their observed fluxes. Preliminary results of an ab initio calculation of the relative intensities of O II Multiplet 1 lines as a function of electron density are now available. Applications of those new data to observations show that the cool, high-metallicity component of plasma has higher electron densities than the “normal” component, as one would expect if the high metallicity plasma originates from evaporation of high density condensations or clumps of H-deficient material deposited in the nebula. The analysis also shows that the amount of metal deposited in those H-deficient clumps is substantial and comparable to that in the “normal” component.

Temperature Fluctuations and Planetary Nebulae Abundances

Manuel Peimbert and Antonio Peimbert, Instituto de Astronomia, Universidad Nacional Autonoma de Mexico

Many planetary nebulae show spatial temperature variations that are larger than those predicted by static, chemically homogeneous, photoionization models. To determine accurate chemical abundances it is necessary to know the cause of these temperature variations. There are two main ideas that have been proposed to explain this result: that the temperature variations in most of the nebulae are due to excess cooling produced by chemical inhomogeneities or that the temperature variations in most of the nebulae are due to excess heating produced by shock waves. In this review we discuss the observational evidence in favor of the presence of temperature variations and the evidence in favor of the possibilities mentioned above. The importance of this problem is paramount to test the stellar evolution models of intermediate mass stars and to test the galactic chemical evolution models of C, N, and He relative to H.

High-Resolution Spectroscopic Study of the Halo PNe

Otsuka, M., National Astronomical Observatory of Japan, Okayama; Tajitsu, A., Subaru Telescope; Tamura, S., Department of Astronomy, Tohoku Univ.

Up to now, about 10 planetary nebulae (PNe) are regarded as Galactic halo members in terms of the spatial velocity, low-metal abundances, and their locations. Therefore, they should evolve from a low mass star. In spite of their small membership, halo PNe have been intensively studied because of their chemical characteristics. We have observed halo PN, H 4-1 with high dispersion ($R > 50,000$) echelle spectrograph (HDS) of 8.2m Subaru telescope, and obtained spatially resolved high-dispersion spectra at the several position angles. Our analyses of the internal kinematics revealed the sign of asymmetrical nebular expansion and the strong absorption by dust in it. Furthermore the near infrared imaging with UH/QUIRC shows the existence of the strong H_2 1-0 S(1) emission along position angle of $\sim 70^\circ$ and multipolar structure such as NGC 2440 and NGC 7026. Normally, these features are considered to be seen in PNe with a massive progenitor. In order to investigate this inconsistency, we are carrying out a project to analyze the internal kinematics and the chemical abundances of the halo PNe with Subaru/HDS. We will present the latest results of these analyses of the halo PNe.

Unravelling the Chemical Inhomogeneity of PNe with VLT FLAMES Integral-Field Unit Spectroscopy

Yiannis G. Tsamis, Physics and Astronomy Dept, University College London; Jeremy R. Walsh, ST-ECF, ESO; Daniel Pequignot, Observatoire de Paris-Meudon, et al.

One of the most important yet intractable problems in nebular astrophysics is that conflicting temperatures are obtained from different diagnostics for many PNe. A closely related problem is the systematic discrepancy between heavy element abundances derived from collisional and recombination lines in these objects. This problem has been around since the 80's and is related to earlier work that formed the basis of a vast literature researching the ramifications of this issue for galactic and extragalactic nebular studies.

The currently most viable explanation for both problems, which has implications for accurate abundance determinations of all emission nebulae, is one in which a normal PN of typical composition harbours hydrogen-deficient inclusions. Unlike however the famous cases of PNe such as Abell 30, whose embedded H-deficient knots have been clearly resolved, thus far this proposition has not been observationally verified for typical PNe.

To directly address this issue we acquired VLT FLAMES spectroscopy of three typical Galactic PNe exhibiting a wide range of temperature/abundance discrepancies - NGCs 5882, 6153 and 7009. The Argus integral field unit and the Giraffe spectrometer enabled unprecedented high spatial (0.3 arcsec pixels) and spectral resolution (32,000) observations to isolate the nebular inhomogeneities both spatially and as a function of the line of sight via the gas velocity. The observations also allowed high signal-to-noise 2D emission-line, temperature, density and abundance maps of the nebulae to be produced. The results which will be presented are unique in mapping out the small-scale chemical inhomogeneities present in these nebulae.

Planetary Nebulae as Probes for Galactic Chemical Evolution

Roberto D. D. Costa, IAG/USP

The role of planetary nebulae as probes for the galactic chemical evolution is reviewed. Their abundances throughout the Galaxy are discussed for key elements such as helium, carbon, oxygen and other alpha-elements. The abundance distribution derived from planetary nebulae leads to the establishment of abundance gradients that are important constraints to model the chemical evolution of the Galaxy. The radial gradient is well determined, and will be examined for distinct regions. For the galactic anticenter in particular, the observational data confirm results from galactic evolution models that point to a decreasing in the gradient slope at large galactocentric distances. The possible time evolution of the radial gradient is also examined comparing samples of planetary nebulae of different ages. The galactic bulge is another important region whose modeling can be constrained by observational results derived from planetary nebulae. Results derived in the last years point to a decreasing in the gradient slope for the central region, and the abundances found for these objects indicate that bulge nebulae have abundance distribution similar to that from disk objects, however with a larger dispersion.

Abundances of Red Giants

Bengt Gustafsson, Dept of Astronomy and Space Physics, Uppsala University

What is known today about the chemical abundances of red-giant stars, in various stages of their evolution? How reliable is this knowledge? What possibilities are there in the future to improve it? How does it fit, and relate to the corresponding knowledge for PNe? What significant new information concerning the PNe may be expected from further studies of RG abundances in the next coming years? These questions will be addressed, and partly answered, in my review.

Advances in Nebular Photoionisation Modelling

Barbara Ercolano, University College London

The study of photoionised gas in planetary nebulae (PNe) has played a major role in furthering our understanding of physical processes pertinent to a broad range of fields from atomic physics to stellar evolution theories. Whilst empirical techniques are routinely employed for the analysis of nebular emission line spectra, the accurate interpretation of the observations often requires the solution of a set of coupled equations, via the application of a photoionisation/plasma code. A number of large-scale codes exist today, that use various analytical or statistical techniques for the transfer of continuum radiation, mainly under the assumption of spherical symmetry and a few in 3D. I will review the recent advances in the field of nebular photoionisation modelling, focusing on how the models can be used to extract useful information from new observational constraints available today. The development of the codes has been driven by the observational constraints available, but also compromised by the available computer power. Modern codes are faster and more flexible, with the ultimate goal being a realistic reproduction of the observations which relies on the smallest number of parameters possible. In this light, recent advances have included atomic data updates, the development of more realistic treatments for dust grains mixed in the ionised and photo-dissociation regions (PDRs) and the expansion of some codes to PDRs with the inclusion of chemical reaction networks. Furthermore, the last few years have seen the development of fully 3D photoionisation codes based on the Monte Carlo method.

A Magnetically Collimated Jet from an Evolved Star

Wouter H. T. Vlemmings and Philip J. Diamond, Jodrell Bank Observatory; Hiroshi Imai, Kagoshima University

We present the first direct measurements of the magnetic field strength and direction in a collimated jet from an evolved star on its way to become a planetary nebula. Very Long Baseline Array (VLBA) observations of the linear and circular polarization of the water masers in the collimated jet of W43A reveal a strong toroidal magnetic field, indicating that the jet is magnetically collimated. The magnetic field strength in the jet extrapolated back to the stellar surface yields a surface field of several Gauss, consistent with the measurements of maser polarization in a large sample of evolved stars. The origin of the magnetic field is yet unknown, although the jet precession might point to the existence of a heavy planet or stellar companion. This is the first direct observational evidence for magnetic collimation in a jet, that likely plays an important role in shaping planetary nebulae. (recently accepted for publication in Nature)

The Formation of Globules in Planetary Nebulae

P. J. Huggins, NYU; A. Frank, Univ. of Rochester

We report a new model for the fragmentation of circumstellar gas and the formation of globules in planetary nebulae (PNe) based on the Rayleigh-Taylor (RT) and the magnetic Rayleigh-Taylor (MRT) instabilities. We show that the RT instability leads to the breakup of shells in PNe formed by fast winds or ionization fronts and can produce globules with the global geometry and within the mass range observed. We also show that the presence of a magnetic field in the circumstellar gas can play an important role in the fragmentation process. Using field strengths measured in the precursor AGB envelopes, we find that close to the central star where the fields are relatively strong, the wavelengths of unstable MRT modes are larger than the shell dimensions, and the development of small scale structure is suppressed. The wavelength of the most unstable MRT mode decreases with increasing distance from the star as the fields become weaker, and when the wavelength becomes comparable to the shell thickness, it can lead to the sudden, rapid break-up of the shell. For typical PN parameters and magnetic fields comparable to those in AGB envelopes, the model predicts shell break-up into numerous fragments with a mass scale and a separation scale similar to those observed in PNe. Our results provide a potential link between global models of PN shaping and the formation of small scale structures in the nebulae.

Macrostructures and Microstructures in Planetary Nebulae

Romano L. M. Corradi, Isaac Newton Group, La Palma, Spain

Planetary nebulae display a variety of large and small-scale structures which have been the object of a large number of observational programmes and theoretical studies in the last two decades.

In this review, I will present: 1) a brief summary of all the structures observed in Galactic PNe and of their physical properties; 2) the new observational results since the previous IAU symposium; 3) a critical discussion about the morphological components of PNe whose formation we believe we understand, and those which instead are still poorly understood.

Hydrodynamical Interpretation of Basic Nebular Structures

Matthias Steffen and Detlef Schönberner, Astrophysikalisches Institut Potsdam, Germany

Based on existing hydrodynamical simulations, we review our present understanding of the formation and evolution of planetary nebulae (PN) and discuss the relevant processes responsible for the development of the basic (1D) nebular structures.

Careful studies performed during the last decade have demonstrated that 1D time-dependent hydrodynamical models can explain the different morphological types and expansion properties of observed spherical or elliptical PNe, provided they take into account a realistic description of the preceding mass loss history at the end of the AGB. Recent models including electron heat conduction can even explain roughly the observed X-ray emission emerging from the central regions of PNe studied by Chandra/XMM during the past years.

MHD Paradigms for Proto-PNe and PNe.

Adam Frank, University of Rochester

The debate over the role of magnetic fields in both launching and shaping outflows from post-AGB, proto-PNe and PNe has now reached a critical point. Substantial observational evidence and theoretical argumentation now exist to support the claim that dynamically strong fields are a critical player in the creation and evolution of evolved star outflows. In my talk I will review new and existing theoretical models developed by our group and others which demonstrate that either stellar or disk driven dynamos produce fields that can account for both large scale structures and small scale organized clumping. We further show that only some classes of MHD models can recover the observed energy and momenta budgets for outflows. We also address criticisms of MHD paradigm including angular momenta considerations. Finally we draw connections with other kinds of MHD outflows such as YSO and AGN jets demonstrating that the PNe phenomena can be seen as part of a ubiquitous process in which gravity, rotation and magnetic fields collude to produce collimated outflows.

Dynamical PN Evolution with Magnetic Fields

Guillermo Garcia-Segura, Instituto de Astronomia, Universidad Nacional Autonoma de Mexico

In this paper, we focus on some features that are addressed by several works on MHD. We review different scenarios for the origin of magnetized winds, either for Protoplanetary Nebulae or Planetary Nebulae, and discuss the production of axisymmetric flows, the confinement of flows and the production of jets and ansae, point-symmetric nebulae and the periodic shells around PNe and proto-PNe.

Properties of the Magellanic Cloud Planetary Nebulae

Richard A. Shaw, NOAO

Over the past 15 years the growth of detailed information about Planetary Nebulae in the Large and Small Magellanic Clouds (MCPN) has been explosive, to the point where these galactic laboratories are the preferred context for furthering and refining our understanding of this late phase of stellar evolution. Deep, photometrically uniform surveys have pushed the population of confirmed MCPN above 1100, high-quality optical spectra exist for the bulk of these nebulae, infrared (Spitzer) and satellite UV spectra of a few dozen PNe are archived or will become available soon, and high-resolution (HST) images have been archived for over 150 nebulae. In this presentation I will review the bounds of our knowledge of MCPN: including nebular physical and chemical properties, and their relation to morphological characteristics; central star properties and what they tell us about the progenitor population; and what new insight has been gained through MCPN about the evolution of the combined PN+central star systems, and the implications for understanding the physical origin of the PN luminosity function.

The IRS Spitzer Spectra of the Magellanic Cloud Planetary Nebulae: Revealing the Dust and Gas Chemistry

Letizia Stanghellini, NOAO; Pedro Garcia-Lario, ESAC/ESA; Arturo Manchado, IAC; Jose Vicente Perea and Anibal Garcia-Hernandez, ESAC, ESA; Richard A. Shaw, NOAO; and Eva Villaver, STScI/ESA

Planetary nebulae (PNe) in the Magellanic Clouds (LMC, SMC) offer a unique opportunity to study both the population and evolution of low- and intermediate-mass stars in an environment which is free of the distance scale bias that hinders Galactic PN studies. The emission shown by PNe in the 5-40 micron range is characterized by the presence of a combination of solid state features (from the dust grains) and nebular emission lines over-imposed on a strong dust continuum. We acquired low resolution IRS spectroscopy of a selected sample of LMC and SMC PNe whose morphology, size, central star brightness, and chemical composition are known. The data have been acquired and reduced, and the IRS spectra show outstanding quality as well as very interesting unexpected features. The detailed analysis of these data will allow us to i) determine the dominant chemistry (C-rich vs. O-rich) of the PN dust through the study of the solid state features, with the ultimate goal of evaluating the dust formation efficiency versus metallicity; ii) establish connections between chemistry, morphology, and evolutionary stage of the PNe; iii) test the current models of stellar evolution at various initial metallicities, comparing predicted composition of the dredged-up material and observed composition in the PNe as a function of the mass of the progenitor star; iv) recover the AGB mass loss history from the analysis of the overall spectral energy distribution; v) determine the contribution of the infrared to the total PN luminosity.

Properties of Planetary Nebulae in Other Galaxies

Michael G. Richer, Instituto de Astronomía, UNAM

I review the properties of bright planetary nebulae in other galaxies that may be derived from spectroscopy. It is becoming increasingly clear that the evolution of both the host galaxy as well as the stellar progenitors have a significant effect upon some of the chemical abundances observed in bright planetary nebulae. Perhaps it is not surprising, but chemical enrichment of nebular envelopes appears to be much more variable for bright planetary nebulae arising from old stellar populations than those arising from young ones. Spectroscopy can also address the question of whether a single progenitor population is likely to give rise to bright planetary nebulae in all galaxies. Both the degree of excitation of the nebular shell and its kinematics argue that there are several routes to producing the brightest extragalactic planetary nebulae.

Planetary Nebulae as Probes of Stellar Populations

Robin Ciardullo, Penn State University

Planetary nebulae are important tools for our understanding of extragalactic stellar populations. Indeed, in many systems, not only are PNe the only individual stars that can be identified, but also the only single objects amenable to spectroscopic analysis. We review the ways that an ensemble of PNe can be used to probe the metallicity, age, and history of a stellar population. In particular, we discuss three regimes: the fully spectroscopic regime, where one has knowledge of the line-strengths of many of a PN's faint lines (including [O III] 4363), an intermediate regime, where only a PN's brightest lines are visible, and the photometric case, where the only information available is the luminosity of [O III] 5007. We show that each of these cases has the potential to provide unique insights into the parameters of a stellar population.

How PN Shells Interact with Their Local Environment

Eva Villaver, STScI/ESA; Guillermo Garcia-Segura, IA-UNAM; Arturo Manchado, IAC; Letizia Stanghellini, NOAO

Planetary Nebula (PN) shells and AGB circumstellar envelopes evolve under a wide range of external conditions: from the high ISM densities found in the Galactic plane, to the rarefied and hot intra-cluster medium where the systemic velocity of the star can be as high as 2000 km/s. We have explored the effects that the external pressure and/or stellar systemic velocity have on the observable properties of PNe. We have studied how the mass and size of the PNe halos are reduced when using stellar systemic velocities. We have also investigated how the mass of the circumstellar envelope is fed by ISM material when high ISM densities characteristic of the Galactic plane are considered. By studying the evolution of PNe under the intra-cluster medium in Virgo we infer shorter PN lifetimes than what is usually adopted. PN lifetimes strongly affect the fraction of intra-cluster light derived from PN studies.

Kinematics Subcomponents in the Coma Cluster Core Traced by Intracluster Planetary Nebulae

Magda Arnaboldi, ESO; Ortwin Gerhard, MPE, Garching; Kenneth C. Freeman, MSSSO, et al.

The Coma cluster is the richest and most compact of the nearby clusters, yet there is growing evidence that its formation is still on-going. A sensitive probe of this evolution is the dynamics of intracluster stars, which are unbound from galaxies while the cluster forms, according to cosmological simulations. With a new multi-slit imaging spectroscopy technique pioneered at the 8.2 m Subaru telescope and FOCAS, we can now detect and measure the line-of-sight velocities of the intracluster planetary nebulae which are associated with the diffuse stellar population of stars, at 100 Mpc distance. We detect strong velocity substructures within a 6 arcmin diameter field, centred on the Coma X-ray cluster emission. A strong substructure is present at ~ 5000 km/s, probably from infall of a galaxy group, while the main intracluster stellar component moves at ~ 6800 km/s, offset by ~ 450 km/s from the main cD galaxy NGC 4874. We discuss the implications of these velocity measurements on our understanding of the Coma cluster formation.

Planetary Nebulae as Mass Tracers in Galaxies

Aaron J. Romanowsky, Dept. Physics, Univ. Concepcion

Planetary nebulae (PNe) are of great importance in the kinematical study of galaxies as proxies for low surface brightness stellar distributions. Until recently, there were only a handful of galaxies with PN kinematics available, but with the advent of new instrumentation, the sample is now exploding. I will review the kinematics results for elliptical, lenticular, and spiral galaxies. These data are used not only to infer galaxy mass distributions, but also to study the coupling between PNe and the underlying stellar populations.

High-Quality Slitless Radial Velocities of Extragalactic Planetary Nebulae with Subaru and FOCAS

R. H. Mendez, A. M. Teodorescu, and R. P. Kudritzki, Institute for Astronomy, Univ. of Hawai'i

We have adapted to the 8-m Subaru telescope and its Cassegrain FOCAS spectrograph the onband, offband, grism+onband imaging and calibration technique developed to obtain slitless radial velocities of extragalactic planetary nebulae with the VLT and FORS. One advantage of this slitless technique is that we obtain radial velocities for all detected PNs in the field, irrespective of their number and distribution.

