THE AGB NEWSLETTER

An electronic publication dedicated to Asymptotic Giant Branch stars and related phenomena

No. 132 — 1 June 2008

http://www.astro.keele.ac.uk/AGBnews

Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 132nd issue of the AGB Newsletter. AGB-related papers continue to appear at a frequency of well over one per day.

Important releases have been announced, of the Dartmouth stellar evolution models and the MARCS atmospheric models. The initial-final mass relation has been refined (Catalán et al.) and after Mattsson et al.'s recent Letter, Wachter et al. have now published a comprehensive discussion of theoretical predictions for the mass loss from metal-poor carbon stars. Two papers discuss Fluorine production (Cunha et al. and Lugaro et al.), and Mira's tail also receives plenty of attention: an H I counterpart has been discovered (Matthews et al.) and a new wind model is presented (Raga et al.).

For those of you who are interested in AGB stars and Planetary Nebulae in the Magellanic Clouds, IAU Symposium 256 on "The Magellanic System: Stars, Gas, and Galaxies" takes place at Keele University from 28 July until 1 August (2008) — registrations and poster abstracts are accepted until 18 July. Please see the website for further details: http://www.astro.keele.ac.uk/iaus256.

The next issue will be distributed on the 1st of July; the deadline for contributions is the 30th of June.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

All AGB stars have a tail

Reactions to this statement or suggestions for next month's statement can be e-mailed to agbnews@astro.keele.ac.uk (please state whether you wish to remain anonymous)

Spitzer Space Telescope evidence in NGC 6791: no super-mass-loss at super-solar metallicity to explain helium white dwarfs?

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We use archival *Spitzer* Space Telescope photometry of the old, super-solar metallicity massive open cluster NGC 6791 to look for evidence of enhanced mass loss, which has been postulated to explain the optical luminosity function and low white dwarf masses in this benchmark cluster. We find a conspicuous lack of evidence for prolificacy of circumstellar dust production that would have been expected to accompany such mass loss. We also construct the optical and infrared luminosity functions, and demonstrate that these fully agree with theoretical expectations. We thus conclude that there is no evidence for the mass loss of super-solar metallicity red giants to be sufficiently high that they can avoid the helium flash at the tip of the red giant branch.

Accepted for publication in ApJ Letters
Available from arXiv:0804.4559

The structure and chemistry of the massive shell around AFGL 2343: ^{29}SiO and HCN as tracers of high-excitation regions

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The yellow hypergiant stars (YHGs) are very massive objects that are expected to pass through periods of intense mass loss during their evolution. Despite of this, massive circumstellar envelopes have been found only in two of them, IRC +10420 and AFGL 2343. The envelopes around these objects and the processes that form them are poorly known. We aim to study the structure, dynamics and chemistry of the envelope around AFGL 2343. We have obtained interferometric maps of the rotational lines ^{29}SiO J= 2–1, HCN J= 1–0 and SO J(K)= 2(2)–1(1) towards AFGL 2343. We have used an LVG excitation model to analyze the new observations and some previously published line profiles of AFGL 2343. The analysis of the observational data and the fitting results show the presence of a thin, hot and dense component within the previously identified CO shell. This component can be associated with recently shocked gas, but it could also be due to a phase of extremely copious mass loss. We suggest that this shell is the responsible for the whole ^{29}SiO emission and significantly contributes to the HCN emission. The presence of such a dense shell rich in SiO can be related with that previously found for IRC +10420, which was also suggested to result from a shock. This may be a common feature in the evolution of these stars, as a consequence of the episodic mass loss periods that they pass during their evolution. We present new results for the mass loss pattern, the total mass of the circumstellar envelope and the molecular abundances of some species in AFGL 2343.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:0804.2367

Metallicity and effective temperature of the secondary of RS Oph

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The recurrent nova RS Oph undergoes nova eruptions every $\sim 10-20$ years as a result of thermonuclear runaway on the surface of a white dwarf close to the Chandrasekhar limit. Both the progress of the eruption, and its aftermath, depend on the (poorly known) composition of the red giant in the RS Oph system. Our aim is to understand better the effect of the giant secondary on the recurrent nova eruption. Synthetic spectra were computed for a grid of M-giant model atmospheres having a range of effective temperatures $3200 < T_{\rm eff} < 4400$ K, gravities $0 < \log g < 1$ and abundances $-4 <$[Fe/H]< 0.5, and fit to infrared spectra of RS Oph as it returned to quiescence after its 2006 eruption. We have modelled the infrared spectrum in the range $1.4-2.5$ μm to determine metallicity and effective temperature of the red giant. We find $T_{\rm eff} = 4100 \pm 100$ K, $\log g = 0.0 \pm 0.5$, [Fe/H] $= 0.0 \pm 0.5$, [C/H] $= -0.8 \pm 0.2$, [N/H] $= +0.6 \pm 0.3$ in the atmosphere of the secondary, and demonstrate that that inclusion of some dust 'veiling' in the spectra cannot improve our fits.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:0804.3316

The Dartmouth Stellar Evolution Database

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The ever-expanding depth and quality of photometric and spectroscopic observations of stellar populations increase the need for theoretical models in regions of age-composition parameter space that are largely unexplored at present. Stellar evolution models that employ the most advanced physics and cover a wide range of compositions are needed to extract the most information from current observations of both resolved and unresolved stellar populations. The Dartmouth Stellar Evolution Database is a collection of stellar evolution tracks and isochrones that spans a range of [Fe/H] from -2.5 to $+0.5$, [α/Fe] from -0.2 to $+0.8$ (for [Fe/H]≤ 0) or $+0.2$ (for [Fe/H]> 0), and initial He mass fractions from $Y = 0.245$ to 0.40. Stellar evolution tracks were computed for masses between 0.1 and 4 $M_\odot$, allowing isochrones to be generated for ages as young as 250 Myr. For the range in masses where the core He flash occurs, separate He-burning tracks were computed starting from the zero age horizontal branch. The tracks and isochrones have been transformed to the observational plane in a variety of photometric systems including standard UBV(RI)$_{\rm c}$, Stromgren uvby, SDSS ugriz, 2MASS JHK$_{\rm s}$, and HST ACS-WFC and WFPC2. The Dartmouth Stellar Evolution Database is accessible through a website (http://stellar.dartmouth.edu/~models/) where all tracks, isochrones, and additional files can be downloaded.

Accepted for publication in ApJS
Available from arXiv:0804.4473
and from http://stellar.dartmouth.edu/~models/

Stellar Exotica in 47 Tucanae

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We present far-ultraviolet (FUV) spectroscopy obtained with the Hubble Space Telescope (HST) for 48 blue objects in the core of 47 Tuc. Based on their position in a FUV-optical colour-magnitude diagram, these were expected to include cataclysmic variables (CVs), blue stragglers (BSs), white dwarfs (WDs) and other exotic objects. For a subset of these sources, we also construct broad-band, FUV through near-infrared spectral energy distributions. Based on our analysis of this extensive data set, we report the following main results. (1) We detect emission lines in three previously known or suspected CVs and thus spectroscopically confirm the status of these systems. We also detect new dwarf nova eruptions in two of these CVs. (2) Only one other source in our spectroscopic sample exhibits marginal evidence for line emission. Thus CVs are not the only class of objects found in the gap between the WD and main sequences, nor are they common amongst objects near the top of the WD cooling sequence. Nevertheless, predicted and observed numbers of CV agree to within a factor of about 2-3. (3) We have discovered a hot ($T_{\rm eff}$ = 8700 K), low-mass ($M = 0.05$ M$_{\odot}$) secondary star in a previously known 0.8 day binary system. This exotic object completely dominates the binary's FUV-NIR output and is probably the remnant of a subgiant that has been stripped of its envelope. Since this object must be in a short-lived evolutionary state, it may represent the "smoking gun" of a recent dynamical encounter. (4) We have found a Helium WD, only the second such object to be optically detected in 47 Tuc, and the first outside a millisecond pulsar system. (5) We have discovered a bright BS with a young WD companion, the only BS-WD binary known in any GC. (6) We have found two additional candidate WD binary systems, one containing a MS companion, the other containing a subgiant. (7) We estimate the WD binary fraction in the core of 47 Tuc to be 15^{+17}_{-9} (stat) $^{+8}_{-7}$ (sys) per cent. (8) The mass of the optically brightest BS in our sample may exceed twice the cluster turn-off mass, but the uncertainties are too large for this to be conclusive. Thus there is still no definitive example of such a "supermassive" BS in any GC. Taken as a whole, our study illustrates the wide range of stellar exotica that are lurking in the cores of GCs, most of which are likely to have undergone significant dynamical encounters.