With FOCAS we are able to demonstrate high accuracy, with radial velocity errors of about 10 km/s. This is mostly due to the availability of a new echelle grism, very efficient, with 175 grooves/mm, used in the 4th order. The use of a rigid calibration mask also appears to help.

We describe the calibration tests and present a first astrophysical application: the discovery and measurement of PNs in the remote outskirts of the elliptical galaxy NGC 4697, extending to 4 effective radii a previous study (Mendez et al. 2001, ApJ 563, 135, which only reached to about 2.7 effective radii). With significantly more accurate velocities, and with 25 PNs beyond 3 effective radii from the center of this flattened galaxy, we fail again to find any evidence of dark matter, and the rotation far from the center is even slower than measured earlier. More galaxies have been observed, and the data are being reduced.

POSTERS (in alphabetical order by first author)**1. 555 New Planetary Nebulae as Tracers of the Galactic Bulge**

Agnes Acker & Alan Peyaud, Strasbourg Observatory; Quentin Parker, Macquarie University, Sydney, et al.

555 MASH (Macquarie/AAO/Strasbourg H α) planetary nebulae were discovered towards the galactic bulge using the AAO/UKST H α survey and the spectroscopic follow-up missions (doubling the number of catalogued PN, 422 CAT PN). For 405 MASH PN (with a diameter less than 35 arcsec) we classify as GBPN, we obtain a surface brightness value, the diameter and the dynamical age of the nebulae. From lines intensity ratio of 133 GBPN observed with the 6dF device, we could estimate their density and ionized mass, and the temperature of their central stars. We discover 15 bipolar and/or helium-rich GBPN having probably massive stellar progenitors.

2. New PN Tracing the Kinematics of the Bulge

Agnes Acker & Alan Peyaud, Strasbourg Observatory; Quentin Parker, Macquarie University, Sydney, et al.

Through graphic and wavelets analysis of the radial velocities of 740 GBPN (405 MASH and 335 CAT), we could derive an estimated number of 35,000 PN in the Galaxy, study the rotation of the inner Bulge and depict a few sub-structures. A N-body simulation was made in an attempt in producing a stable bar in a realistic galaxy. We confirm and precise key parameters defining the bar: pattern speed, co-rotation radius, inclination angle, shape, ratio of the major to minor axis.

3. The Variability of Hot Protoplanetary Objects and the Stellar Wind from Central Stars of Planetary Nebulae

V. P. Arkhipova, N. P. Ikonnikova, G.V. Komissarova, & R. I. Noskova, Sternberg State Astronomical Institute of Moscow University, Moscow, Russia

The results of longtime systematic UB V -observations of 6 hot protoplanetary nebulae (PPN) with early B spectra - V886 Her, V1853 Cyg, LSIV-12 $^{\circ}$ 111, IRAS19200+3437, IRAS07171+1823, OY Gem - are given. Fast stochastic brightness variations in the range of 0.2-0.4 magnitudes (in V-band) have been found. The minimal time scale of the oscillations is from several hours to one day. The colour indices do not correlate with the star's brightness. The repeated spectral observations of hot protoplanetaries have shown obvious variability in the hydrogen emission lines. The P Cyg profiles of HeI lines are seen in most cases. Forbidden lines are represented by [NII], [SII], [OII], [OI], and [FeII]. The nebular [OIII] lines are now observed only in the spectrum of OY Gem. It is suggested that the stellar wind from the future planetary nebula nucleus with variable M is responsible for variations observed in hot PPNs. The circumstellar extinction was revealed for the studied objects. Hot dust with a temperature in excess of 1000 K, besides cold dust with $T_d \approx 200$ K, is observed in IRAS07171+1823 and particularly in OY Gem. We infer that all the observed PPNs are at an initial stage of the planetary nebula ionization, at an earlier phase than for the youngest planetary Hen 1357. Among the 6 objects, the most advanced is OY Gem ($T \approx 28000$ K); IRAS07171+1823 ($T \approx 25000$ K), LSIV-12o111 and V886 Her ($T \approx 24000$ -21000 K), V1853 Cyg ($T \approx 20000$ K) follow.

4. Planetary Nebulae in Elliptical Galaxies: A Puzzling Problem for Stellar Evolution

M. Arnaboldi, ESO & INAF; A. Buzzoni, INAF; R. L. M. Corradi, ING, La Palma & IAC, Tenerife

We investigated the relative deficiency of Planetary Nebulae (PNe) in elliptical galaxies, and the observed trend of the luminosity- specific PN number, better known as the ‘alpha’ ratio, with galaxy optical colors.

Our study (Buzzoni, A., Arnaboldi, M., Corradi R.L, 2006,astro- ph/0602458) supports the presence of a prevailing fraction of low-mass cores ($M_{\text{core}} \leq 0.55M_{\odot}$) in the PN distribution associated with early-type galaxies, and a reduced visibility timescale for the nebulae as a consequence of the increased AGB transition time. The stellar component with $M_{\text{core}} \leq 0.52M_{\odot}$, which overrides the PN phase, could provide an enhanced contribution to hotter HB and Post-HB evolution, as directly observed in M32 and the bulge of M31. This implies that the most UV-enhanced ellipticals should also display the lowest values of ‘alpha’, as confirmed by the Virgo cluster early-type galaxy population.

Furthermore any blue-straggler population, invoked as progenitor of the $M_{\text{core}} > 0.7M_{\odot}$ PNe in order to preserve the constancy of the bright luminosity-function cut-off magnitude in ellipticals, must be confined to a small fraction (few percents at most) of the whole galaxy PN population.

5. Radiation Driven Wind Theory in Center Stars of Planetary Nebulae

Anabel Arrieta, Universidad Iberoamericana; Letizia Stanghellini, National Optical Astronomy Observatory

Based on HST and IUE data of Central Star of Planetary Nebulae in the Large Magellanic Cloud and in our Galaxy we investigate the relation between the modified wind momentum Π versus the luminosity of these stars.

6. The Most Collimated Planetary Nebulae

Bruce Balick, U. Washington

The process(es) that collimate stellar outflows in PNe remain elusive and contentious. Decisive observations to test the viability of these concepts—mass exchange and tidal effects in binaries and magnetic fields—have not been forthcoming. The problems are daunting: fields can be sampled locally in masers, but they cannot yet be traced globally. As for the binary systems, limited spatial resolution and dust prevent direct observations of the collimation processes that might operate on scales of the orbital separations.

Whatever the dominant collimation process(es), the best hope of probing their shaping mechanism(s) lies in the most extreme examples of collimated PNe and protoPNe. I present a set of images of the most collimated PNe and protoPNe culled from a new image catalogue of over 600 objects that will help to define the essential characteristics of a highly collimated outflow. Certainly length-to-width ratios of features are important. More subtle features also emerge as characteristic of collimated nebulae. I will compare the quintessential collimated PN to numerical models, and show that recent MHD models by Washimi et al. (2006) and by Garcia-Segura et al. (2005) provide a surprisingly solid framework for understanding their morphologies.

7. Thick Disk Planetary Nebulae

Jayendra K. Baliga & D. C. V. Mallik, Indian Institute of Astrophysics, Bangalore, India

In this work we find candidates for Planetary Nebulae (PNe) of the thick disk population of the Galaxy, making use of the proper motion and radial velocity data available in literature. Despite the fact that existing proper motion data for PNe are sparse and highly uncertain, we search for thick disk PNe through simulation and Bayesian likelihood analysis. Making use of the established kinematical properties of the thick disk/thin disk/halo (TD/D/H) population of the Galaxy, we generate synthetic TD/D/H populations of PNe in velocity space (U,V,W). Using positional information for the PNe, we compute the distribution functions for radial velocity and proper motions for the synthetic populations and making use of the available proper motion and radial velocity data, the likelihood of each PN being a member of the TD/D/H population is estimated. The relative likelihoods follow directly from this, and are used to select candidate TDPNe. Given the situation that accurate proper motion data for PNe are unlikely to be obtained until future missions like GAIA, best use is made of the existing proper motion data, however uncertain they may be, to select prospective TD/D/H candidates. We find 12 candidate TDPNe whose probability of TD membership is 80% or greater, of which 9 have probability greater than 90%. Spectroscopy of the TD candidates is being planned and we hope this will shed light on the chemical characteristics of the TD population of the Galaxy, in the context of Planetary nebulae.

8. Evolution of Molecular Gas in Planetary Nebulae

Dana S. Balser & Joseph P. McMullin, NRAO

We present 7mm GBT observations of a sample of planetary nebulae (PNe). These observations are used to explore theories of stellar evolution through isotopic abundances in the ejected material. In addition, we contrast the emission distributions of molecular tracers in PNe, proto-planetary nebulae, AGB stars and star forming regions to highlight the different chemical evolution taking place in the gas; implications for observational studies of PNe molecular gas are discussed.

9. Gemini-S bHROS Observations of Recombination Line and Forbidden Line Widths in NGC 7009

M. J. Barlow, UCL; X.-W. Liu, Peking University; A. Hales, UCL, et al.

We present high spectral resolution observations ($R=150,000$) of the planetary nebula NGC 7009, acquired during the July 2005 bHROS commissioning run at Gemini South. They reveal that the [OIII] 4363Å collisionally excited line (CEL) has a FWHM linewidth that is 1.5 times larger than that shown by OII optical recombination lines (ORLs) in the same spectrum, despite the fact that all of these lines are emitted by the O^{2+} ion. High spectral resolution observations of this type may provide a key to understanding why ORLs yield systematically higher heavy element abundances for photoionized nebulae than do the classical forbidden line CELs emitted by the same ions; NGC 7009 has a notably high ORL/CEL abundance discrepancy factor (ADF) of 4.7. Due to the opposite temperature dependences of ORLs and CELs, the former should be preferentially emitted by colder plasma.

10. Iron Project: Atomic Data for IR Lines

M. A. Bautista & C. Mendoza, Physics Center, IVIC, Caracas, Venezuela; K. A. Berrington, School of Science & Mathematics, Sheffield Hallam University, UK; V. M. Burke, SERC Daresbury Laboratory, Warrington, UK, et al.

The Iron Project [1] is an international consortium dedicated to the computation of atomic data for astrophysical applications (for a complete list of publications, see [2]). Data sets are currently available online from the atomic database TIPbase [3] at the CDS, France. Although the project has been mainly concerned with ions from the iron group, the earlier papers gave priority to calculations of A-values and electron impact collision strengths for infrared transitions. In the present report we include a compilation of these data which will become useful in the spectral modelling of planetary nebulae.

1. Hummer D. G., et al. 1993, A&A 279, 298
2. <http://vizier.u-strasbg.fr/tipbase/ref/publi.html>
3. <http://vizier.u-strasbg.fr/tipbase/home.html> "bautista_etal_abstract" [dos] 26L, 1156C

11. NICMOS Imaging of Proto-Planetary Nebulae

Matthew Bobrowsky, CSC / STScI; Toshiya Ueta, NASA Ames Research Center/SOFIA; Margaret Meixner, STScI

Near-infrared images from a NICMOS survey revealed the circumstellar matter around several proto-planetary nebulae (PPNe), including IRAS 18184–1623, AFGL 4106, and HD 179821 (=IRAS 19114+0002). The IRAS 18184 data was previously analyzed by O'Hara et al. (2003). Here we present the data on the other two objects.

The true nature of HD 179821 is still a subject of some debate. It could be a yellow hypergiant or a post-AGB star. Regardless, the NICMOS images show that it is surrounded by a nebula with a diameter of $\sim 12''$. Until 1600 years ago, it was losing mass at a rate of $3 \times 10^{-4} M_{\odot} \text{ yr}^{-1}$. It now exhibits multiple concentric shells with small bipolar outer protruberances.

AFGL 4106 was known previously as a spectroscopic binary, consisting of a luminous F-type post-red-supergiant and an M-type red supergiant. It is surrounded by a faint nebula with a diameter of $\sim 3''$. Here we present the first image that shows, not only the nebula, but also the binary companion. It appears at a position angle of $\sim 270^{\circ}$ and a separation of $0.''3$.

12. The Light Echo around V838 Monocerotis and Its Connection with Planetary Nebulae

Howard E. Bond, Space Telescope Science Institute

The outburst of V838 Mon is illuminating a circumstellar dust envelope. Because of the geometry of a light echo, it is possible to determine both a geometric distance to the star, and the 3-dimensional structure of the envelope. Our latest observations of the echo with the Hubble Space Telescope are showing remarkable parallels with the structure of planetary nebulae.

13. New Planetary Nebulae towards the Galactic Bulge

Panayotis Boumis & Stavros Akras, Institute of Astronomy & Astrophysics, National Observatory of Athens, Greece; Peter Van Hoof, Royal Observatory of Belgium, Belgium, et al.

We present deep $H\alpha+[N II]$ CCD images of selected new Planetary Nebulae (PNe) discovered through an $[O III] 5007 \text{ \AA}$ emission line survey in the Galactic bulge region with $l > 0 \text{ deg}$. In total, we detected 240 objects, including 44 new PNe. Deep $H\alpha+[N II]$ images as well as low resolution spectra were obtained for the new PNe in order to study them in detail. Photo-ionization models of the new PNe with CLOUDY resulted in first estimates of the physical parameters and abundances. They are compared with the abundances of Galactic disk PNe.

14. The Centimeter-Wave Continuum in Compact PNe

Simon Casassus, U. de Chile; Lars-Ake Nyman, ESO; Tony Readhead, Caltech, et al.

A byproduct of experiments designed to map the CMB is the recent detection of a new component of foreground galactic emission. The anomalous foreground at 10-30GHz, unexplained by traditional emission mechanisms, correlates with $100\mu\text{m}$ dust emission, and is thus presumably due to dust.

We will present evidence obtained with the CBI and SIMBA+SEST supporting the existence of a 31GHz excess over free-free emission in PNe. The statistics of the excess in a sample of PNe bring surprising information on the nature of their cm-wave continuum.

15. Investigating the Formation of Planetary Nebulae

Luciano Cerrigone & Joseph L. Hora, CfA; Grazia Umamã & Corrado Trigilio, INAF, Italy

The formation of planetary nebulae is a poorly understood phase of stellar evolution. In particular it is still not clear what mechanism leads to the complicated morphologies observed in such sources. In the last years we have started a systematic study of objects in transition from the post-AGB to the planetary nebula. To detect transition objects we have selected a sample of post-AGB stars with B[e] spectral type (pre-PN). The sample was observed with the VLA and the ATCA and in 18 out of the 36 observed sources radio emission was detected, indicating the presence of an ionized shell in these targets. In the attempt of characterizing our sources, we have performed multi-frequency and high angular resolution VLA observations, which show that a bipolar morphology is present in most of our nebulae. We have also planned an infrared follow-up using Spitzer Space Telescope. Several questions arise in fact about the relation between ionized and molecular gas/dust, regarding their locations and physical conditions (role of dust rings as shaping agents, spatial coexistence of molecular and ionized gas). In this poster we show some preliminary results obtained so far with our project.

16. V605 Aql: 80 Years after the Final Helium Shell Flash

G. C. Clayton, LSU; J. M. Fedrow, Evergreen State Coll.; P. A. Crowther, Univ. of Sheffield, et al.

Only three stars have been observed going through a final helium shell flash since the advent of modern instrumentation, FG Sagittae (in 1894), V605 Aquilae (in 1919) and Sakurai's Object (in 1996). In 1921, a spectrum was taken of V605 Aql while it was in its cool giant phase. This spectrum was identical to that typically seen in R Coronae Borealis (RCB) stars with $T(\text{eff}) = 5000$ K. The star is very faint at present, behind thick clouds of dust. The star is at the center of A58, an old Planetary Nebula. Despite being extremely faint ($m(V)=23$), we have been able to obtain new optical spectra with the VLT of V605 Aql and its nebula. These spectra indicate that V605 Aql has evolved significantly in only 80 years. It now has a $T(\text{eff}) \sim 95,000$ K, and has abundances similar to those seen in [WC] central stars but not to those in a typical RCB star.

17. The Dusty Circumstellar Envelopes of Post-AGB Stars

Kim Clube & Tim Gledhill, University of Hertfordshire

Mid-IR images of a small sample of post-AGB stars have been obtained with the mid-IR camera, OSCIR, mounted on the 8-m Gemini North Telescope. Model calculations, using a 2-D dust RT code, have been performed in order to constrain the physical and chemical properties of the dust in the envelopes, for each object. Studies of individual objects in this transitional phase can be used to investigate the final period of AGB mass loss and improve our current understanding of the evolution of PN. Mid-IR images and modelling results for IRAS 22223+4327 are presented here. The observed mid-IR structure, which shows two emission peaks, is interpreted as the detection of two limb brightened edges of a dust torus. The position of the dust torus is in agreement with the position of the outflows observed in the archived HST optical images. This object deviates from axisymmetry, in the same way as several other post-AGB stars, where one of these peaks is brighter than the other. From the modelling of the SED of this object, estimates for the mass of the dust in the envelope and the mass loss rate are derived.

18. The Luminosity-Specific Planetary Nebula Density in the Local Group Galaxies

R. L. M. Corradi, ING, La Palma, Spain, & IAC, Tenerife, Spain; A. Buzzoni, INAF, Oss. di Bologna, Italy; M. Arnaboldi, ESO, Garching, Germany & INAF, Oss. di Torino, Italy

The luminosity-specific PN density in a galaxy, known as the “alpha ratio”, is computed using population synthesis models applied to simple stellar populations as well as to elaborated galaxy templates covering the full range of star-formation history as displayed by the different Hubble morphological types. Theoretical predictions were then compared with the updated (and deepest) PN census in the Local Group galaxies.

The main result is that alpha is remarkably constant along the Hubble sequence. This implies that: 1) data favour the empirical initial-to-final mass relation by Weidemann (2000), corresponding to a stronger mass loss for the PN progenitors compared to the standard scenario for PopII stars as in globular clusters; 2) the PN population is dominated by a narrow range of post-AGN core masses ($<0.60-0.65 M_{\odot}$); 3) the lifetime of a considerable fraction of PNe is constrained by the dynamical timescale of nebula evaporation rather than the stellar core mass evolution, supporting a small dependence of alpha with age and distance, and hence a “universality” of the PN luminosity function. These results are part of an article by Buzzoni, Arnaboldi & Corradi (2006), in press on MNRAS (astro-ph/0602458).