Accepted for publication in ApJ

Available from arXiv:0805.0140

and from http://www.astro.soton.ac.uk/∼christian (under "Research")

VLTI monitoring of the dust formation event of the Nova V1280 Sco

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We present the first high spatial resolution monitoring of the dust forming nova V1280 Sco performed with the Very Large Telescope Interferometer (VLTI). These observations aim at improving the distance determination of such events and constraining the mechanisms leading to very efficient dust formation under the harsh physical conditions encountered in novae ejecta. Spectra and visibilities were regularly obtained from the onset of the dust formation 23 days after discovery (or 11 days after maximum) till day 145, using the beam-combiner instruments AMBER (near-IR) and MIDI (mid-IR). These interferometric observations are complemented by near-infrared data from the 1.2m Mt. Abu Infrared Observatory, India. The observations are first interpreted with simple uniform models but more complex models, involving a second shell, are necessary to explain the data obtained from $t = 110$ d after outburst. This behavior is in accordance with the light curve of V1280 Sco which exhibits a secondary peak around $t = 106$ d, followed by a new steep decline, suggesting a new dust forming event. Spherical dust shell models generated with the DUSTY code are also used to investigate the parameters of the main dust shell. Using uniform disk models, these observations allow us to determine an apparent linear expansion rate for the dust shell of 0.35 ± 0.03 mas day^{-1} and the approximate time of ejection of the matter in which dust formed as $t_{\rm ejec} = 10.5 \pm 7$ d, i.e. close to the maximum brightness. This information, combined with the expansion velocity of 500±100 km s^{-1}, implies a distance estimate of 1.6±0.4 kpc. The sparse *uv* coverage does not allow to get clear indications of deviation from spherical symmetry. The dust envelope parameters were determined. The dust mass generated was typically $2 - 8 10^{-9}$ M$_\odot$ day^{-1}, with a probable peak in production at about 20 days after the detection of dust and another peak shortly after $t = 110$ d, when the amount of dust in the shell was estimated as $2.2 10^{-7}$ M$_\odot$. Considering that the dust forming event lasted at least $200 - 250$ d, the mass of the ejected material is likely to have exceeded 10^{-4} M$_\odot$. The conditions for the formation of multiple shells of dust are also discussed.

Accepted for publication in Astronomy and Astrophysics
Available from arXiv:0804.4129