19. Evolution of Maser/IR Objects with Very Thick Dust Envelope

Shuji Deguchi, Nobeyama Radio Observatory

Some stellar maser sources at preplanetary stage have very thick circumstellar envelopes for which counterparts were not found in near-infrared bands. We investigated such stars with radio/NIR/MIR wavelengths using NRO 45-m, UH2.2-m, SUBARU 8.2-m telescopes. Furthermore, using Spitzer/Glimpse survey in the Galactic plane, we found counterparts in the 3.5 micron band for all of the OH/IR objects without previous NIR identification. One of interesting objects among these is IRAS 18450-0148 (W43A), for which the spectral energy distribution has a steep inclination between 3.5 and 5.4 micron. The spectra indicate that they have a massive thick disk, which were formed by binary-interactions.

20. A Search for Mid-Infrared H₂ Rotational Line Emission in Planetary Nebulae

Harriet L. Dinerstein, U. Texas, Austin; Matthew J. Richter, U. Calif., Davis; Kris Sellgren, Ohio State U.; John Lacy, U. Texas, Austin

Many planetary nebulae (PNe) show near-infrared quadrupole emission from vibrationally excited H₂ which results from radiative excitation by stellar UV photons (fluorescence) and/or heating of residual molecular material by shocks. This material should also emit longer-wavelength (mid-infrared) transitions from the excited rotational levels of the ground vibrational state. These pure rotational ($v = 0-0$) lines should be good indicators of the temperature of the molecular gas, since the populations of the lowest few rotational levels are dominated by collisions. However, such rotational line emission has been surprisingly hard to detect in PNe, and was seen by ISO in only a few of the nearest (e.g. the Helix) and brightest (NGC 7027) objects. In this poster, we present results from a search for the 17.0 micron $v = 0-0$ S(1), 12.3 micron S(2), and 8.03 micron S(4) lines using TEXES (Lacy et al. 2000) on NASA's Infrared Telescope Facility (IRTF) on Mauna Kea. The high spectral resolution (up to $R = 80,000$) of this cross-dispersed echelle spectrometer provides much better sensitivity than do lower spectral resolution space instruments, for detecting narrow emission lines with low line to continuum contrast against the strong thermal dust emission at these wavelengths. We set 3-sigma upper limits of a few times 10^{-19} W m⁻² on the 17.0 micron S(1) line in two compact nebulae, IC 5117 and Hb 12; for IC 5117, this is about a factor of 50 lower than the limit set from a recent Spitzer IRS spectrum. We do detect the S(1) line in NGC 7027, which was not reported as being present in spectra taken by either ISO or Spitzer (although some of the higher-J lines are seen). Our upper limits on the ratio of the 17.0 micron 0-0 S(1) line to 2.122 micron 1-0 S(1) in IC 5117 and Hb 12 are incompatible with predictions from moderate-density PDR models, but may be consistent with evolutionary models of PN envelopes (Natta & Hollenbach 1995) where the gas densities are greater than 10^6 cm⁻³.

21. Kinematical Analysis of Bipolar Planetary Nebulae

Martina Dobrincic, Instituto de Astrofisica de Canarias, Spain, et al.

We present kinematical data of a sample of bipolar planetary nebulae that covers a wide range of observed morphologies: from low to highly collimated objects. The equatorial expansion velocities measured in our objects are always in the low to medium range (3 to 16km/s). However, the polar expansion velocities we measure range from low (18km/s) to very high (~ 100 km/s). More interestingly, we find deceleration in one of the objects analyzed. We have estimated the kinematical ages of our objects by using distances estimates from rotation curves when available, otherwise statistical distances have been used. None of the objects in our sample, even those that show extreme collimation, seems to be young. We have compared our results with the state-of-the-art theoretical models of bipolar PNe formation. We find good agreement between our measured observed expansion velocities and numerical models that use magnetic fields as collimation mechanism.

22. CLOUDY Modeling of Weird Far-IR Emission in the Central Zone of the Helix Nebula

Adrienne Dove & Angela Speck, University of Missouri - Columbia

The central zone of the Helix Nebula appears as a hole in the classic optical image, yet has been found to produce both He II and [OIV] emission. Strong emission has been observed at 60-100 microns, but is not detected in the mid-IR, or at 160 or 180 microns. The emission in this region is suspected to be due to cool dust grains. We present the results of modeling using the photoionization code, CLOUDY, to match this observed emission. Our best fit models fill the central zone with 1 micron sized grains, with a gas-to-dust ratio of 500. These grains are composed of both graphite and astronomical silicate, with little sensitivity to specific grain composition. Additional models were run to limit the distribution of grain sizes. Grains between 0.5-2 microns, with a power law distribution of a $a^{-3.5}$ fit within error, as did Gaussian distributions centered at 1 micron, with FWHM up to 0.6 microns, indicating that the dust grains must fall within a fairly narrow range of sizes. As previously predicted, the resulting grain temperatures in the central zone were around 30K. The effects of radiation pressure and Poynting-Robertson drag on dust grains surrounding the central star were also calculated; however, these calculations cannot explain the predicted size distribution. Thus, we also discuss the nature and origin of the dust grains in this region.

23. Simulations of Stopped Outflows in Pre-Planetary Nebulae

Vikram Dwarkadas, Univ of Chicago; Raghvendra Sahai, NASA JPL; Chin-Fei Lee, CfA

Pre-planetary nebulae (PPNs) represent the crucial evolutionary phase between the AGB and planetary nebula (PN) phases. PNs are formed from PPNs when the central stars become hot enough to ionize the circumstellar medium. Many PPNs show the presence of fast, highly collimated outflows. We have carried out high-resolution numerical simulations to investigate the formation and evolution of these outflows using the Zeus-2D code. We have investigated the scenario when the wind from the central star is turned off after a finite time, a possible mechanism to explain multipolar shapes in some PPNs. In these simulations a collimated wind with a given mass-loss rate, wind velocity, and opening angle expands into a surrounding AGB wind with a higher mass-loss rate and a lower velocity, forming a collimated lobe. After some years the fast wind from the star is turned off. The lobe cavity begins to shrink because there is no more material pushing out on it. The wall of the lobe expands and becomes thicker, although its overall density decreases. Its dense tip becomes flatter and expanded, and there is a long ‘nose’ behind it. The tip of the lobe still has enough inertia to continue expanding for at least a few doubling times or so, before the interaction with the ambient medium eventually slows it down. We present initial results and outline the significance for PPN evolution.

This work is supported by NASA grant HST-AR-10317 awarded by STScI to RS and VVD, and by NSF award AST 0319261 to VVD.

24. Three-Dimensional Ionisation, Dust RT and Chemical Modelling of PNe

B. Ercolano (1), M.J. Barlow (1), P.J. Storey (1), T. A. Bell (1), D. Poelman (2,3), S. Viti (1) & M. Spaans (2)

(1) University College London, UK; (2) Kapteyn Astronomical Institute, Netherlands; (3) SRON Netherlands Institute for Space Research

Our understanding of the physical and chemical properties of photoionised regions in our own and other galaxies heavily relies on the interpretation of spectral and kinematical data. Our state-of-the-art 3D Monte Carlo photoionisation code (MOCASSIN) includes a fully self-consistent treatment of the radiative transfer (RT) of dust grains that are intermixed with the gas, both in the ionised (HII) and in the photo-dissociation (PDR) regions.

The current publicly available version of the MOCASSIN code is described here. We also provide a progress report of our on-going efforts to the expansion to a fully self-consistent modelling of PDRs observed in many PNe.

25. Family Members Not Invited to Dinner: What the Awkward Relatives Tell Us about Planetary Nebulae Hosting Binary Systems

Adam Frankowski, Institut d'Astronomie et d'Astrophysique, Univ. Libre de Bruxelles

Planetary Nebulae (PNe) are a continuous inspiration to both observers and theoreticians. Our understanding of PNe phenomena grows steadily, but alongside grow new questions. One of the still unresolved issues is the connection between PNe and binarity. Is a binary companion vital for PN formation? What is its role in the shaping of a nebula? How to reproduce orbital period distributions for known post-AGB and post-PN binaries? Is there a link between binarity and circumstellar chemistry? Some light on these issues can be shed by other families of objects related to binary central stars of PNe: post-AGB binaries, symbiotics, or chemically peculiar Ba/CH/S stars. These are usually not so striking in appearance, but they have also gone through the PNe phase in the more or less distant past. One of such potentially telling cases is 56 Peg, a barium star that has recently been found to be a spectroscopic binary. It is prominent in having an extremely low mass function and second shortest orbital period among barium stars, in connection with X-ray activity and unusual spectral line variability. Another example is WeBo 1, a PN hosting a chromospherically active barium star in the center. A rather peculiar class of d'- symbiotics, notable for their spectral properties and high spin rates, seems also relevant. The symbiotic novae and their nebulae tell us yet another interesting family story. I discuss what we can (and do) learn about PNe from the aforementioned classes of binaries, with a particular stress on a few exemplary objects.

26. A Search for New Emission Nebulae from the SHASSA and VTSS Surveys

David J. Frew (Macquarie), Greg Madsen (AAO), and Quentin Parker (Macquarie/AAO)

As an adjunct to the planetary nebula (PN) search from the AAO/UKST $H\alpha$ survey, a visual search was conducted for new emission nebulae from the SHASSA and VTSS surveys, above 10 degrees in Galactic latitude. Fifteen new objects were found from SHASSA and three from the available VTSS fields. With one exception, all objects are >5 arcmin across, as smaller nebulae are confused with large numbers of artifacts and compact emitters on these surveys. All previously known PNe larger than this size in the search area, as well as Hewett 1, PG 0108, and PG 0109, were recovered in this blind search. Candidates were selected as discrete, morphologically symmetric $H\alpha$ enhancements, to differentiate them from the ubiquitous diffuse emission structure of the ISM. Most of the new discoveries are probable Stromgren spheres in the ISM (high-latitude HII regions). However, some show unusual line ratios (e.g. strong [OIII] or [NII] emission) based on slit spectroscopy and WHAM data (see Madsen et al., this conference), suggesting these are ionised by a very hot subdwarf or white dwarf star, and may be possible PNe. Our most interesting discovery is a rare bowshock nebula around a bright, previously unnoticed, nova-like cataclysmic variable.

27. IRS/SPITZER Observations of OHPNe

D. A. Garcia-Hernandez & J. V. Perea-Calderon, ESAC, ESA; M. Bobrowsky, Space Telescope Science Institute, et al.

We present IRS SPITZER spectra of a selected sample of galactic ‘OHPNe’. This is a rare class of infrared sources displaying both radio continuum and OH maser emission at 1612 MHz. Our observations show that they are heavily obscured O-rich stars whose mid-infrared spectra are dominated by the presence of strong and broad silicate absorption features at 9.7 and 18 microns.

Our observations confirm that the onset of the ionization has already started in some of the sources in the sample. We propose that these heavily obscured OHPNe may represent the youngest population of high-mass PNe in the Galaxy.

28. The Breakage of Planetary Nebulae at the End of the Windy Phase

G. Garcia-Segura, J. A. Lopez, J., Meaburn, W. Steffen, and A. Manchado

In this paper, we explore the remaining dynamic of initially “ionized bounded” planetary nebulae that loose their winds as a result of the evolution of their central stars. When the stellar winds end or become negligible, the hot, shocked bubbles depressurize and the thermal pressure of the photoionized regions, at the inner edge of the swept-up shells, becomes dominant. At this moment, planetary nebulae break up into pieces, creating clumps with comet-like tails and long, photoionized trails in between, while the photoionized material expands backward toward the central stars. Once that the photoionized gas fills up the whole cavity, it presents a linear increasing kinematic that goes from null velocity at the centers to 50 kms at the edges.

29. NLTE Model for the Central Star of NGC6543

Leonid Georgiev, Instituto de Astronomia, UNAM, Mexico, et al.

Based on our deep optical spectrum (Georgiev et al. 2006, ApJ, in press) and archival UV data, we performed NLTE modeling of the wind of the central star of NGC6543. In the poster we present the obtained parameters of the star and an estimation of the iron composition. We discuss the composition of the wind related to the missing Fe XIV emission from the wind-nebula interacting region.

30. Search for a Magnetized Disk toward K 3-35

Yolanda Gomez, CRyA-UNAM, Mexico; Daniel Tafoya, Harvard- Smithsonian, CfA, USA; Guillem Anglada, IAA, Granada, Espana, et al.

K 3-35 is one of the two planetary nebulae (PNe) where water maser emission has been detected, suggesting that these kind of objects departed from the AGB phase some decades ago. We present VLA (Very Large Array) observations of the 1720, 1667, 1665 and 1612 MHz OH maser emission from the central region of K 3-35. Circular polarization was found in the 1720, 1665, and 1612 MHz transitions. There are several models where the presence of toroidal magnetic fields have been invoked to explain bipolar planetary nebula. The OH 1665 MHz spots toward K 3-35 are distributed in an elongated structure, along the minor axis of the radio continuum bipolar outflow. An estimate of the magnitude of the magnetic field, derived from the 1665 lines, toward this young planetary nebula is ~ 0.14 mG at a radius of 250 AU.

31. The Chemical Content of Nearby Galaxies: NGC 147

Denise R. Gonçalves, IAG, Universidade de São Paulo, Brazil; Laura Magrini, INAF, Osservatorio Astrofisico di Arcetri, Italy; Pierre Leisy, Isaac Newton Group of Telescopes, Spain, et al.

Are dwarf ellipticals and spheroidals the evolved descendant of previous star-forming dwarfs? A way of answering this question is through the study of the metallicity-luminosity relation of the dwarf galaxies—the LG is plenty of them—determined from PNe which are present from early- to late-type galaxies.

The dwarf spheroidal galaxy NGC 147 is one of the companions of the Andromeda galaxy. In this contribution we present the first spectroscopic results of the PNe population of NGC 147, obtained from the GEMINI Multi-Object Spectrographs (GMOS) in 2005.

Our chemical analysis is based on those PNe elements that are not processed during the stellar lifetimes, then representing the chemistry of the galaxy at the time PNe progenitors were born. Through the comparison of NGC 147 PNe abundances with the abundances of the galaxy oldest POP II stars, we discuss the chemical evolution of this galaxy, which seems to be different from the evolution of its sister galaxy, NGC 185.

32. 3D Photo Modelling: Proving That ICF Overestimates the Nitrogen Abundances of FLIERS

Denise R. Gonçalves, IAG, Universidade de São Paulo, Brazil; Barbara Ercolano & Aurelio Carnero, University College London, UK, et al.

We recently (Gonçalves et al. 2006) showed that the apparent enhanced nitrogen abundance previously reported in the fast, low-ionization emission regions (FLIERS) of PNe, particularly in NGC 7009, is due to ionization effects.

We reached this conclusion through the 3D photoionization modeling of the bright inner rim of NGC 7009 and its pair of FLIERS, with constant nitrogen abundance throughout the nebula.

The $(N^+/N)/(O^+/O)$ ratio predicted by our model is 0.60 for the rim and 0.72 for the knots, clearly in disagreement with the $N^+/N=O^+/O$ assumption of the ionization correction factors method, ICF. Therefore the ICFs will be underestimated in both components, rim and knots, but more so in the knots. This effect is partly responsible for the apparent inhomogeneous N abundance previously derived for the FLIERS.

In short, what we pointed out with this study is that a realistic density distribution is essential to the modeling of a non-spherical object, if useful information is to be extracted from spatially resolved observations.

The apparent N-enrichment in FLIERS obtained with the ICF method (Balick et al. 1994; Gonçalves et al. 2003)—not reliable for spatially resolved PNe—has been interpreted as an evidence that FLIERS originate from recent high-velocity ejections of the PN central star, perhaps hiding the true nature of these structures.

Based on the above results we are also investigating what would be the effect of the N/O ICF overestimation on the definition of Type I PNe which do not have peculiar structures like FLIERS.

33. New Small Planetary Nebulae Discovered in the Galactic Center Direction

Slawomir K. Gorny, Copernicus Astronomical Center, Poland

We report on an ongoing search for small planetary nebulae (PNe) in the southern hemisphere. The program utilises public data from the scanned images of the AAO/UKST $H\alpha$ survey supplemented with other broad-band visual photometry available. The selected sources are spectroscopically observed with the 1.9m telescope of the South African Observatory.

In the best observed field of 45 square degrees near the Galactic center 22 new PNe candidates have been discovered by us in addition to 48 PNe previously known. Eight of our nebulae with intermediate diameters have been independently discovered during the recent post-survey follow-up spectroscopic program of the AAO/UKST $H\alpha$ team (Q. Parker, private communication). The remaining objects are all very small or star-like in appearance. Our search in this Galactic field is so far complete down to $H\alpha$ equivalent R magnitude of about 15 but is planned to reach 17mag and should reveal obscured high extinction candidates with $E(B - V) = 4$.

In this report we describe our selection procedures and comment on some other existing possibilities to look for new PNe with available data from large near-infrared, radio and visual surveys. We derive also preliminary conclusions about the completeness of the known PNe population and their distribution in the Galactic center direction.

34. The XPN Database

Martin A. Guerrero, IAA-CISC; You-Hua Chu & Robert A. Gruendl, Univ. of Illinois

Diffuse X-ray emission from hot gas in planetary nebulae (PNe) was hinted by ROSAT and ASCA, but only the improved sensitivity and spatial resolution of XMM-Newton and Chandra have allowed detailed studies of the hot gas in PNe. These studies are helping us to better assess the effects of fast stellar winds and collimated outflows in the shaping and evolution of individual PNe, but a comprehensive picture is lacking, because the X-ray analysis of different PNe is not homogeneous and, therefore, cannot be compared. Furthermore, a significant number of X-ray observations of PNe that did not detect X-ray emission have not been reported. We have undertaken a systematic study of all XMM-Newton and Chandra observations of PNe benefiting from an homogeneous analysis using the most up-to-date versions of SAS and CIAO, respectively, and the recently released calibration files with greater accuracy for energies below 1.0 keV. All reprocessed event files, derived data products (X-ray images and spectra), supporting observations at other wavelengths, and analysis results are forming a database, the XPN Database, that can be accessed at <http://www.iaa.csic.es/xpn>

35. Observations and Models of NGC 2610

J. Patrick Harrington, Univ. Maryland

We argue that there is still a need for clean observational tests of photoionization codes. NGC 2610 is a high-excitation planetary nebula which, even at HST resolution, is smooth and symmetric. Helium is He^{++} throughout this nebula and it has a high electron temperature (18,000 K), resulting in strong ultraviolet lines. It is the best object we know of to test the performance of photoionization codes without the complication of low ionization knots or filaments. Its large angular diameter ($\sim 40''$) allows spatial gradients to be observed. In 2001 and 2003, we obtained HST STIS long-slit observations with good spatial resolution to test against models. Observed lines cover wavelengths from 1240Å to 6563Å and include H I, He II, C III], C IV, N IV], N V, [O III], O IV], [Ne III], [Ne IV], and [Ne V]. The He II 1640Å/He II 4686Å line ratio determines the (small) reddening accurately. The fluxes are in reasonable agreement with the only other UV spectra, obtained with IUE in 1981. The [O III] 4363Å line flux is needed to determine the temperature of the nebular gas and to construct the models. Since this line proved unmeasurable in the HST spectra, we have obtained ground-based (Kitt Peak 4-m) observations at the same slit position as the HST data.