The Dearth of UV-Bright Stars in M 32: Implications for Stellar Evolution Theory

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Using the Space Telescope Imaging Spectrograph on the Hubble Space Telescope, we have obtained deep far-ultraviolet images of the compact elliptical galaxy M 32. When combined with earlier near-ultraviolet images of the same field, these data enable the construction of an ultraviolet color-magnitude diagram of the hot horizontal branch (HB) population and other hot stars in late phases of stellar evolution. We find few post-asymptotic giant branch (PAGB) stars in the galaxy, implying that these stars either cross the HR diagram more rapidly than expected, and/or that they spend a significant fraction of their time enshrouded in circumstellar material. The predicted luminosity gap between the hot HB and its AGB-Manqué (AGBM) progeny is less pronounced than expected, especially when compared to evolutionary tracks with enhanced helium abundances, implying that the presence of hot HB stars in this metal-rich population is not due to $(\Delta Y)/(\Delta Z) > 4$. Only a small fraction ($\sim 2\%$) of the HB population is hot enough to produce significant UV emission, yet most of the UV emission in this galaxy comes from the hot HB and AGBM stars, implying that PAGB stars are not a significant source of UV emission even in those elliptical galaxies with a weak UV excess.

Accepted for publication in The Astrophysical Journal
Available from arXiv:0804.3376

Near-Infrared Constraints on the Presence of Warm Dust at Metal-Rich, Helium Atmosphere White Dwarfs

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Here, we present near-infrared spectroscopic observations of 15 helium atmosphere, metal-rich white dwarfs obtained

at the NASA Infrared Telescope Facility. While a connection has been demonstrated between the most highly polluted, hydrogen atmosphere white dwarfs and the presence of warm circumstellar dust and gas, their frequency at the helium atmosphere variety is poorly constrained. None of our targets show excess near-infrared radiation consistent with warm orbiting material. Adding these near-infrared constraints to previous near- and mid-infrared observations, the frequency of warm circumstellar material at metal-bearing white dwarfs is at least 20% for hydrogen-dominated photospheres, but could be less than 5% for those effectively composed of helium alone. The lower occurrence of dust disks around helium atmosphere white dwarfs is consistent with Myr timescales for photospheric metals in massive convection zones. Analyzing the mass distribution of 10 white dwarfs with warm circumstellar material, we search for similar trends between the frequency of disks and the predicted frequency of massive planets around intermediate mass stars, but find the probability that disk-bearing white dwarfs are more massive than average is not significant.

Accepted for publication in AJ
Available from arXiv:0804.3398

The initial-final mass relationship of white dwarfs revisited: effect on the luminosity function and mass distribution

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The initial-final mass relationship connects the mass of a white dwarf with the mass of its progenitor in the main-sequence. Although this function is of fundamental importance to several fields in modern astrophysics, it is not well constrained either from the theoretical or the observational points of view. In this work we revise the present semi-empirical initial-final mass relationship by re-evaluating the available data. The distribution obtained from grouping all our results presents a considerable dispersion, which is larger than the uncertainties. We have carried out a weighted least-squares linear fit of these data and a careful analysis to give some clues on the dependence of this relationship on some parameters such as metallicity or rotation. The semi-empirical initial-final mass relationship arising from our study covers the range of initial masses from 1.0 to 6.5 $M_\odot$, including in this way the low-mass domain, poorly studied until recently. Finally, we have also performed a test of the initial-final mass relationship by studying its effect on the luminosity function and on the mass distribution of white dwarfs. This was done by using different initial-final mass relationships from the literature, including the expression derived in this work, and comparing the results obtained with the observational data from the Palomar Green Survey and the Sloan Digital Sky Survey (SDSS). We find that the semi-empirical initial-final mass relationship derived here gives results in good agreement with the observational data, especially in the case of the white dwarf mass distribution.

Accepted for publication in MNRAS
Available from arXiv:0804.3034

The screening of the 11.3-μm SiC feature by carbonaceous mantles in circumstellar shells

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Silicon carbide, a refractory material, condenses near the photospheres of C-rich AGB stars, giving rise to a conspicuous emission feature at 11.3 μm. In the presence of a stellar wind, the SiC grains are carried outwards to colder regions, where less refractory carbonaceous material can condense, either by itself or in mantles upon SiC grains. Enough carbon can condense on the latter that their specific feature is completely veiled. Thus may be explained a) the

coexistence of the SiC feature protruding above a carbonaceous continuum, with a range of contrasts, corresponding to various volume ratios of mantle to core; b) the ultimate disappearance of the 11.3-μm feature from the interstellar medium, where the mantle has become completely opaque due to the much higher cosmic abundance of carbon.