We have constructed photoionization models of this nebula, which we compare with these observations. Collisional excitation of H^0 is an important coolant.

36. Parallaxes of 16 Planetary Nebulae

Hugh C. Harris, US Naval Observatory

Improved trigonometric parallaxes of 16 nearby planetary nebulae are presented. Continued observations now give reduced errors and additional nebulae since initial results were given in 1997. Twelve nebulae have parallax errors less than 20 percent. Comparisons with other distance estimates are discussed. The distances tend to be greater than many other estimates, but are somewhat smaller than estimated from spectroscopic analysis of the central stars.

37. The Sulfur Abundance Anomaly in Planetary Nebulae

R. B. C. Henry, Univ. of Oklahoma; K. B. Kwitter, Williams College; J. B. Milingo, Franklin & Marshall U., et al.

The failure of S and O abundances in most planetary nebulae to display the same strong direct correlation between these two elements that is observed in extragalactic H II regions represents one of the most perplexing problems in the area of PN abundances today. Galactic chemical evolution models as well as large amounts of observational evidence from H II region studies support the contention that cosmic abundances of alpha elements such as O, Ne, S, Cl, and Ar increase together in lockstep. Yet abundance results from both the Kingsburg & Barlow (1994) and Henry, Kwitter, & Balick (2004) databases show a strong tendency for most PNe to have S abundances that are significantly less than expected from their observed level of O, especially at low O. The most likely explanation for the sulfur anomaly is the past failure to properly measure the abundances of unseen ionization stages above S^{+2} . Our team's proposed observations of [S III] and [S IV] lines with Spitzer will allow us to test this hypothesis.

38. Planetary Nebulae Luminosity Function in NGC6822

Liliana Hernández-Martínez, (IA-UNAM), Miriam Peña (IA-UNAM, U de Chile)

We present preliminary results of CTIO 4-m MOSAIC 2 data in NGC 6822. At this time, in this galaxy there are about 17 Planetary Nebulae (PNe) reported. We obtained on-band off-band ([OII] 5007, Ha) data of the whole galaxy to search for more PNe. We measured [OIII] 5007 fluxes for the whole sample. We are studying if the PNe Luminosity Function (PNLF) can be used as distance indicator in this galaxy because there are some problems involved: few PNe and an apparent anomalous distribution in the PNLF (Leisy et al. 2005).

39. The Orbital Parameters of the Close Binary Central Stars of NGC 6337 and NGC 6026

Todd Hillwig, Valparaiso University; Howard Bond, STScI; Melike Afsar, Ege University

We present the results of time-resolved photometry and spectroscopy of the central stars of the planetary nebula NGC 6026 and time-resolved photometry of the central star of the planetary nebula NGC 6337. The results of period analysis give an orbital period of 0.528088 days for NGC 6026 and a photometric period of 0.173474 days for NGC 6337. In the case of NGC 6337 it appears that the photometric period accurately reflects the orbital period and that the variability is the result of an irradiated hemisphere on the cool companion. For NGC 6026, however, radial velocities from spectroscopy show that the orbital period is twice the photometric period. In this case, the photometric variability is due to an ellipsoidal effect in which one of the companions fills, or nearly fills, its Roche lobe. The short orbital periods in both systems lead to the conclusion that both passed through a common envelope phase prior to ejection of the planetary nebula. Based on the data and modeling using the Wilson-Devinney code, we discuss the physical parameters of the two systems. We also relate the physical parameters to the shape and orientation of the nebulosity.

40. Using H₂ Emission to Study the Fast Wind in Bipolar Proto-Planetary Nebulae

Bruce J. Hrivnak, Valparaiso University

The shaping of bipolar proto-planetary nebulae is thought to occur as a fast wind from the central star interacts with a circumstellar envelope containing a latitudinal density dependence. But when does this fast wind begin? Collisionally-excited H₂ emission in the nebulae provides a tracer of the fast wind as it interacts with the remnant AGB mass loss which forms the circumstellar envelope. We have carried out a study of the kinematics of the H₂ emission in IRAS 17150-3224, IRAS 16594-4645, Rob 22, and Hen3-401, using high-resolution, long-slit spectra obtained with the Phoenix spectrograph on Gemini-South and the KPNO 4-m telescopes. All four have bipolar nebulae and in all four the H₂ is collisionally-excited. The spatially-resolved spectra are compared with HST-NICMOS H₂ images and resulting kinematical models developed.

41. Atlas of Monochromatic Morphologies of Galactic PNe

Trung Hua, L.A.M.-C.N.R.S.; Michael Dopita, Mt Stromlo, Australia; Sun Kwok, University of Calgary, et al.

We report monochromatic images taken through narrow bandpass (less than 10 Å) interference filters for a large sample of galactic planetary nebulae. Wide field pictures from the OHP 120-cm and/or the ATT 2.3-m telescope often provide outermost structures, whereas high-spatial resolution allows seeing detail in the bright PN cores. Ring systems can be outlined between the primary envelopes using special smoothing processes.

42. 3mm to 1mm Molecular Line Survey of NGC 7027

Huang, Yu-Chin, Academia Sinica Institute of Astronomy and Astrophysics (ASIAA); Kwok, Sun, ASIAA; & Dinh, Van-Trung, ASIAA

We present the sensitive spectral line survey of NGC 7027 in 3mm and 1.3mm bands using the Arizona Radio Observatory 12m and HHT 10m telescopes. NGC 7027 is a young carbon-rich planetary nebula with high surface brightness. It is strong in infrared emission and has many molecular lines. However, there is no spectral line survey of NGC 7027 covering the whole 3mm and 1.3mm bands until now. We have completed a large part of the survey and detected many lines such as hydrogen recombination lines, rotational transitions of CN, CO, and its isotope. Identifying features and measuring the line strengths which can be used to estimate the abundance of important molecular species are what we plan to do.

43. Winds in Central Stars of Planetary Nebulae in Our Galaxy

M. Ibarrola & A. Arrieta, U. Iberoamericana; L. Georgiev, IA UNAM, et al.

We have chosen from IUE data base some central stars of planetary nebulae in our Galaxy that show stellar continuum and PCyg profiles in resonant lines. After spectra correction for the galactic extinction, we derived the temperatures by fitting the stellar and nebular continuum. We fit the P Cyg profiles correspondent to the C IV 1548/1551 AA, Si IV 1394/1403 AA and N V 1239/1243 AA lines using a line transfer code together with a genetic minimization algorithm (Georgiev and Hernandez, 2004) and we obtained the mass loss rates and the terminal velocities for winds in these stars. We use those results in order to discuss the theory of wind acceleration and the distance to the planetary nebulae.

44. A Molecular Jet in the Proto-Planetary Nebula Candidate IRAS19134+2131

Imai H., Department of Physics, Kagoshima University; Morris M., Department of Physics and Astronomy, Univ. California, Los Angeles; Sahai R., Jet Propulsion Laboratory, NASA

Using the VLBA at 6 epochs during 2003 January – 2004 April, we have observed water maser emission in the proto-planetary nebula candidate, IRAS19134+2131, in which the water maser spectrum has two groups of emission features separated in radial velocity of ~ 100 km/s. The morphology and 3-D kinematics indicates the existence of a fast collimated flow with a dynamical age of only ~ 50 years. Such a “water fountain” source implies the moment of a stellar jet, which may shape the planetary nebula. The locations of the water maser features have been measured with respect to the extragalactic reference source J1925+2106, which accurately trace the feature motion along the Galactic plane. This enables us to estimate the distance to the water maser source on basis of the measurement of an annual parallax and the kinematic distance method.

45. Far UV Emission from NGC7009

Rosina C. Iping, the Catholic University of America; G. Sonneborn, NASA GSFC; You-Hua Chu, Univ. of Illinois, et al.

The high-excitation planetary nebulae NGC7009 and its central star were observed with FUSE through the 30×30 aperture. To isolate the inner and outer parts of the nebulae from the central star, the narrow slit, 1.25×20 arcsec, was used and positioned at two different locations in the nebula as well as on the central star. The nebular spectra show strong emission from He II, C II, N II, N III, S III, S IV, S VI and O VI with stronger emission closer to the central star. In this paper we present results obtained on the spatial variation of these tracers of highly ionized gas. The hot central star of NGC7009 is discussed in a separate paper by Sonneborn et al.

46. A Catalog of Extragalactic Planetary Nebulae

George H. Jacoby, WIYN Observatory; Agnes Acker, Observatoire de Strasbourg

We are preparing a catalog of all extragalactic planetary nebulae. The current estimate of the number of entries is about 8,000 objects, with the most significant samples coming from the Local Group (SMC, LMC, M33, and M31), but with representation from over 50 galaxies.

The SMC catalog is complete, with a draft version available on-line (<http://www.nao.edu/wiyn/jacoby/pncat/smc-pn.htm>). The LMC catalog, along with most of the distant galaxies, will be completed in the summer of 2006 in collaboration with Quentin Parker, and M31 will follow a year later.

The catalog will offer a uniform naming convention that follows IAU guidelines, and with aliases to the more common names in the literature. Coordinates are all converted to J2000, and other information is provided when available (e.g., discoverer, fluxes, velocity, central star properties). As an electronic catalog hosted by the Centre de Données astronomiques de Strasbourg (CDS), it is extensible to add new identifications as they arise, or to delete entries if a candidate PN is shown to be a false identification. Observers are encouraged to send us their data to be included in the catalog.

47. The Nature of the Low Metallicity PN SBS 1150+599 (=PN G135.9+55.9)

G. H. Jacoby, WIYN; P. M. Garnavich, U. Notre Dame; H. E. Bond, STScI; A. Noriega-Crespo, Caltech; J. Quinn & J. S. Gallagher, U. Notre Dame; D. Garcia-Galili

We have observed SBS 1150+599 spectroscopically in the UV using HST to derive the chemical abundances of carbon ($C/H \sim 7.6$) and nitrogen ($N/H \sim 7.0$) for the first time. The central star temperature is better constrained with the UV data to about 130,000K, but still is not fully constrained. This uncertainty dominates the uncertainty in the oxygen abundance, which has been the subject of some debate. With these data, SBS 1150+599 still has the lowest O/H of any PN. Furthermore, the physics of this object are so extreme that minor differences in atomic modeling impact the composition analysis quite strongly.

We also report on the binary nature of the central star, and its photometric and kinematic variations. The light curves typically exhibit CV-like properties with an amplitude of 13% and an orbital period of 3.924 hours.

48. Calibrating Type Ia SN Using the Planetary Nebula Luminosity Function

George H. Jacoby, WIYN; Mark M. Phillips, LCO; John J. Feldmeier, Youngstown State Univ.

Determining the Hubble constant directly to high precision, although seemingly old-fashioned, is still vital to cosmological models. While recent results from WMAP imply a Hubble constant roughly equal to that found from the usual distance indicators, that result assumes an equation of state ($w = -1$). Independent measures are critical to determine cosmological parameters while constraining the equation of state. Type Ia SN are excellent distance indicators over great cosmological distances, provided that the relationship between maximum magnitude and decline rate is taken into account (Phillips et al 1999). However, it has been historically difficult and controversial to calibrate the zero point for this distance indicator, and to assess the presence of systematics between old and young populations that can impact measurements of dark energy.

Using the high precision [O III] 5007 Planetary Nebulae Luminosity Function distance indicator, we can nearly double the number of known distances to nearby Type Ia SN, and hence improve the zero point calibration. We report three new PNLF distances and two new lower limits for five galaxies: NGC 524, 1316, 1380, 1448, & 4526. All have well-observed SN Type Ia. We derive a revised Hubble constant, and compare our results against those from the Cepheid calibration of Type Ia host galaxies. We also apply a new, higher accuracy, IR approach to dealing with internal dust in the SN Ia light curves.

49. Nebular Emission Lines in IRAS 17347-3139

Francisco Jimenez-Esteban, Hamburger Sternwarte, Hamburger University; Jose Vicente Perea-Calderon, European Space Astronomy Center; Pedro Garcia-Lario, Research and Scientific Support Department of ESA, et al.

In this poster we report for the first time the detection of nebular emission lines in both optical and mid-infrared spectrums of IRAS 17347-3139. The presence of these emission lines is a clear indication that ionization of its circumstellar envelope has already started. Thus, despite this source still presents most of the typical AGB star characteristics, in fact, it is an infrared Planetary Nebula heavily obscured in the optical.

50. **ELSA: An Integrated, Semi-Automated Nebular Abundance Package**

M. D. Johnson, Wesleyan U.; J. S. Levitt, Williams Coll.; R. B. C. Henry, U. Oklahoma, et al.

We present ELSA, a new modular software package, written in C, to analyze and manage spectroscopic data from emission-line objects. In addition to calculating plasma diagnostics and abundances from nebular emission lines, the software provides a number of convenient features including the ability to ingest logs produced by IRAF's "splot" task, to semi-automatically merge spectra in different wavelength ranges, and to automatically generate various data tables in machine-readable or LaTeX format (the latter intended to be nearly publication quality). ELSA features a highly sophisticated interstellar reddening correction scheme that takes into account temperature and density effects as well as He II contamination of the hydrogen Balmer lines. Abundance calculations are performed using a 5-level atom approximation with recent atomic data, based on R. Henry's "abun" program. Improvements planned in the near future include use of a three-region ionization model, similar to IRAF's "nebular" package, error propagation, and the addition of ultraviolet and infrared line analysis capability. Detailed documentation for all aspects of ELSA is available.

51. **Cometary Globules in the Ring Nebula**

Eric Josselin, Univ. Montpellier II; Rafael Bachiller, OAN Madrid; Patrick J. Huggins, Univ. New York, et al.

Planetary nebulae exhibit complex structures, both on global and local scales. Among the most intriguing features are the so-called cometary globules, whose origin is still debated. We report high-resolution imaging of cometary globules in the Ring Nebula in the millimeter CO J=1-0 and J=2-1 lines. The most prominent globules are resolved and can thus be studied in detail. These structures are typically a few arcseconds wide and have a mass of $3\text{-}6 \times 10^{-4} M_{\odot}$. Only one among the six globules analyzed here has a tail, which is randomly oriented with respect to the central star of the nebula. The properties of these globules are fully consistent with an origin linked with instabilities in the nebula. Furthermore, regarding their spatio-kinematic properties, these globules seem to have formed in filaments, which are probably a signature of a magnetic field.

52. Long-term Photometric and Spectral Study of Planetary Nebula Variability

E. B. Kostyakova, Sternberg State Astronomical Institute, Moscow, Russia

During long-term (1968-2005) photoelectric study we revealed several planetaries with marked variations of their integral UBV brightness: NGC 6572, IC 4997, NGC 6891, Hu 2-1, and NGC 6543. Systematic spectral study of these objects showed also noticeable changes in their spectra. The most remarkable photometric and spectral behaviour was found for the young nebula IC 4997. Over several years (1968-1985) it exhibited a gradual decline in the total UBV brightness, reached generally 0.4 - 0.6 mag, an abrupt stop of this decline in 1985-1986, and since the late 1986 to the present days - almost linear brightening, amounted 0.4 - 0.5 mag in each of three filters.

The most spectral characteristics of IC 4997 - the brightest emission lines and the continuum of the central star - are also changed in time. Over 1972-1992 the increase of excitation and ionization degrees of the nebula was detected. The most representative ratio R (the ratio of the [O III] λ 4363 and H_{γ} fluxes) exhibited the greatest change: between 1972 and 1992 its value became threefold; its maximum ($\log R = +0.28$) was reached in 1992. The spectral analysis showed that over aforesaid period the nebula's total electron density and electron temperature rose essentially, and the effective central star temperature rose from 40000 K to 60000 K, or even higher. The growth of the nebula's activity, which began in the late 1960s, had stopped in the early 1990s and began to lower till the present days.

The nebula NGC 6572 over 1968-1978 showed an ascent of visual brightness, reached 0.4 - 0.5 mag. During following years it had undergone quasiperiodic (of order of two decades) fluctuations of the brightness in the range of 0.2 mag. Several spectral features showed the rise of nebula's spectral activity - the increase of the excitation and ionization degrees over the whole observational period. The ratio R became almost doubled over 1972 - 2005. The continuum of the central star also showed variability.

Distinctly, the studied planetaries are in an active stage of their evolutionary development.

53. Gallery of Planetary Nebula Spectra

Karen B. Kwitter, Williams College; Richard B. C. Henry, University of Oklahoma

We present the updated Gallery of Planetary Nebula Spectra now available at oit.williams.edu/nebulae. The website offers high-quality, moderate resolution (~ 7 - 10 \AA FWHM) spectra of Galactic planetary nebulae from 3600-9600 \AA , obtained by Kwitter, Henry and colleagues with the Goldcam spectrograph at the KPNO 2.1-m or with the RC spectrograph at the CTIO 1.5-m. The updated Gallery includes spectra for a total of 128 PNe covering Type I, Type II and halo objects. The master PN table, which contains atlas data and an image link, can be re-ordered by object name, galactic or equatorial coordinates, distance from the sun, the galactic center, or the galactic plane. A selected object's spectrum is displayed in a zoomable window; line identification templates are provided. In addition to the spectra themselves, the website also contains a brief discussion of PNe as astronomical objects and as contributors to our understanding of stellar evolution. We envision that this website, which concentrates a large amount of data in one place, will be of interest to a variety of users: researchers might need to check the spectrum of a particular object of interest; the non-specialist astronomer might simply be interested in perusing such a collection of spectra; and finally, teachers of introductory astronomy can use this database to illustrate basic principles of atomic physics and radiation. To particularly encourage this last use, we have developed two paper-and-pencil exercises to introduce beginning astronomy students to the wealth of information that PN spectra contain.

54. Planetary Nebulae in the GLIMPSE survey

Sun Kwok, University of Hong Kong; Nico Koning, University of Calgary; Hsiu-Hui Huang, Institute of Astronomy & Astrophysics, Academia Sinica

We report the observations and search for new planetary nebulae in the Spitzer Space Telescope Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE) survey. Identifications were based on the morphology, infrared colors in the four Infrared Array Camera (IRAC) bands 3.6, 4.5, 5.8, and 8.0 μm , and spectral energy distribution. The infrared images of a number of possible new planetary nebulae are presented.