Accepted for publication in MNRAS
Available from arXiv:0804.4838

Fluorine Abundances in the Milky Way Bulge

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Fluorine (^{19}F) abundances are derived in a sample of 6 bulge red giants in Baade's Window. These giants span a factor of 10 in metallicity and this is the first study to define the behavior of ^{19}F with metallicity in the bulge. The bulge results show an increase in F/O with increasing oxygen. This trend overlaps what is found in the disk at comparable metallicities, with the most oxygen-rich bulge target extending the disk trend. The increase in F/O in the disk arises from ^{19}F synthesis in both asymptotic giant branch (AGB) stars and metal-rich Wolf-Rayet (WR) stars through stellar winds. The lack of an s-process enhancement in the most fluorine-rich bulge giant in this study, suggests that WR stars represented a larger contribution than AGB stars to ^{19}F production in the bulge when compared to the disk. If this result for fluorine is combined with the previously published overall decline in the O/Mg abundance ratios in metal-rich bulge stars, it suggests that WR winds played a role in shaping chemical evolution in the bulge. One star in this study exhibits a very low value of F/O while having a large O-abundance; this chemical mixture can be understood if this star formed from gas that was enriched by metal-poor core-collapse supernovae and may indicate that chemical evolution in the bulge was inhomogeneous.

Accepted for publication in ApJ Letters
Available from arXiv:0804.1284

Hot DQ White Dwarfs: Something Different

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We present a detailed analysis of all the known Hot DQ white dwarfs in the Fourth Data Release of the Sloan Digital Sky Survey (SDSS) recently found to have carbon dominated atmospheres. Our spectroscopic and photometric analysis reveals that these objects all have effective temperatures between $\sim 18,000$ and 24,000 K. The surface composition is found to be completely dominated by carbon, as revealed by the absence of Hβ and He I 4471 lines (or determination of trace amount in a few cases). We find that the surface gravity of all objects but one seems to be "normal" and around $\log g = 8.0$ while one is likely near $\log g = 9.0$. The presence of a weak magnetic field is directly detected by spectropolarimetry in one object and is suspected in two others. We propose that these strange stars could be cooled down versions of the weird PG 1159 star H 1504+65 and form a new family of hydrogen and helium deficient objects following the post-AGB phase. Finally, we present the results of full nonadiabatic calculations dedicated specifically to each of the Hot DQ that show that only SDSS J142625.70+575218.4 is expected to exhibit luminosity variations. This result is in excellent agreement with recent observations by Montgomery et al. who find that J142625.70+575218.4 is the only pulsator among 6 Hot DQ white dwarfs surveyed in February 2008.

Accepted for publication in Astrophysical Journal
Available from arXiv:0805.0331

The evolved stars of Leo II dSph galaxy from near-infrared UKIRT/WFCAM observations

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We present a study of the evolved stellar populations in the dwarf spheroidal galaxy Leo II, based on JHK_s observations obtained with the near-infrared array WFCAM at the UKIRT telescope.
Combining the new data with optical data, we derived photometric estimates of the distribution of global metallicity [M/H] of individual red giant stars from their $V - K_s$ colours. We used the new data to derive the properties of a nearly complete sample of asymptotic giant branch (AGB) stars in Leo II. Using a near-infrared two-colour diagram, we were able to obtain a clean separation from Milky Way foreground stars and discriminate between carbon- and oxygen-rich AGB stars.
We simulate the JHK_s data with the TRILEGAL population synthesis code together with the most updated thermally pulsing AGB models, and using the star formation histories derived from independent work based on deep HST photometry. After scaling the mass of Leo II models to the observed number of upper RGB stars, we find that present models predict too many O-rich TP-AGB stars of higher luminosity due to a likely under-estimation of either their mass-loss rates at low metallicity, and/or their degree of obscuration by circumstellar dust. On the other hand, the TP-AGB models are able to reproduce the observed number and luminosities of carbon stars satisfactorily well, indicating that in this galaxy the least massive stars that became carbon stars should have masses as low as ~ 1 M$_\odot$.