55. High Resolution Echelle Spectroscopy of Central Stars of Bipolar Planetary Nebulae: Disclosing the Shaping Mechanisms of Asymmetric Planetary Nebulae

Ting-Hui Lee & Letizia Stanghellini, National Optical Astronomy Observatory; Lilia Ferrario & Dayal Wickramasinghe, The Australian National University

We present high resolution echelle spectroscopy of central stars (CSs) of Southern bipolar planetary nebulae (PNe). The spectra were acquired with NTT/ESO with the objective of studying the shaping mechanism of the highly bipolar structures observed. In particular, we look for Zeeman splits of the stellar lines caused by possible magnetic fields associated with the CSs. A possible magnetic field has been detected in one case. The data set offers further insight in the shaping mechanism, in particular, that of the rare optical P-Cygni profile probing strong CS winds.

56. Carbon Abundances in Magellanic Cloud Planetary Nebulae

Ting-Hui Lee, Letizia Stanghellini, & Richard Shaw, NOAO, et al.

As an ongoing study of Magellanic Cloud PNe we have obtained UV spectra of 9 PNe in the SMC to measure their carbon abundances. The spectra have been acquired with ACS HRC/PR200L and SBC/PR130L. The ACS prisms give a reasonable resolution in the range of 1200 – 2500 Å to detect the C IV, C III], and C II] nebular emission, essential for chemical studies of the PNe. The carbon abundances of SMC PNe, together with those of the LMC previously determined with STIS spectroscopy, will allow a comparative study of nebular enrichment and provide the basis for comparison with stellar evolution models at various metallicity.

57. Investigating the Dusty Waists of PPNe with the Keck Natural and Laser Guide Star Adaptive Optics.

David Le Mignant, W. M. Keck Observatory, USA; Raghvendra Sahai, Jet Propulsion Laboratory, USA; Carmen Sanchez-Contreras, Instituto de Estructura de la Materia, Madrid, SPAIN, et al.

We report on an observing campaign of 3 young PNe and 11 PPNe at the diffraction limit of the Keck II telescope, from 50 milli-arcseconds (mas) in H band (1.65 micron) to 100mas in the Ms band (4.7 micron). This campaign is part of a larger project that aims at understanding the physical processes that are responsible for the shaping of post-AGB stars (see posters from Sanchez-Contreras et al. & Sahai et al.) with emphasis on investigating the possible role of collimated fast wind in the earliest stages of the evolution of the PPN (Sahai & Trauger, 1998, Huggins et al., 2000). Coupling high spatial resolution with near infrared (1-5micron) allows us to probe deeper through the dusty post-AGB circumstellar medium. This poster focuses into the equatorial regions of three well-known and relatively extended PPNe: the Red Rectangle, Frosty Leo and the Egg Nebula to study the color and the dynamics of these regions from the scattered light of the central engine. For these three cases, we are able to identify and resolve dusty knots revealed by enhanced scattered light at various wavelengths; yet we see no evidence for any stellar companions at separation larger than 100 mas from the central star. We also report on the H₂ emission from these very central regions.

58. Identifying the Youngest Proto Planetary Nebulae!

B. M. Lewis, Arecibo Observatory

While mass-loss from OH/IR stars appears to be spherically symmetric, many proto planetary nebulae exhibit a prominent bipolar structure interacting with the pre-existing slow wind from its previous OH/IR star phase. So the initiation of a bipolar wind occurs soon after the PPN phase begins, a development that may be tracked observationally (with patience in a single object) if we could diagnose the onset of the PPN phase. This can be done for O-rich stars by taking into account their NIR & MIR colors, their variability, and the evolution of their OH masers. However one complicating factor is the recent demonstration that OH/IR stars do indeed exhibit a severe modulation of their mass-loss rates, which was foreshadowed by the sequence of bright, edge-enhanced rings seen in Hubble images of PPN & PN. In the case of IRAS 19479+2111 the strong modulation of the mass-loss rate completely quenched its 1612 MHz masers for several years. But such behaviour can be differentiated from that of a PPN by the presence or absence of long-period optical variability. Perhaps the youngest known PPN is IRAS 18455+0448. We will present a list of young PPN identified from the Arecibo set of OH/IR stars with our criteria.

59. Integral Field Observations of Post-AGB stars with UKIRT and SINFONI-VLT

Krispian T. E. Lowe, University of Hertfordshire; Tim M. Gledhill, University of Hertfordshire

Bipolar post-AGB stars show dramatic collimation of the mass-loss winds. This can indicate a fast wind in the direction of the long axis of the nebula. We use H_2 as a marker to trace the shocks to detect the interaction between the older and slower AGB wind and the newer fast wind. In this poster we use Integral field spectroscopy (IFS) as a tool to probe the interactions of these winds, using H_2 emission as a diagnostic. The measurement of the various line ratios, 1-0S(1), 2-1S(1), 3-2S(3) and $Br\gamma$ transitions makes it possible to differentiate between the excitation mechanisms.

We have obtained K-band observations of 16 *IRAS* objects with UIST+IFU at UKIRT and SINFONI at VLT. The UKIRT observations provide a 3.3 by 6 arcsec field of view, enabling us to locate the areas of emission. Whilst SINFONI, commissioned 2004, can provide diffraction limited sub-arcsecond observations of limb-brightened edges, rings and other features. Applying IFS enables us to locate and map these areas and search for excitation mechanisms, and in some cases we can map the kinematics of H_2 . For example *IRAS* 19306+1407 is a hot B spectral type post-AGB/Young PN with a bipolar outflow and displays a mixture of shocks and fluorescence. It has emission lines that emanate from an elongated bipolar structure and bright arcs. The combination of H_2 and existing polarimetry enables us to analyse the gas and dust around evolved stars.

60. New Results on the Time Variation of the Radial Abundance Gradients from Planetary Nebulae

W. J. Maciel, IAG/USP; L. G. Lago, IAG/USP; R. D. D. Costa, IAG/USP

New results on the time variation of the radial abundance gradients in the galactic disk are presented on the basis of four different samples of planetary nebulae. These comprise both smaller, homogeneous sets of data, and larger but non-homogeneous samples. Four different chemical elements are considered, namely, oxygen, sulphur, argon and neon, and other objects such as open clusters, cepheids and HII regions are also taken into account. Our analysis supports our earlier conclusions in the sense that, on the average, the radial abundance gradients have flattened out during the last 6 to 8 Gyr, with important consequences for models of the chemical evolution of the Galaxy.

61. An Optical Emission Line Survey of Large Planetary Nebulae

G. J. Madsen, Anglo-Australian Observatory; D. Frew, Macquarie University; R. J. Reynolds, Univ. of Wisconsin - Madison, et al.

Accurate emission line fluxes from planetary nebulae (PNe) provide important constraints on the nature of the late stages of stellar evolution. Large, evolved PNe may trace the latest stages of PN evolution, where material from the AGB wind is returned to, and interacts with, the interstellar medium. However, the low surface brightness and spatially extended emission of large PNe have made accurate measurements of line fluxes difficult with traditional long-slit spectroscopic techniques. Furthermore, distinguishing these nebulae from HII regions, supernova remnants, or interstellar gas ionized by a hot, evolved stellar core in the vicinity can be challenging. Here, we report on an ongoing multiple emission line survey of more than 50 large Galactic PNe ($r > 4'$). The study has been undertaken with the Wisconsin H-Alpha Mapper (WHAM), a Fabry-Perot spectrograph designed to detect faint diffuse optical emission with high sensitivity and spectral resolution ($R \sim 25,000$). Our sample includes newly revealed $H\alpha$ enhancements from the AAO/UKST, SHASSA, and WHAM $H\alpha$ surveys. We present line fluxes of $H\alpha$, $[\text{NII}]\lambda 6583$, and $[\text{OIII}]\lambda 5007$ which, when combined with our accurate kinematic data, are used as a powerful discriminant compared to other data. The new emission line data and kinematics of the ionized gas enable a clear re-assessment the identification of some nebulae.

62. Molecular Hydrogen Cometary Knots in NGC 6853

Arturo Manchado, IAC; Eva Villaver, STSCI; Guillermo Garcia-Segura, UNAM, et al.

We present subarcsecond ($0''.6$) molecular hydrogen $\text{H}_2 \nu=1-0 \text{ S}(1)$ images of the planetary nebula (PN) NGC 6853. A mosaic of 11 fields of 4.2×4.2 arcminutes was covered, with a total area of 952×737 arcseconds. The central image reveal a rich structure in the form of cometary knots and filaments (often aligned towards the central star). The outer halo (0.54 pc) shows a more diffuse H_2 emission which indicates that the knots have more likely been formed by hydrodynamical plus photoionization processes rather than to interaction with the interstellar medium. The knots are found at distances from the central star that vary from 0.008 to 0.35 pc, with typical sizes in the 310 to 723 AU range. Line ratios $\text{H}_2 / \text{Br}\gamma$ in the knots show upper limits higher than 20, typical values for H_2 emission due to shock excitation. Line fluxes range from 0.9 to $4.5 \cdot 10^{-4} \text{ erg cm}^{-2} \text{ sr}^{-1}$, with peak values of $8.7 \text{ erg cm}^{-2} \text{ sr}^{-1}$. The central star ionization flux sets a photoevaporation rate of the knots which ultimately determine their survival time and allow us to set an upper limit to their densities. In addition, our results will be compared with current hydrodynamical models on the formation of knots in PNe.

63. Sub-arcsec Mid-IR Imaging of OH231.8+4.2

Muthu Mariappan, Institute of Astronomy and Astrophysics, Academia Sinica, Taiwan; Sun Kwok, Department of Physics, University of Hong Kong, Hong Kong; Kevin Volk, Gemini Observatory, Hilo, Hawaii, U.S.A.

We present sub-arcsec resolution, nearly diffraction limited narrow and broad band thermal images of OH231.8+4.2 (the Rotten Egg Nebula) taken with the Thermal-Region Camera and Spectrograph (T-ReCS) on the 8 m Gemini (south) telescope. These observations were aimed at finding the size and geometry of the emission regions as well as the properties of the emitting dust.

The mid-IR emission peaks at the nebular core of size 1 arcsec (FWHM), with extended emissions in the polar lobes and the emission at longer wavelengths. The SEDs of the core and the lobes obtained from narrow band filters show significant differences: the core shows featureless 10 micron absorption band whereas the lobes show sharp bottom end features at 10micron; a larger opacity at the long wavelength wing of 10micron and at the 18 micron band was seen in the core than in the lobes. We present one dimensional radiative transfer models for the core and the lobe and show that these differences could be accounted by the presence of amorphous alumina and crystalline enstatite respectively at the core and lobes along with the silicate dust component. Dust masses estimated from our mid-IR observations and from IRAS fluxes show that a large amount of cold dust is present at larger radial distance which is unseen in mid-IR wavelengths.

64. VLT Adaptive Optics System and Mid-Infrared Interferometric Observations of the Dusty Torus in the Bipolar Post-AGB Star OH 231.8+4.2

M. Matsuura, National Astronomical Observatory of Japan; O. Chesneau, Observatoire de la Cote d'Azur; A. A. Zijlstra, University of Manchester, et al.

We have observed the bipolar post-AGB star OH 231.8+4.2 using the mid-infrared recombiner MIDI and the adaptive optics system NACO on the Very Large Telescope. The 8-meter diffraction limited images at 2.12 and 3.8 micron show material expelled from a warped disk, and an unresolved core (approximately 100 mas) located at the centre of the system. This compact source is resolved with the interferometer. We used two unit 8-metre telescopes with four different baselines, covering a projected baseline length from 62 to 47 metres, and a projected position angle from 112 to 131 degrees, almost perpendicular to the bipolar outflow. Fringes from 8 to 9 micron and from 12 to 14 micron were detected, whilst the strong silicate self-absorption prevented detection of a signal between 9 and 12 microns. All of the fringes from four baselines consistently show the presence of a dusty disk/torus with an inner radius of 30-40 mas, which is equivalent to 40-50 AU at 1.3 kpc. As the radius of the star is estimated to be 6 AU (Sanchez Contreras et al. 2002), the inner radius of the disk corresponds to 6-8 stellar radii, which is consistent with the theoretical prediction with disk model (Mastrodemos and Morris 1999). This disk should be responsible for the formation of bipolar outflow.

Mastrodemos N. and Morris P., 1999, ApJ 523, 357

Sanchez Contreras C., Desmurs J.F., Bujarrabal V., Alcolea J., Colomer F., 2002, A&A, 385, L1

65. The 250 Ky GRIP Archives Show the Signature of a Point Source of Cosmic Rays: An Analysis of the Data Leads to NGC 6543 as Being the Most Probable Source

Aden B. Meinel, Astronomy, Optical Sciences, Univ. Arizona, Tucson; Marjorie P. Meinel, Jet Propulsion Laboratory, retired; Barbara Meinel, Meinel Group, Las Vegas, et al.

Irradiation of the Earth by a jet of cosmic rays from a point source beginning 80Ky BP and lasting ~ 75 Ky was recorded in the Greenland ice sheet as being a modulated flux of ^{10}Be . The flux signature is not consistent with a solar source. Analysis of the modulation caused by the precession of the geomagnetic field indicates the source is within a 10° circle at $19\text{h } +65^\circ$ within which the only active object is NGC 6543. Cygnus X-3 has been suggested as a possibility but is 40° away and its jet definitely is not aimed Earthward. If it is NGC 6543 we have observational evidence that a planetary nebula can emit a jet of cosmic rays. A key fact is that the HST radial velocity measurements are consistent with a dynamic age for NGC 6543 of 80-100 Ky (depending on how radial velocity is converted into transverse velocity). Other key signatures include a drop in the galactic cosmic ray flux at the start of the event 80 Ky BP, recognized from solar flare physics as being evidence of a significant magnetic field accompanying a plasma stream. We suggest that the central star is a close binary system, consistent with the Keck II AO imagery. The associated separation of ~ 2 AU shows that the AGB evolution of the binary will be dominated by the Roche surface. We also present a computer simulation of the encounter with this jet of cosmic rays.

66. Galactic Abundance Patterns via Peimbert Types I & II Planetary Nebulae

J. B. Milingo, Franklin & Marshall College; K. B. Kwitter, Williams College; R. B. C. Henry, University of Oklahoma, et al.

Planetary Nebulae (PNe) abundance patterns have long been used to note signatures of nuclear processing and to trace the distribution of metals throughout galaxies. In this poster abundance gradients and heavy element ratios are presented based upon newly acquired spectrophotometry of a sample of Galactic Peimbert Type I PNe. This new data set is extracted from spectra that extend from $\lambda 3600 - 9600\text{\AA}$ allowing the use of [S III] features at $\lambda 9069$ and 9532\AA . Since a significant portion of S in PNe resides in S^{+2} and higher ionization stages, including these strong features should improve the extrapolation from observed ion abundances to total element abundance. S is believed to be precluded from enhancement and depletion across the range of PNe progenitor masses making it an alternate metallicity tracer to the canonical O. If S can be reliably determined in PNe, its stability in intermediate mass stars makes it a valuable tool to probe the natal conditions as well as the evolution of PNe progenitors. This is a continuation of our Type II PNe work, the impetus being to compile a relatively large set of line strengths and abundances with internally consistent observation, reduction, measurement, and abundance determination, minimizing systematic affects that come from compiling various data sets. This research is supported by the AAS Small Research Grants program, the Franklin & Marshall Committee on Grants, and NSF grant AST-0307118.

67. Imaging and Long-Slit Spectroscopy of Compact Planetary Nebulae with Collimated Outflows

Luis F. Miranda, Instituto de Astrofísica de Andalucía, CSIC; Martin A. Guerrero, IAA-CISC

Collimated outflows are found in a noticeable number of planetary nebulae (PNe) and, in particular, in very young ones. Collimated outflows are believed to play an important role in the shaping of PNe. To assess the dynamical action of this kind of outflows in PNe, we have started a study of the morphological and kinematical properties of young compact PNe with evidence of collimated outflows. In this work we present preliminary results of five objects, revealing the internal structure and the presence of collimated outflows for the first time. The implications of collimated outflows in the formation of PNe are discussed.

68. On the Origin of Bipolar Planetary Nebula

Shigeki Miyaji & Daigo Saito, Graduate School of Science and Technology, Chiba University

We present a numerical simulation on a toy model for the origin of bipolar planetary nebula from a single post AGB star. At the late stage of AGB star, convective envelope and/or convection of shell burning zone would create differential rotation between the core and the envelope of such a star. If the core has sufficient magnetic fields, this differential rotation creates a twist of magnetic fields. As like a cosmic jet model of accretion disk, such a twist of magnetic fields piles up a tower of magnetic fields atop on the pole of the progenitor core and creates a Pointing flux dominated jet.

By 2D MHD hydrodynamic simulations, we successfully create jets and equatorial plain flow. This equatorial plain flow would be stabilized by outer ring which is expected to be formed by previous slow equatorial wind. If this equatorial plain flow forms an expanding disk at the equator, this disk would become another anchor of the magnetic fields, and by the similar mechanism of accretion disk jets, it would power up already existing polar jets. As a result, the polar jets would blow off the last envelope of the progenitor.

69. Do All PN Come from Binaries?

Maxwell Moe, University of Colorado; Orsola De Marco, American Museum of Natural History

We present a population synthesis calculation to derive the total number of planetary nebulae (PN) in the Galaxy from single star and common envelope (CE) progenitors. By combining the most up-to-date literature regarding galactic and stellar formation as well as stellar evolution, we determined the total number of PNe from single stars (and primary stars in binaries) to be 66000 ± 21000 . This calculation takes into account that stars with main sequence masses smaller than $0.90 M_{\odot}$ do not make PNe because they evolve too slowly after the AGB. The PN visibility times are calculated according to stellar evolutionary timescales and nebular kinematics. By using common envelope calculations and observational results of main sequence binaries, we determined the fraction of all binaries that have separations small enough and mass ratios high enough to produce a PN if a CE takes place. We predict that 4600 ± 1500 post-CE PN exist in the Galaxy today.

The actual number of Galactic PNe has been calculated in several ways. We adopt the method of Peimbert who derived a total number of 7800 ± 1800 . This number is much lower than our prediction if single stars produce PNe, but it is closer to the prediction if only CE interactions produce PNe. This suggests that many single stars do not produce PNe and that most PN we observe derive from post-CE interactions on the AGB. This result is in line with the suggestion of De Marco et al. that most central stars have close companions.

70. Cloudy_3D, a New Pseudo-3D Photoionization Code

Christophe Morisset, IA-UNAM

I present a new modelling tool (available on request to CM) to make quick models of ionized regions. The code is running Cloudy (Ferland) various time, changing at each run the input parameters according to an angular law describing the morphology of the object. Then a cube is generated by interpolating the outputs of Cloudy. In each cell of the cube, the physical conditions (electron temperature and density, ionic fractions) and the emissivities of lines are determined. Associated tools (VISNEB and VELNEB_3D) are used to rotate the nebula and to compute surface brightness maps and emission line profiles, given a velocity law. Integrated emission line profiles are computed, given aperture shapes and positions. The main advantage of this tool is the short time needed to compute a model.

71. Catalog of Emission Line Profiles for Planetary Nebula

Christophe Morisset, IA-UNAM; Grazyna Stasinska, Obs. Meudon

We use Cloudy_3D (Morisset, same symposium) to generate a catalog of synthetic emission line profiles for planetary nebulae. We change the morphologies (spherical, ellipsoidal, bipolar shapes), the thickness and the angular density law of the nebulae, and compute the line profiles for 5 emission lines, through 7 apertures, using 2 different expansion laws (with and without turbulence). The actual version of the catalog contains some 5000 line profiles. The catalog is then used to define “profile families”, which are obtained by looking for all the models giving similar profile shapes.

72. A Binary-Driven Pinwheel Outflow from the Extreme Carbon Star, AFGL3068

Mark Morris, UCLA; Raghvendra Sahai, JPL; Keith Matthews, Caltech; Judy Cheng, Johns Hopkins Univ.; Jessica Lu, UCLA

The extreme carbon star, AFGL3068, is losing mass at a rate in excess of $10^{-4} M_{\odot} \text{ yr}^{-1}$, and is consequently hidden by a thick dust photosphere having a color temperature of $\sim 300\text{K}$. Consequently, it has so far been detected only in the infrared. With the ACS camera on the Hubble Space Telescope, we have observed this object with broad filters having central wavelengths of 5907 and 8333 Angstroms. The star remains obscured, but we have discovered at both wavelengths a thin, apparently continuous spiral arc winding 4 or 5 times around the location of the star, from angular radii of 2 to 10 arcseconds. We interpret this as the projection of nested spiral shells such as were predicted to occur when the mass-losing star is a member of a binary system (Mastrodemos & Morris 1999). In this case, the illumination is presumably provided by ambient galactic starlight. Subsequent near-IR observations with the NIRC2 camera on the Keck II telescope using adaptive optics corrections with a natural guide star reveal that AFGL3068 has two components separated by 0.11 arcsecond, or 109 AU at a distance of 1 kpc. One very red component is presumably the mass-losing carbon star, while the other component is apparently a much bluer companion. Assuming both components have mass M , and ignoring the projection of the separation vector, we find the binary period to be $575 M^{-0.5}$ yrs, strikingly comparable to the 710-year separation of the shells obtained from the known outflow velocity of 14.7 km s^{-1} .

73. The Molecular Envelope around the Supergiant Star VY CMA

Sebastien Muller, Din-van-Trung, Jeremy Lim, ASIAA, et al.

We present millimeter observations of the molecular envelope around the red supergiant VY CMA with the Submillimeter Array. We will discuss the morphology and kinematics derived from the CO, ^{13}CO (2-1), SO (65-54) line emission and continuum with an angular resolution of $\sim 2'$, i.e., ~ 3000 AU. We propose a model of the envelope to explain our data.

74. NIR High-Resolution Imaging and Radiative Transfer Modeling of the Frosty Leo Nebula

Koji Murakawa, Keiichi Ohnaka, Gerd Weigelt, MPIfR, Germany, et al.

We present HK-band polarimetry and a K-band speckle image of the proto-planetary nebula Frosty Leo obtained using the 8 m Subaru telescope and the 6 m SAO telescope, respectively. Besides the well-known hourglass-like nebula our speckle image reveals a bright central star and clumpy structures in the bipolar lobes. The polarimetric data shows a centrosymmetric polarization vector pattern in the lobes and a so-called polarization disk between them. Furthermore, we identified an elongated feature with small polarization, possibly caused by a collimated outflow. We have performed radiative transfer calculations to model the dust shell structure of the Frosty Leo nebula. We found that micron-size grains in the equatorial dense region and small grains in the bipolar lobes are required to explain the observed total intensity images, the polarization images and the spectral energy distribution.

75. Disklike Structure in the Semiregular Pulsating Star X Her

Jun-ichi Nakashima, U. of Illinois/ASIAA

This paper reports the results of Berkeley-Illinois-Maryland (BIMA) array interferometric observations in the CO $J = 1-0$ line toward X Her and EP Aqr, the semiregular pulsating stars with a composite CO line profile, and also reports finding of a disklike structure in X Her. In the CO spectrum both of X Her and EP Aqr, a composite profile including narrow and broad components is seen as reported by the previous single-dish observations. The spatial structure of the broad component region of X Her shows a bipolar shape, and that of the narrow component shows an elliptical/spherical shape. The blue- and red-shifted parts of the X Her narrow component show a systematic difference in the velocity integrated intensity map. The spatio-kinetic properties of the X Her narrow component are reminiscent of a Keplerian rotating disk with a central mass of $0.9 M_{\odot}$; however, an interpretation as an expansion disk seems to be more natural. The spatial distributions of both the narrow and the broad components of EP Aqr appear to be roughly round with the same peak positions; no significant velocity gradient is seen. The spatio-kinetic properties of EP Aqr are reminiscent of a multiple-shell structure model rather than of a bipolar flow and disk model.

76. Do PNe Trace Stars in Early-Type Galaxies?

Nicola R. Napolitano, INAF-OAC, et al.

We compare spatial and velocity properties of PNe observed with the Planetary Nebulae Spectrograph with photometry and stellar kinematics in a sample of early-type galaxies. We discuss whether PNe are good tracers of the underlying stellar population and derive clue on the PN specific density parameter.

77. Spectroscopic Survey and Complete Model of Crl618 between 80 and 276 GHz

Juan R. Pardo & Jose Cernicharo, Departamento de Astrofisica Molecular e infrarroja, IEM, CSIC, Spain

We present a complete survey and model of the emission from the C-rich protoplanetary nebula CRL 618 at the frequencies accessible with the IRAM-30m telescope (80.25-115.75 GHz, 131.25-179.25 GHz, and 204.25-275.25 GHz). Although the number of lines detected is large (several hundreds), the number of chemical species from which they arise is rather small. In fact, lines from cyanopolyynes HC_3N and HC_5N dominate by far the longwave spectrum of CRL618, with detection of numerous vibrationally excited states and isotopic substituted species. The line profiles as a function of frequency for the different species allow to infer their location with respect to the continuum source (an ultracompact HII region surrounded by dust). The physical parameters of the different gas regions have been established by studying the large number of detected lines from cyanopolyne species. Using these constraints, the abundances of many other species relative to HC_3N could also be determined and a general model, that reproduces the whole data set at a very detailed level of agreement, could be built.

78. High Resolution Spectroscopy of PB6

Antonio Peimbert, I.A. Univ. Mexico

Echelle spectrophotometry of the type I planetary nebula PB6 is presented. The data consist of VLT UVES observations in the 3100 to 10360 Å range. Electron temperatures and densities have been determined using different line intensity ratios. We determine the H, He, C, and O abundances based on recombination lines, these abundances are almost independent of the temperature structure of the nebula. We also determine the N, O, Ne, S, Cl, and Ar abundances based on collisionally excited lines, the ratios of these abundances relative to that of H depend strongly on the temperature structure of the nebula.

79. Deep Spectroscopy of Planetary Nebulae and Compact HII Regions in NGC 3109 and NGC 6822

M. Peña,, Instituto de Astronomía, UNAM, DAS-U. Chile; L. Hernandez & M. Richer, Instituto de Astronomía, UNAM, et al.

NGC3109, Sextans A and B, form a small group of gas-rich dwarf Irr galaxies just beyond the Local Group. They are metal poor objects. Particularly, NGC3109 seems to be similar to the SMC, in luminosity, chemical composition and other characteristics.. Richer & Mc Call (1992) reported the discovery of 7 PN candidates and some compact HII regions in the central region of the galaxy. We have performed VLT “on band-off band” imaging of the whole galaxy. This allows us to identify more than 20 PN candidates, selected as stellar objects with no detectable stellar continuum. Also many compact HII regions were identified. Further spectroscopy (with VLT FORS multi-object) in the 3700-6800 Å range has confirmed the PN nature of several candidates. For 4 of them , the [OIII] 4363 line was detected, allowing thus a trustworthy determination of chemical abundances. Some of the PNe appear as low excitation nebulae. For about 8 HII regions, [OIII] 4363 was also detected. Therefore a comparative analysis of chemical composition in both type of objects are being performed. A similar analysis is being carried out for PNe and HII regions in the dIrr NGC 6822. The characteristics of this galaxy make it similar to the LMC. This time, the data were acquired with the GEMINI South multi-object spectrograph. Our purpose is to analyze the chemical composition of the different populations in both galaxies and to study the star formation history and the chemical evolution of these objects so similar to the Magellanic Clouds.

80. The Double-Dust Chemistry Phenomenon around PNe with [WC]-type Central Stars

J. V. Perea-Calderon, European Space Astronomy Centre (ESAC); D. A. Garcia-Hernandez & P. Garcia-Lario, ESAC, Research and Scientific Support Department of ESA, et al.

We present Spitzer/IRS spectra of a sample of 19 galactic PNe with [WC]-type central stars, most of them located in the direction of the Galactic Bulge. We report the detection of double-dust (C-rich and O-rich) chemistry in all the stars in the sample for which a good S/N spectrum is available. The mixed chemistry is derived from the simultaneous presence of PAH features in the 6-15 micron range and crystalline silicates beyond 20 microns.

Our observations reveal that the simultaneous presence of oxygen and carbon-rich dust features in the infrared spectra of [WC]-type PNe is not restricted to late/cool [WC]-type stars, as previously suggested in the literature, but it is found to be a common feature associated to all kind of [WC]-type PNe. In particular, mixed chemistry is observed in at least seven early/hot [WC]-type PNe in the sample. Various scenarios (single versus binary star evolution, late thermal pulse in the AGB, hot bottom burning termination induced by enhanced mass loss at the end of the AGB) are discussed to interpret the results obtained in the framework of the chemical evolution of PNe.

81. A New Population of Planetary Nebulae Discovered in the Large Magellanic Cloud

Warren Reid, Macquarie University; Quentin Parker, Macquarie University & AAO

A stack of 12 deep, high resolution $H\alpha$ and 6 short red images taken over a three year period using the UKST has revealed hundreds of faint, highly evolved PNe in the Large Magellanic Cloud (LMC). These images cover the central 25 square deg. region and were combined using the SuperCOSMOS measuring machine. Candidate emission sources were found using an adaptation of an excellent image merging technique available within KARMA. The SR and $H\alpha$ images were each assigned a different colour. Careful selection of software parameters then allowed the intensity of the pixel matched FITS images to be perfectly balanced, allowing only peculiarities of one or other pass-band to be observed and measured.

Follow-up spectral confirmation has been acquired using 2dF on the AAT, FLAMES on the VLT, the 1.9m at SAAO and the 2.3m at MSSSO. We now have low and high resolution spectra of over 2,000 emission objects across the entire survey area including all the previously known PNe. The high resolution spectra from 2dF have been used to acquire accurate velocity measurements of the complete sample of bright young and faint evolved PNe populations uncovered. These are compared directly with previous PN results and other populations such as emission-line stars and HII regions. Results are presented including a complete distribution map of PNe across the LMC.

82. Light Metals in PG1159 Central Stars

Elke Reiff, Klaus Werner, Thomas Rauch, Institute for Astronomy and Astrophysics, University of Tübingen, et al.

Quantitative spectral analyses of post-AGB stars during the last decade revealed two distinct evolutionary sequences. Besides the hydrogen-rich sequence which is established by CSPN from early post-AGB to the hot white dwarf stages, a hydrogen-deficient sequence has been discovered. It is composed of Wolf-Rayet-type central stars which evolve into PG 1159 stars and finally might evolve into non-DA white dwarfs. State-of-the-art NLTE spectral analysis of PG 1159 stars by means of model atmosphere techniques revealed a “typical” abundance pattern He:C:O of 33:50:17 by mass.

Recent evolutionary calculations have shown that the hydrogen-deficiency is caused by a (very) late helium-shell flash which brings the star back to the AGB. During this phase, the complete envelope is mixed and the entire H-rich shell (about $10^{-4} M_{\odot}$) is burned. These stars therefore provide a direct view onto the former intershell material which is now exhibited at the stellar surface. A new spectral analysis of eleven PG 1159 stars (five of them have an ambient planetary nebula) based on FUV spectra obtained by FUSE allows us to investigate on this intershell matter and to derive the photospheric abundances of light metals like Ne, S, Si, and P. First results show that the predictions can be confirmed for Si and P, while we found a significant underabundance for S, which contradicts the theoretical values. This allows us to constrain the predictions of evolutionary theory and to achieve information about the nuclear processed material which is going into the interstellar medium via PNe and thus, determines the chemical evolution of our Galaxy.

83. Morpho-Kinematic Analysis of PNe with Intense [NII] and [SII] Emission Lines

H. Riesgo & J.A. López, IA-UNAM

From the sample of 613 planetary nebulae used in the paper “Revised Diagnostic Diagrams for Planetary Nebulae” (Riesgo & López, 2006, RMAA accepted) we have isolated a subsample of 51 PNe defined by $\log \text{Ha}/[\text{N II}] < 0$ and $\log \text{Ha}/[\text{S II}] < 0.4$. These objects have extremely intense [N II] and [S II] lines with respect to Ha and are indicative of either very low excitation conditions, abundance effects in the case of N, or cooling effects in shock excited regions, such as those expected in high velocity, collimated outflows. We have undertaken an imaging and detailed kinematic study for all the members of the subsample visible from the northern hemisphere. In this work we discuss the results and correlations found between the anomalous line ratios in these objects and their morphological and kinematic characteristics.

84. Planetary Nebulae and H II regions in NGC 300

L. Rizzi & R. H. Mendez, Institute for Astronomy, Univ. of Hawai‘i; W. Gieren, Universidad de Concepcion, Chile

We are building a catalogue of PNs and H II regions covering the full extent of the spiral galaxy NGC 300. It is based on many ESO 2.2-m + Wide Field Imager exposures through on-band (5012 Angstroms), off-band and $\text{H}\alpha$ narrow-band filters. A distance estimate based on the [O III] 5007 PN luminosity function will be presented.

85. Spitzer Observations of M83 and the Hot Star, H II Region Connection

Robert Rubin, NASA/Ames Research Center

H II regions play a crucial role in the measurement of current interstellar abundances. Like planetary nebulae, they also serve as laboratories for atomic physics and provide fundamental data about heavy element abundances that serve to constrain models of galactic chemical evolution. We observed emission lines of [S IV] 10.5, [Ne II] 12.8, [Ne III] 15.6, & [S III] 18.7 micron cospatially with the Spitzer Space Telescope using the Infrared Spectrograph (IRS) in short-high mode (SH). Our goal is to determine the $\text{Ne}^{++}/\text{Ne}^+$ and $\text{S}^{3+}/\text{S}^{++}$ abundance ratios in ~ 25 H II regions in the substantially face-on spiral galaxy M83. We covered a full range of galactocentric radii (R_G). Important advantages compared with prior optical studies are: 1) the IR lines have a weak and similar electron temperature (T_e) dependence while optical lines vary exponentially with T_e and 2) the IR lines suffer far less from interstellar extinction. We present the variation of the $\text{Ne}^{++}/\text{Ne}^+$ and $\text{S}^{3+}/\text{S}^{++}$ abundance ratios with R_G . Additionally, these data may be used as constraints on the ionizing spectral energy distribution for the stars exciting these nebulae by comparing the above ionic ratios with predictions using stellar atmosphere models from several different nonLTE model sets.

86. Complete Study of the Physical Structure of NGC 3242

Nieves Ruiz; Martin A. Guerrero, IAA-CISC; You-Hua Chu & Robert A. Gruendl, Univ. of Illinois; Karen Kwitter, Williams College; & Margaret Meixner, STScI

The formation and evolution of planetary nebulae (PNe) is largely due to the interaction of the fast stellar wind with the wind of the Asymptotic Giant Branch (AGB), and to the dynamical effects of the photo-ionization of the nebular material. The fast stellar wind, shock-heated in its interaction with the nebular material, is highly pressurized and snowplows the nebular material to produce a thin inner shell. On the other hand, the photo-ionization of the nebular material increases its thermal pressure, driving the nebular expansion. The physical structure of a PN can be used to assess the relative importance of these different effects in its shaping and evolution, but there is little information on the hot gas content of PNe. Using our recent XMM-Newton observations of NGC 3242, we have studied the complete physical structure of this nebula, bringing together the physical conditions of the shocked fast stellar wind in its interior with the spatio-dynamical structure and physical conditions of the photo-ionized material, derived from optical images and intermediate- and high-dispersion spectra. The results are compared with the predictions of the most recent hydro-dynamical models of PNe.

87. The Role of Magnetic Fields in Post-AGB Objects

Laurence Sabin, ING, Spain/University of Manchester, UK; Albert A. Zijlstra, University of Manchester; Jane S. Greaves, University of St Andrews, UK

Between the AGB and the Post-AGB phase we observe a deviation in the symmetry of some stars: from round they become elliptical, bipolar or even quadripolar. The shaping of Post-AGB stars and Planetary Nebulae is still an open question and several theories are suggested. Among them, is the action of magnetic fields. We present here new submillimeter polarimetric data (450 and 850 microns) obtained with SCUBA at the JCMT, concerning the four bipolar objects NGC 6537, NGC 7027, NGC 6302 and CRL 2688. We unveiled the presence of toroidal magnetic fields in the equatorial plan of the three first stars and a more complex “double” structure for CRL 2688. The correlation between the disturbance of the field and the presence of the “off axis” jets is also presented, particularly in the carbon-rich stars of our sample.

All these new results tend to comfort the shaping action of the magnetic field in these late type objects.

88. Normal, Nascent and Stalled Pre-Planetary Nebulae—Unique Probes of Late Stellar Evolution

Raghvendra Sahai, JPL/Caltech; Mark Morris, UCLA; Carmen Sanchez Contreras, Instituto de Estructura de la Materia, et al.

Pre-Planetary Nebulae (PPNs) have traditionally been understood as rare objects that represent a transitory phase in the evolution of AGB stars to planetary nebulae (PNs). However, in recent years, mainly due to high-resolution imaging surveys with HST, it has become possible to start studying the detailed physical properties for a sufficient number of these objects.