Accepted for publication in MNRAS
Available from arXiv:0805.0735

Fluorine in carbon-enhanced metal-poor stars: a binary scenario

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A super-solar fluorine abundance was observed in the carbon-enhanced metal-poor (CEMP) star HE 1305+0132 ([F/Fe] = +2.90, [Fe/H] = −2.5). We propose that this observation can be explained using a binary model that involve mass transfer from an asymptotic giant branch (AGB) star companion and, based on this model, we predict F abundances in CEMP stars in general. We discuss wether F can be used to discriminate between the formation histories of most CEMP stars: via binary mass transfer or from the ejecta of fast-rotating massive stars. We compute AGB yields using different stellar evolution and nucleosynthesis codes to evaluate stellar model uncertainties. We use a simple dilution model to determine the factor by which the AGB yields should be diluted to match the abundances observed in HE 1305+0132. We further employ a binary population synthesis tool to estimate the probability of F-rich CEMP stars. The abundances observed in HE 1305+0132 can be explained if this star accreted 3-11% of the mass lost by its former AGB companion. The primary AGB star should have dredged-up at least 0.2 M$_\odot$ of material from its He-rich region into the convective envelope via third dredge-up, which corresponds to AGB models of $Z \simeq 0.0001$ and mass $\simeq 2$ M$_\odot$. Many AGB model uncertainties, such as the treatment of convective borders and mass loss, require further investigation. We find that in the binary scenario most CEMP stars should also be FEMP stars, that is, have [F/Fe] $> +1$, while fast-rotating massive stars do not appear to produce fluorine. We conclude that fluorine is a signature of

low-mass AGB pollution in CEMP stars, together with elements associated with the *slow* neutron-capture process.

Accepted for publication in A&A Letters
Available from arXiv:0805.1121

AGB stars as tracers of metallicity and mean age across M 33

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Wide-field JHK_s near-infrared observations covering an area of $1.8^\circ \times 1.8^\circ$ centred on M 33 were obtained using WFCAM at UKIRT. These data show a large population of intermediate-age asymptotic giant branch stars (AGB). We have used both C-type and M-type AGB stars to determine spatial variations in metallicity and mean age across the galaxy. We distinguished between C-type and M-type AGB stars from their location in the colour-magnitude diagram ($J–K_s$, K_s). The distribution of these stars is supported by a cross-identification between our sample and a catalogue of optically confirmed, long-period variable stars, as well as with the list of sources detected by Spitzer in the mid-infrared. We calculated the C/M ratio and the orientation of the galaxy in the sky, and compared the K_s magnitude distribution with theoretical distributions spanning a range of metallicities and star formation rates (SFRs). The C/M ratio surface map confirms a metallicity gradient in the galaxy corresponding to a spread in [Fe/H]=0.6 dex with substructures in the inner and outer galaxy. Magnitude and colour variations suggest orientation and extinction effects on the galaxy disc. Maps showing the distribution of mean age and metallicity obtained from the K_s method suggest that: the outer galaxy disc/halo is metal poorer than the nuclear region and metal-rich clumps in the inner galaxy change location with time. The average outer ring and nuclear stellar population is ~ 6 Gyr old while central regions are a few Gyr younger.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:0805.1143

Towards a Spectral Technique for Determining Material Geometry Around Evolved Stars: Application to HD 179821

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HD 179821 is an evolved star of unknown progenitor mass range (either post-Asymptotic Giant Branch or post-Red Supergiant) exhibiting a double peaked spectral energy distribution (SED) with a sharp rise from $\sim 8 - 20\ \mu$m.