We present results from three large surveys of PPNs with HST (and supporting ground-based observations) conducted using candidate PPN lists of objects based on very simple IRAS-color criteria. We find PPNs with a range of sizes (validating our selection criteria) and morphologies; the inferred ages are tentatively consistent with the three broad age-categories defined as normal, nascent and stalled PPNs. Our results indicate that most OH/IR stars discovered via galactic-plane OH-maser surveys are really PPNs, and a good fraction of AGB stars with dense mass-loss seen in mm-wave CO emission are nascent PPNs. The presence of PPNs with (i) quadrupolar/multipolar morphologies, (ii) very optically-thick but geometrically-thin waists, and (iii) the existence of a number of PPNs with very large expansion ages and/or low luminosities, all point to PPNs being a source of many challenging problems for our understanding of late stellar evolution. Of fundamental concern is whether physical processes in a binary system can drastically slow down the evolution of PPNs to PNs, and/or produce low-luminosity PPNs. We propose that PPNs are a unique (and so far, rather poorly exploited) probe of late stellar evolution and the mass-loss processes which govern it.

89. New Observations of the Halo Radial Temperature Structure in NGC7662

Christer Sandin, Detlef Schönberner, Martin M. Roth, AIP, et al.

We report on our new studies of the physical structure of the planetary nebula NGC7662. Observations have been carried out using the PMAS integral field spectroscopy unit placed on the 3.5m telescope at Calar Alto. Compared to earlier long-slit observations, our new data has been sampled covering several adjacent larger areas out to a distance of forty arcseconds west of the central star. After carefully selecting spatial elements (spaxels) in these areas we have been able to accurately measure the electron temperature at a larger number of radial locations than before. Our results show a strong temperature gradient that confirms and strengthens the observations of Middlemass et al. 1991 for this object. They also support the finding of Marten 1993 that the temperature in hydrodynamic models of the halo increases drastically when compared to the PN core; such a gradient could be explained by the physical process “radiation hardening”. The presence of a temperature gradient should be investigated in other objects as well to establish its properties. This would also provide necessary constraints for further advancement of physical models and our understanding of these faint objects.

90. A Case in Which the Expansion Parallax Method Fails

Miguel Santander-García, Instituto de Astrofísica de Canarias; Romano Corradi, Isaac Newton Group of Telescopes; Antonio Mampaso, Instituto de Astrofísica de Canarias, et al.

Possible systematic errors in the application of the expansion parallax method for determining the distance to planetary nebulae have been recently addressed by an increasing number of authors. The presence of expanding shocks, responsible for the observed expansion of the nebula in the plane of the sky, would systematically lead to underestimate the distance of the targets.

A paradigmatic example could be the nebula around the symbiotic Mira He2-147. HST multi-epoch images and VLT integral-field, high resolution spectroscopy allowed us a robust determination of the 3-D geometry and orientation of the nebula. Applying the expansion parallax method, by comparing the ‘tangential’ expansion in the plane of the sky with the line-of-sight Doppler shift velocities of the gas, results in a distance which is significantly larger than the one obtained via the Period-Luminosity relationship for its Mira component.

The disagreement is however removed if, as suggested by the extremely broadened nebular line profiles, a strong shock front is associated with the expanding nova ejecta, and it is taken into consideration in the determination of the expansion of the nebula in the plane of the sky.

91. Hydrodynamical Models of Planetary Nebulae and the Luminosity Function

D. Schönberner, R. Jacob, & M. Steffen, Astrophysikalisches Institut Potsdam, Potsdam, Germany

We used our hydrodynamical model sequences to investigate how their line luminosities depend on initial envelope configurations and central-star masses. Based on these models which show reasonable agreement with the observations concerning their morphology and expansion velocities we found the following: (i) Models with central-star masses above about $0.65 M_{\odot}$ remain optically thick during the whole evolution across the H-R diagram; (ii) models with less massive central stars become optically thin during their horizontal part of the evolution towards the white-dwarf regime. The line luminosity of [O III] increases only during the optically thick stage and decreases after the model becomes optically thin. Even later, during recombination, the line luminosity does not reach again the previous maximum. This is in sharp contrast to the models of Marigo et al. (2004, A&A 423, 995) which predict that the maximum [O III] luminosity occurs during the recombination phase close to the turn-around point of the stellar track. According to our models the observed cut-off of the PN luminosity function can already be reached by models with central-star masses between 0.6 and $0.65 M_{\odot}$, depending somewhat on the initial envelope parameters.

92. Doppler Tomography for Investigation of Binary Central Stars in Planetary Nebulae: Computer Modeling

Olga I. Sharova, Radiophysical Research Institute, Nizhny Novgorod, Russia

At least in 20 planetary nebulae the central stars are included in the close binary systems with the short orbital periods. To study an interaction between stars the Doppler tomography technique is very useful and is widely used. It translates emission line profiles $I(V_R, \phi_i)$ taken at series of orbital phases ϕ_i into a distribution of emission $I(V_x, V_y)$ over the binary star system in velocity coordinates V_x, V_y in the orbital plane. The binary components which cannot be directly resolved are resolved in velocity space. The radio astronomical TC CLEAN method has been modified for an application to reconstruct Doppler tomography maps instead of a traditional method of the filtered back-projections. Several simple models are considered that can take place at various stages of evolution of the central stars with mass transfer. A set of the gravitational equipotential surfaces, the places of Lagrangian points, ballistic trajectories from these points have been calculated in velocity coordinates. A reconstruction of two-dimensional Doppler map has been carried out. The influence of noise, number of the orbital phases and their irregular distribution to quality of reconstruction is considered. Then we have refused from assumption $V_z = 0$ and consider gas streams out of the orbital plane. A modeling of reconstruction of three-dimensional distribution $I(V_x, V_y, V_z)$ has been made. In the spectra of the central stars emission in spectral lines frequently are not observed, but the gas streams in a close binary system can be detected in this case on a Doppler tomogram.

93. Radio Continuum from Planetary Nebulae as a Mirror of the Evolution of the Central Stars

Olga I. Sharova, Radiophysical Research Institute, Nizhny Novgorod, Russia

The radio continuum variations from galactic planetary nebulae in the process of the central star evolution without helium flashes are considered. On the base of our distance scale we obtained empirical evolutionary dependences for the ionized mass and the hydrogen atoms concentration. The parameters of theoretical model of the interacting stellar winds (ISW, Kwok 1982) are determined to reach an agreement between empirical and theoretical dependences. In this model the time dependences are obtained for the critical frequency and for the intrinsic flux density at several frequencies. The critical frequency strongly depends on the mass of star nucleus. For the nucleus mass $0.546 M_\odot$ it is always lower than 1 GHz. But planetary nebula remains optically thick at 15 GHz up to kinematical age of 100 years if the central star mass is $0.836 M_\odot$. The intrinsic flux density changes in a wide interval of values in some orders of power. Radio flux at 15 GHz continues to increase up to age of 10^4 years in model with $0.640 M_\odot$, up to 10000 years in the model with $0.565 M_\odot$. The maximum rate of the flux density $8\% \text{ yr}^{-1}$ increase is obtained for the model with $0.640 M_\odot$ in the interval from 200 to 1100 years. Further the flux density decrease with rate $0.8\% \text{ yr}^{-1}$. We have obtained the sequences of instantaneous spectra at 0.960-21.7 GHz for a group of planetary nebulae (IC 418, NGC 6369 et al.) by using of RATAN-600. They were compared to theoretical conclusions.

94. Finding the Missing PNe in the Galactic Plane: A [S III] Imaging Survey

Josh Shiode, Dan Clemens, & Ken Janes, Institute for Astrophysical Research, Boston University, et al.

Current estimates of the total number of Galactic planetary nebulae (GPNe) are highly uncertain; the most inclusive current catalog contains only $\sim 1,500$ PNe. A complete and minimally contaminated catalog of GPNe is needed for a variety of ongoing studies. We are employing the method used by Jacoby & Van de Steene (2004), who surveyed the Galactic bulge for [S III] $\lambda 9532$. We are using the PRISM wide-field imager on the 1.8m Perkins Telescope at Lowell Observatory to conduct a pilot survey of key sections of the Galactic plane, looking for [S III] emission from PNe obscured by dust and so missed by previous surveys of H α and other short wavelength lines. We will employ two newly acquired 20 Å wide interference filters to sample the [S III] emission and the spectrally adjacent continuum. In addition to seeing through more of the extinction, the use of [S III] emission line will a priori reject many of the most troublesome catalog contaminants—ultracompact HII regions. The results of Jacoby & Van de Steene and our own preliminary results suggest that we will detect tens to hundreds of new GPNe candidates, to be verified against existing centimeter-wavelength radio surveys.

95. Carbon and Oxygen Stars Evolution in Post-AGB Phase

Natasza Siodmiak, STScI, USA; CAMK, Poland; Ryszard Szczerba, CAMK, Poland; Margaret Meixner, STScI, USA, et al.

Despite many studies, the post-AGB phase is still not well understood. To make a progress in this field, we searched for various information about proto-planetary nebulae and built a catalogue of post-AGB objects. Based on collected data we were able to trace the evolution of stars in their late stages with the distinction between carbon and oxygen-rich objects. Our special attention focused on spectral features seen in ISO data and clues for AGB nucleosynthesis. Together with the newest HST images of post-AGB objects we can study correlations between morphological types and chemical and physical properties of stars to improve our understanding of stellar evolution.

96. The Stellar Wind from the Central Star of NGC 7009

George Sonneborn, NASA/GSFC; Rosina Iping, NASA/GSFC & CUA; You-Hua Chu, UIUC, et al.

Observations of NGC 7009, including its central star HD 200516, have been obtained with the Far Ultraviolet Spectroscopic Explorer (FUSE) satellite, providing spectra covering 905-1187 Å with spectral resolution of 15 km/sec. One observation was made with the 30×30 arcsec aperture and includes the star plus the entire nebula. A second observation used the 1.25×20 arcsec slit significantly reducing the nebular ‘contamination’ of the stellar spectrum. This poster discusses the spectrum of the central star. A strong FUV continuum, as expected for $T_{\text{eff}}=82,000\text{K}$, dominates the spectrum. The most prominent spectral feature is a very strong P-Cygni profile of O VI 1032-1038. This paper presents models of the stellar spectrum and the wind features to further refine the stellar parameters and mass loss rate.

97. Spitzer/MIPS Infrared Imaging of the Extremely Extended Circumstellar Dust Shells of
Angela K. Speck, Mizzou; Toshiya Ueta, NASA Ames; Robert Stencel, University of Denver, et al.

Evolved intermediate mass stars are major contributors to the interstellar medium. However, the mechanisms by which they do this are not well understood. The circumstellar shells of evolved stars (AGB and post-AGB stars) contain the fossil record of their mass loss, and therefore have the potential to verify many aspects of stellar evolution. IRAS and ISO data indicate that huge dust shells exist around many such objects, extending several parsecs from the central star. Furthermore, some of these large dust shells show evidence for mass-loss variations that correlate with evolutionary changes in the star itself. Previous observations lacked the sensitivity and spatial resolution to investigate the full extent and detailed structure of these large dust shells. We present $160\mu\text{m}$ images of the very extended dust shell around HD161796 and AFGL 2688. We present preliminary studies of these observations and compare them to previous FIR observations of this and other post-AGB stars. From this study we will be able to (a) constrain the masses of the progenitor stars; (b) test theories of stellar evolution and mass-loss mechanisms; (c) determine the effect of dust chemistry on mass loss (and therefore on stellar evolution).

98. The PN Abundance Gradient in the Milky Way Revisited

Grazyna Stasinska (Observatoire de Meudon, France), Slawomir K. Gorny (Copernicus Astronomical Center, Poland), Miriam Pena (Instituto de Astronomia UNAM, Mexico)

We present a project aimed at reexamination of the abundance gradients in the Milky Way as derived from planetary nebulae (PNe). While the PNe probe a larger age range than other abundance indicators, their use requires special attention to the problems of i) inhomogeneity of the analysed samples, ii) poorly known distances and iii) possible modifications of nebular abundances due to stellar nucleosynthesis.

In this progress report we give an account of our efforts to constitute an adequate sample of PNe. We have observed over 130 PNe using low- and high-resolution spectroscopy at 2m class telescopes and combined this data with large, good quality data samples from the literature. We have derived the abundances of all the PNe of the resulting sample in a consistent way.

We report also a new method to determine PNe distances based on interpolation in a grid of photoionization models. It remains statistical as it assumes that all PNe are well represented by a certain type of model which however can be refined in the future. The advantage of the method is that it does not depend on assumptions on a nebular mass or any other nebular or stellar property that is supposed to hold for all PNe.

Preliminary results concerning abundance gradients and their possible variation in time are presented with a due account to all the uncertainties present in their derivation.

99. Morph-Kinematic Modeling of Planetary Nebulae with SHAPE

Wolfgang Steffen & José Alberto López, Instituto de Astronomía, UNAM

We present a powerful new tool to analyse and disentangle the 3D geometry and kinematic structure of gaseous nebulae. The method consists in combining commercially available digital animation software to simulate the 3D structure and expansion pattern of the nebula with a dedicated, purpose built rendering software that produces the final images and long slit spectra which are compared to the real data. We show results for the complex planetary nebulae NGC6369, NGC6302 and Abell 30 based on long slit spectra obtained at the San Pedro Mártir observatory.

100. Investigating X-ray Emission from Pre-Planetary and Planetary Nebulae Using Numerical Simulations

Matthias Stute & Raghvendra Sahai, JPL/Caltech

The shaping of Planetary and Pre-Planetary nebulae (PNs and PPNs) is believed to result from the interaction of a fast, collimated post-AGB wind (CFW) plowing into the slow, dense wind emitted during the AGB phase (Sahai & Trauger 1998). Due to the large speed of the fast wind, one expects PPNs and PNs to be ubiquitous sources of extended X-ray emission. However, X-ray emission was only detected in 3 of 60 PNs observed with ROSAT, followed by a few more from CHANDRA and XMM (e.g. Guerrero et al. 2005), and there is only one confirmed X-ray detection in PPNs so far (Sahai et al. 2003). We are therefore performing numerical simulations to understand the properties of the X-ray emission as a function of CFW properties and the evolutionary phase, using the FLASH code.

X-ray emission provides us with a unique probe for constraining the physical properties of the CFW (speed, mass-flux, opening angle) and its interaction with the AGB wind. As a first step, we have computed the X-ray emission using one-dimensional simulations of interacting winds. We compare our results with analytical, self-similar, spherically-symmetric models (Akashi et al. 2006), and find broad agreement as well as interesting differences. The differences are indicative of the higher accuracy in our simulations resulting from the self-consistent treatment of radiative cooling and hydrodynamics. We present results of these one-dimensional, as well as progress on two- and three-dimensional simulations which are needed for adequately modelling real PPNs and PNs, which generally have bipolar/multipolar morphologies.

101. The Three-Dimensional Circumstellar Environment of SN 1987A: A High-Mass PN Analog

Ben Sugerman, STScI; Arlin P. S. Crotts, Columbia University, et al.

Surrounding SN 1987A is a three-ring nebula attributed to interacting stellar winds, yet no model has successfully reproduced this system. Fortunately, the supernova (SN) has provided an ideal opportunity to reconstruct the progenitor's mass-loss history through scattered-light echoes, which trace the three-dimensional (3-D) morphology of the circumstellar dust. Using PSF-matched difference imaging to study both phenomena, we have built the most complete map to date of the circumstellar environment (CSE). The CSE is a richly-structured bipolar nebula. An outer, double-lobed "peanut" is a prolate shell extending 28 ly along the poles and 11 ly near the equator, but is pinched to 6 ly at the waist. Interior, a cylindrical hourglass, 1 ly in radius and 4 ly long, connects to the peanut by a thick equatorial disk. The nebulae are inclined 40° south and 8° east of the line of sight, slightly elliptical in cross section, and marginally offset west of the SN. Echo fluxes suggest that between the hourglass and bipolar lobes: the gas density drops from 1–3 cm⁻³ to >~ 0.03 cm⁻³; the maximum dust-grain size increases from ~0.2 μm to 2 μm; and the silicate:carbonaceous dust ratio decreases. The nebulae have a total mass of ~1.7 M_⊙, suggesting a red-supergiant mass loss of 5 × 10⁻⁶ M_⊙ yr⁻¹.

We compare these results to current formation models, and propose the progenitor evolved through two "blue-loops," during which a fast, low-density blue supergiant wind interacted with previously-ejected, slow, high-density red supergiant material.

102. Detection of HCO^+ toward Planetary Nebula K 3-35

Daniel Tafoya, Harvard-Smithsonian CfA; Yolanda Gomez, Centro de Radio Astronomia y Astrofisica, UNAM; Guillem Anglada, Instituto de Astrofisica de Andalucia, et al.

We report the detection of HCO^+ ($J = 1 \rightarrow 0$) emission toward the planetary nebula (PN) K 3-35 as a result of a molecular emission survey carried out toward this source. K 3-35 is particularly interesting because it is one of the two PNe that exhibit water maser emission, which is present in the central region of K 3-35 as well as 5000 AU far away from the center. We also report new spectra of the ^{12}CO ($J = 2 \rightarrow 1$) transition from this PN, as well as upper limits for the emission of the molecules SiO, H^{13}CO^+ , HNC, HCN, HC_3OH , HC_5N , CS, HC_3N , ^{13}CO , CN, and NH_3 . From the HCO^+ emission we estimate a molecular mass, $M_{\text{mol}} \simeq 0.15 M_{\odot}$, for K 3-35. Using the CO ($J = 2 \rightarrow 1$) emission and from the upper limit for the ^{13}CO ($J = 1 \rightarrow 0$) emission we have constrained the molecular mass for K 3-35 in the range 0.07-0.5 M_{\odot} , that is in agreement with the mass estimated from the HCO^+ emission. This molecular mass estimate suggests that this PN has a massive neutral envelope which could be responsible for the shielding mechanism that prevents water molecules from being destroyed by the ionizing radiation of the central star and also can provide the physical conditions to favor the maser emission at large distances. By comparing the molecular-to-ionized mass ratio with a lower limit to the relative abundance of HCO^+ to HCN derived from the observations and using an empirical diagnostic diagram, we infer that K 3-35 is a PN in a very early stage of its evolution.

103. High Dispersion Spectroscopy of the Planetary Nebula K648 in the Globular Cluster M15

Tajitsu, A., Subaru Telescope, NAOJ; Otsuka, M., Okayama Astrophysical Observatory, NAOJ

Nowadays, over 1,000 objects have been included in the catalogue of galactic planetary nebulae (PNe). And only about ten of them are recognized as galactic halo objects. Generally, these halo PNe formed in the galactic halo are considered that they have evolved from rather low-mass progenitor stars ($0.8 \sim 1M_{\odot}$). They not only provide the opportunity to study the evolution of individual metal-poor stars, but in addition, they serve as probes of halo metallicity at the time of their formation. Among such galactic halo PNe, K648(Ps1, PN G 065.0-27.3) is the most peculiar one, discovered by Küstner in 1921 close to the center of the galactic globular cluster M15. But, the existence of PNe in M15 is unexpected. The turn-off age of M15, 12 billion years, tells that the most massive main sequence stars in M15 should have $M_{\text{initial}} < 0.8M_{\odot}$. Such low mass stars might not ascend to the AGB and eject a PN (Rauch et al. 2002, A&A, 381, 1007). Recent observation of *HST* revealed bipolar and ripple structures in this nebula. It suggests that the progenitor of K648 experienced mass augmentation in a close binary merger (Alves et al. 2000, AJ, 120, 2044). In order to investigate the nebular kinematics of K648 more precisely, we have carried out the highest dispersion spectroscopy ($R \sim 90,000$), using the echelle spectrograph (HDS) of 8.2m Subaru telescope. In the presentation, we will show the latest results of spatially resolved spectrum and discuss the mass loss mechanism of K648.

104. An HST Study of the Molecular Gas in Planetary Nebulae

Josh Tartar, Angela Speck, & Sarah Eyermann, Department of Physics and Astronomy, Univ. Missouri, et al.

Planetary Nebulae (PNe) are major contributors of new elements, gas and dust to the interstellar medium (ISM). A better understanding of the nature of the molecular and ionized gas envelopes of PNe is important both to our understanding of their contribution to the ISM and the evolution of PNe themselves. To that end, we use the Hubble Space Telescope (HST) to study H₂ emission in several PNe. Using HST's unprecedented resolution and sensitivity for near-IR observations, we are studying the distribution and intensity of molecular gas emission from PNe. It has been shown recently that small scale structures (knots and filaments) of molecular gas survive within the ionized regions of PNe. The origin and evolution of these molecular clumps is unclear; to this end, we analyzed the H₂ emission in several PNe as seen by NICMOS, comparing the distribution of molecular gas with that of the ionized gas. Furthermore, we compare the distribution and intensity of the H₂ emission from nebula to nebula to ascertain whether evolutionary trends can be discerned. The origin of the H₂ emission is believed to be mini-photo-dissociation regions (PDR) at the surfaces of dense, optically thick knots of molecular gas and dust. Therefore, we compare the average H₂ surface brightnesses of the nebulae with models for PDR emission from PNe at various stages of evolution.

105. Subaru + FOCAS Observations of PNs in NGC 821

A. M. Teodorescu & R. H. Mendez, Institute for Astronomy, Univ. of Hawai'i; A. Riffeser, Munich University Observatory

We have started a survey for PNs in the elliptical galaxy NGC 821, with the goal of increasing the sample already observed with the PN Spectrograph at La Palma. We will provide photometry and slitless radial velocities for all detected PNs. For the moment we have detected 75 PNs. A distance estimate based on the [O III] 5007 PN luminosity function will be presented.

106. M2-9—an Attempt to Understand Its Central Core

S. Torres-Peimbert, Instituto de Astronomia, U. de Mexico; A. Arrieta, U. Iberoamericana, Mexico; L. Georgiev, Instituto de Astronomia, U. de Mexico

The interpretation of the conditions of the central core of the Butterfly Nebula has been elusive, mainly because its emission originates in regions of different physical conditions.

We attempt to unify the spectroscopic information into a single consistent model.

107. Physical Parameters of Point-Symmetric PNe

Roberto Vázquez, Instituto de Astronomía, UNAM; Sandra Ayala & Luis F. Miranda, Instituto de Astrofísica de Andalucía, CSIC, et al.

We present a systematic observational study of more than 30 PNe which present point-symmetric microstructures, multiple bipolar outflows and other related features. This study includes direct imaging, high and low dispersion spectroscopy and, in some cases, VLA radio continuum. In order to complement our own observations, we also have used some data from the MAST Archive. Preliminary results indicate that, in general, point-symmetric features have lower density than the main body of the nebulae and similar velocity fields. Other variables do not have a clear behavior and deserve a deeper analysis. We discuss possible formation scenarios for the different cases of point-symmetry and related morphologies. This work has been supported by PAPIIT-UNAM grant IN111903-3, CONACYT grant 45848 (Mexico) and AYA2005-01495 grant of the Spanish MEC (co-funded by FEDER funds).

108. New Planetary Nebulae Found by the IPHAS Survey

Kerttu Viironen & Antonio Mampaso, Instituto de Astrofísica de Canarias; Romano Corradi, Isaac Newton Group of Telescopes, et al.

IPHAS (The Isaac Newton Telescope (INT) Photometric H α Survey) is an ongoing imaging survey of the Northern Galactic Plane. When completed, it will cover all the Northern Plane within -5 and 5 degrees of latitude, for a total area of 1800 deg^2 . The images are obtained with Wide Field Camera of the 2.5m Isaac Newton telescope through a narrow-band H α and Sloan r' and i' broad-band filters, reaching down to approximately a magnitude of $r' = 20$.

The survey is expected to discover many thousand new H α emitters, among them several hundred new Galactic planetary nebulae (PNe). The new PNe are searched from the IPHAS data through two methods: an automatic catalogue search based on $r' - \text{H}\alpha$ colours of the objects, and through visual inspection of continuum-subtracted H α mosaics.

In this poster the IPHAS survey is introduced and the methods used for looking for new PNe from the IPHAS data are presented. Also first results from the follow-up spectroscopy of candidate new PNe, obtained both at la Palma and at San Pedro Martir, are presented.

109. Can Planets Survive Stellar Evolution?

Eva Villaver, STScI/ESA; Mario Livio, STScI

In recent years, the quest for Jupiter-like giant planets has been extended to a completely different kind of hosts—white dwarfs. The general assumption is that the planet can survive the star's evolution. Once this is accepted, the fact that white dwarfs are 10^3 to 10^4 times fainter than their main sequence progenitors opens up the possibility to observe the planet through direct imaging in the infrared where the planet emission peaks. In general, it has been assumed that planets survive to the white dwarf stage if they manage to stay in a large enough orbit to avoid engulfment by the star when the latter increases its radius as it ascends the Red Giant and Asymptotic Giant Branch (AGB). However, before the star reaches the white dwarf stage, and immediately after the AGB evolution, the star evolves into a planetary nebula (PN), where the stellar temperature can reach 300,000 K at luminosities of $10^3 L_{\odot}$, while emitting powerful winds. We have explored how a gas planet evolving in such an environment is affected. We have determined the modified orbit due to the AGB mass-loss and describe the evolution of the planet's environment as the star evolves into the PN phase. We provide an estimate of the mass-loss rates and the planet's reaction to them. Ultimately we determine the range of planet masses and distances to the star that allow planet survival.

110. Mid-Infrared Imaging of Planetary Nebulae

Kevin Volk, Gemini Observatory; Sun Kwok, University of Calgary

Mid-infrared images at N-band and Q-band have been obtained for about 25 planetary nebulae, using the T-ReCS and Michelle instruments at the Gemini Observatory. For some objects there are no previous images published in the literature. In most cases there are optical images for comparison. The nebulae are chosen solely on the basis of estimated mid-infrared surface brightness.

In most cases the mid-infrared morphology closely resembles the optical morphology, indicating that the dust is well mixed with the ionized gas. Nebulae for which this is not the case have either unusually high dust extinction or unusually hot central stars. A few objects that are very bright in the mid-infrared are not resolved at N-band. Most of the nebulae are circular or elliptical, very few are highly bipolar in morphology.

Where resolved spectroscopy has been carried out, we do not see any change in the various dust features with position in the nebula, even for the UIR carriers.

111. Molecular Hydrogen Imaging of Planetary Nebulae with CFHT

Mei-Yan Wang, C. Muthu Mariappan, & Sun Kwok, Institute of Astronomy and Astrophysics, Academia Sinica

Near-infrared 2.121 micron $v=1-0$, $J=3-1$ S(1) vibrational-rotational line of molecular hydrogen (H_2) has been detected in a number of planetary nebulae and recent observations show that the emission is much more extended than what was anticipated earlier. As most part of H_2 is shock excited, detection of molecular H_2 emission can help in tracing the regions of dynamical interaction in planetary nebulae. We present here the preliminary results from our deep imaging survey of a sample of planetary nebulae taken with the CFHTIR. The improved sensitivity of CFHTIR attached with 3.6m Canada France Hawaii Telescope helped us to trace the detail structures of the sources for the first time in the near-infrared.

112. The Shaping of Planetary Nebulae through Interaction with the Interstellar Medium

Chris Wareing & Albert A Zijlstra, School of Physics & Astronomy, University of Manchester; Tim O'Brien, Jodrell Bank Observatory, University of Manchester

Interaction with the Interstellar Medium (ISM) cannot be ignored in models of PN evolution and shaping. As first pointed out by Villaver et al. (2003 ApJ 585 L49), this interaction begins during the AGB. We have run extensive sets of 3D simulations, from the beginning of the AGB superwind until the end of the PN phase. A “triple-wind” model is used, including a slow AGB wind, fast post-AGB wind and third wind reflecting the linear movement through the ISM. A wide range of stellar velocities (0 - 200 km/s), mass-loss rates and ISM densities are considered.

We find ISM interaction strongly affects the outer structures. The simulations predict parsec-size shells to be common: previously attributed to mass-loss modulations by thermal pulses. The structure and brightness of ancient PNe is largely determined by the ISM interaction during the AGB and the majority of PNe will have tail structures. A test case comparing simulations of a high speed star to new IPHAS observations of PN Sh 2-188 has given an excellent fit of our model to available data.

The simulations show that for a range of stellar velocities, periodic instabilities form behind the nebula, similar to von Karman vortex streets. This fluid instability has been considered astrophysically in accretion flows onto compact objects, but not, to our knowledge, in ISM interactions. The process leads to enhanced mixing between stellar ejecta and ISM material.

The results of this work, including movies of the simulations if possible, are to be presented at this conference.

113. Formation of the Bipolar Planetary-Nebula M2-9 by Confining Toroidal Magnetic Field and Surrounding High-Ram Pressure

Haruichi Washimi & Gary P. Zank, Institute of Geophysics and Planetary Physics, University of California at Riverside; T. Tanaka, Faculty of Science, Kyushu University; B. Balick, Department of Astronomy, University of Washington

We model the planetary nebula M2-9 which has highly axis-symmetric bipolar lobes. It is assumed that the magnetic pressure of the toroidal field in the stellar wind plays a dominant role in forming the bipolar flow along the rotation axis, and we examine this mechanism by using 3D MHD simulations. We find that the collimated high-density flow is formed by a combination of confinement by the toroidal magnetic field and the surrounding high-ram pressure wind which emerges from the lower and middle latitudes near the star and is accelerated by the magnetic pressure. The stellar wind, which expands in the radial direction, is found to bend poleward with distance from the star due to a magnetic pinch effect, hence the wind density at high latitudes is enhanced and bipolar lobes are formed. This model is found to be consistent with the observational result that the wind speed along the axis is accelerated from 46 km/s near the stellar center (Solf, 2000) to 164km/s at the termination of the bipolar lobe (Schwartz et al., 1997). The overall structure is found to be a self-consistent consequence of the stellar wind itself, corresponding to two kinds of self-consistent circumstellar gas distributions, one a collimated flow and the other enveloping the collimated flow.

114. 3D Photoionisation Modelling of the Dusty Planetary Nebula, NGC6302

N. J. Wright, University College London; M. J. Barlow, University College London; B. Ercolano, University College London

NGC 6302 is a high-excitation bipolar planetary nebula with a complex emission-line spectrum and a major dust component that shows both O-rich and C-rich chemistry. The wide range of ion states, peculiar chemistry and the dominating presence of dust makes NGC 6302 an ideal environment for the application of 3D numerical modelling to study the gas density distribution and the abundances of the various dust species in the extended nebula and edge-on disk.

The presence of dust grains in ionised plasma environments has significant effects on the physical conditions of the gas. The dust grains can compete with the gas for the absorption of continuum UV photons and are also heated by nebular resonance line radiation emitted by the gas. The coupling between the co-existing dust and gas components can only be treated properly in a photoionisation code by the incorporation of all linked processes, such as the scattering, absorption and emission of radiation by dust particles, as well as gas-grain collisions which provide an extra cooling channel for the gas.

We present the results of our 3D photoionisation modelling of NGC 6302, incorporating multiple dust species in an attempt to match the observed ISO spectrum. The modelling of an object with such a complicated structure provides an excellent testing ground for the 3D photoionisation code MOCASSIN, and for the atomic and dust data needed by such a code. A particular goal has been to diagnose the energy distribution and luminosity of NGC 6302's very hot central star.

115. Fluorine Abundances in Planetary Nebulae

Y. Zhang & X.-W. Liu, Department of Astronomy, Peking University

We have determined fluorine abundances from the [F II] $\lambda 4789$ and [F IV] $\lambda 4060$ nebular emission lines for a sample of planetary nebulae (PNe). Our results show that fluorine is generally overabundant in PNe, thus providing new evidence for the synthesis of fluorine in asymptotic giant branch (AGB) stars. [F/O] is found to be positively correlated with the C/O abundance ratio, in agreement with the predictions of theoretical models of fluorine production in thermally pulsing AGB stars. A large enhancement of fluorine is observed in the Wolf-Rayet PN NGC 40, suggesting that high mass-loss rates probably favor the survival of fluorine.

LATE POSTERS

116. Deep Spectroscopy of Planetary Nebulae

W. Wang & X.-W. Liu, Department of Astronomy, Peking University

We report the results of a deep spectroscopic study for 25 Galactic Bulge PNe (GBPNe) plus 6 disk PNe. In this work, long-slit medium resolution spectra in the optical combined with archival infrared and ultraviolet spectra, are utilized to carry out detailed extinction analyses, plasma diagnostics of electron temperatures and densities, as well as elemental determinations, using both the traditional method by means of collisionally excited lines (CELs) and optical recombinations line (ORLs).

Extinction curves toward individual nebulae derived from hydrogen and helium recombination lines/continua are found to vary from nebula to nebula and are generally steeper than the standard law for the general interstellar medium (ISM), suggesting that reddening toward the Galactic center is abnormal and inhomogeneous. Our results of abundance determinations are in good agreement with previous studies for GBPNe (mainly based on CELs) and for disk PNe (using both CELs and ORLs).

GBPNe are found to exhibit similar discrepancies between the results of nebulae plasma diagnostics and heavy element abundance determinations using ORLs on the one hand and CELs on the other, as previously found for many disk PNe and a small number of GBPNe. The discrepancies show similar correlations with some nebular properties as found in previous studies.

Apart from oxygen and nitrogen accessible in the optical, via ORL analysis, we have been able to obtain reliable abundances of the key element carbon for the first time for a significant sample of GBPNe. We find that GBPNe have C/O ratios about 0.2 dex lower than disk PNe. In addition, in 7 out of the total 31 objects, we detected the Mg II 4f-3d 4481.21 line, allowing determinations of the magnesium abundance. The results seem to indicate that GBPNe may have an average magnesium abundance above the solar value. We find that both the means and distributions of the metallicity of GBPNe suggest that GBPNe are metal-rich compared to disk PNe, in accordance with the most recent studies. Finally we find an abundance gradient which is only 0.020 dex per kpc, about one third of values found previously using other tracers.

117. s-Process Abundances in Planetary Nebulae: Br, Kr & Xe

Yong Zhang, Robert Williams, Eric Pellegrini, Kenneth Cavagnolo, Jack A. Baldwin, Brian Sharpee, Mark Phillips, and Xiao-Wei Liu

We identify emission lines of post-iron peak elements in very high signal-to-noise spectra of a sample of planetary nebulae. Analysis of lines from ions of Kr and Xe reveals enhancements in most of the PNe caused by the s-process in the central star progenitors. Kr and Xe are representative elements of the 'light' and 'heavy' s-process peaks, and if Ar is taken as a surrogate for Fe because of the latter's strong depletion onto grains in nebulae, our sample of PNe exhibit relatively high ratios of heavy to light s-process enhancements with a mean of the neutron exposure related parameter $[\text{hs}/\text{ls}] \sim 0.4$. This value is near the upper limit of those derived from the stellar spectra of AGB stars, and indicates that the progenitors of planetary nebulae experience high neutron exposures. Surprisingly, we do not observe lines from Br even though s-process calculations indicate that it should be produced with Kr at detectable levels. We interpret this to be evidence that the solar Br abundance is lower than currently accepted values.

118. Fe/Ni ratio in the Bipolar Planetary Nebula Mz 3

Y. Zhang & X.-W. Liu, Department of Astronomy, Peking University

We analyze the [Fe II] and [Ni II] emission lines in the bipolar planetary nebula Mz3. We find that the [Fe II] and [Ni II] lines arise exclusively from the central regions. Fluorescence excitation in the formation process of these lines is negligible for the low-excitation nebula. From the [Fe II]/[Ni II] ratio, we obtain a higher Fe/Ni abundance ratio with respect to the solar. Our results provide a new evidence that Mz3 is a symbiotic Mira and the central nebula originates from a giant companion since modelling of AGB stars predicts a depletion of Fe/Ni ratio after s-process.

119. Recombination Line Spectroscopy : The OII Spectrum

Robert J. Bastin and Peter J. Storey, University College London

Abstract : Weak recombination lines (RL's) are increasingly being used to determine physical properties in PNe. Recent observations detect transitions (e.g. 4f-3d of OII, Y. G. Tsamis et al., MNRAS, 353, 953-979, 2004) for which the LS approximation (P. J. Storey, A&A, 282, 999-1013, 1994) is not accurate. A full intermediate coupling (IC) treatment of the radiative capture and cascade problem is required. Ab-initio atomic data were calculated using the R-matrix method and RmaX suite of codes (K. A. Berrington et al., J.Phys.B v20 pp6379-97, 1987). In the IC framework, it is possible to account for the distribution of population in the ground levels of the parent ion, which are assumed proportional to statistical weight in current theoretical work, a poor approximation in low density nebulae. We show that a full IC treatment of OIII recombination, including fine-structure dielectronic processes, yields line intensity ratios in much better agreement with observation than previous work, especially for nebulae with densities below 10000 /cm³. Elemental abundances derived from the new theory will therefore be more accurate and consistent. The theory provides new means of determining the conditions in the regions emitting the RL's.

120. New Discoveries from the IPHAS survey

L. Sabin, K. Viironen, A. Mampaso, R. Corradi, R. Greimel, D. Lennon, and IPHAS

Discoveries of planetary nebula candidates in the Galactic anticenter region from images taken with the 2.5m Isaac Newton Telescope and Wide Field Camera.