Such features have been associated with ejected dust shells or inwardly truncated circumstellar discs. In order to compare SEDs from both systems, we employ a spherically symmetric radiative transfer code and compare it to a radiative, inwardly truncated disc code. As a case study, we model the broad-band SED of HD 179821 using both codes. Shortward of 40 μm, we find that both models produce equivalent fits to the data. However, longward of 40 μm, the radial density distribution and corresponding broad range of disc temperatures produce excess emission above our spherically symmetric solutions and the observations. For HD 179821, our best fit consists of a $T_{\rm eff} = 7000$ K central source characterized by $\tau_{\rm V} \sim 1.95$ and surrounded by a radiatively driven, spherically symmetric dust shell. The extinction of the central source reddens the broad-band colours so that they resemble a $T_{\rm eff} = 5750$ K photosphere. We believe that HD 179821 contains a hotter central star than previously thought. Our results provide an initial step towards a technique to distinguish geometric differences from spectral modeling.

Accepted for publication in MNRAS
Available from arXiv:0801.2978

A New Outburst in the Extraordinary central Star of LMC-N66

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This is the first report on the new outburst presented by the central star of the LMC-N66 nebula. This object was classified as a planetary nebula, however, its true nature is under debate. In the period 1955–1990 the central star was almost undetectable and only nebular emission lines were observed. In 1990, the beginning of an outburst was detected and in few months it became much brighter and developed wide He and N lines, typical of a Wolf Rayet star of the N-sequence. The maximum occurred in 1994 and afterwards the star slowly faded. Analysis of its evolution showed that it has a variable mass-loss rate which occasionally increases enormously, creating a false photosphere at a much larger radius, making it appear a few magnitudes brighter. The present outburst has occurred 13 years after the episode from 1994 to 2000. So far this new event has similar characteristics although there are some significant differences in the spectral features. We present optical and FUSE spectra showing the main properties of this latter event.

Accepted for publication in Astrophysical Journal Letters
Available from arXiv:0805.2184

Discovery of an H I Counterpart to the Extended Tail of Mira

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We report the detection of an H I counterpart to the extended, far-ultraviolet-emitting tail associated with the asymptotic giant branch star Mira (*o* Ceti). Using the Nançay Radio Telescope (NRT), we have detected emission as far as 88′ north of the star, confirming that the tail contains a significant atomic component ($M_{\rm HI} \sim 4 \times 10^{-3}$ M$_\odot$). The NRT spectra reveal a deceleration of the tail gas caused by interaction with the local interstellar medium. We estimate an age for the tail of $\sim 1.2 \times 10^5$ years, suggesting that the mass-loss history of Mira has been more prolonged than previous observational estimates. Using the Very Large Array (VLA) we have also imaged the H I tail out to $\sim 12'$ (0.4 pc) from the star. The detected emission shows a "head-tail" morphology, but with complex substructure. Regions with detected H I emission correlate with far-ultraviolet-luminous regions on large scales, but the two tracers are not closely correlated on smaller scales ($\lesssim 1'$). We propose that detectable tails of H I are likely to be a common feature of

red giants undergoing mass-loss.

Accepted for publication in ApJ
Available from arXiv:0805.1730
and from http://www.cfa.harvard.edu/~lmatthew/Mira_HI.pdf

Planetary Nebulae in Face-On Spiral Galaxies. Planetary Nebula Photometry and Distances

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As the first step to determine disk mass-to-light ratios for normal spiral galaxies, we present the results of an imaging survey for planetary nebulae (PNe) in six nearby, face-on systems: IC 342, M 74 (NGC 628), M 83 (NGC 5236), M 94 (NGC 4736), NGC 5068, and NGC 6946. Using Blanco/Mosaic II and WIYN/OPTIC, we identify 165, 153, 241, 150, 19, and 71 PN candidates, respectively, and use the Planetary Nebula Luminosity Function (PNLF) to obtain distances. For M 74 and NGC 5068, our distances of 8.6 ± 0.3 Mpc and $5.4^{+0.2}_{-0.4}$ Mpc are the first reliable estimates to these objects; for IC 342 (3.5 ± 0.3 Mpc), M 83 (4.8 ± 0.1 Mpc), M 94 ($4.4^{+0.1}_{-0.2}$ Mpc), and NGC 6946 (6.1 ± 0.6 Mpc) our values agree well with those in the literature. In the larger systems, we find no evidence for any systematic change in the PNLF with galactic position, though we do see minor field-to-field variations in the luminosity function. In most cases, these changes do not affect the measurement of distance, but in one case the fluctuations result in a ~0.2 mag shift in the location of the PNLF cutoff. We discuss the possible causes of these small-scale changes, including internal extinction in the host galaxies and age/metallicity changes in the underlying stellar population.

Accepted for publication in ApJ
Available from arXiv:0805.1074

Chemical Abundances in Symbiotic Stars

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We have carried out a study of the chemical abundances of ^{1}H, ^{4}He, ^{12}C, ^{13}C, ^{14}N, ^{15}N, ^{16}O, ^{17}O, ^{20}Ne and ^{22}Ne in symbiotic stars (SSs) by means of a population synthesis code. We find that the ratios of the number of O-rich SSs to that of C-rich SSs in our simulations are between 3.4 and 24.1, depending on the third dredge-up efficiency λ and the terminal velocity of the stellar wind $v(\infty)$. The fraction of SSs with *extrinsic* C-rich cool giants in C-rich cool giants ranges from 2.1% to 22.7%, depending on λ, the common envelope algorithm and the mass-loss rate. Compared with the observations, the distributions of the relative abundances of ^{12}C/^{13}C vs. [C/H] of the cool giants in SSs suggest that the thermohaline mixing in low-mass stars may exist. The distributions of the relative abundances of C/N vs. O/N, Ne/O vs. N/O and He/H vs. N/O in the symbiotic nebulae indicate that it is quite common that the nebular chemical abundances in SSs are modified by the ejected materials from the hot components. Helium overabundance in some symbiotic nebulae may be relevant to a helium layer on the surfaces of white dwarf accretors.

Accepted for publication in ApJ
Available from arXiv:0805.0832

Shaping Planetary Nebulae by Light Jets

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We conduct numerical simulations of axisymmetrical jets expanding into a spherical AGB slow wind. The three-dimensional flow is simulated with an axially symmetric numerical code. We concentrate on jets that are active for a relatively short time. Our results strengthen other studies that show that jets can account for many morphological features observed in planetary nebulae (PNs). Our main results are as follows. (1) With a single jet's launching episode we can reproduce a lobe structure having a 'front-lobe', i.e., a small bulge on the front of the main lobe, such as that in the PN Mz 3. (2) In some runs dense clumps are formed along the symmetry axis, such as those observed in the pre-PN M1-92. (3) The mass loss history of the slow wind has a profound influence on the PN structure. (4) A dense expanding torus (ring; disk) is formed in most of our runs. The torus is formed from the inflated lobes, and not from a separate equatorial mass loss episode. (5) The torus and lobes are formed at the same time and from the same mass loss rate episode. However, when the slow wind density is steep enough, the ratio of the distance divided by the radial velocity is larger for regions closer to the equatorial plane than for regions closer to the symmetry axis. (6) With the short jet-active phase a linear relation between distance and expansion velocity is obtained in many cases. (7) Regions at the front of the lobe are moving sufficiently fast to excite some visible emission lines.

Submitted to MNRAS
Available from arXiv:0805.2332

A grid of MARCS model atmospheres for late-type stars I. Methods and general properties

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We have constructed a grid of about 10,000 spherically symmetric and plane-parallel models with the MARCS program, and make it available for public use. Parameter ranges are: $T_{\rm eff}$ = 2500 to 8000 K, $\log g = \log(GM/R^2) = -1$ to 5 (cgs) with various masses and radii, [Me/H]=-5 to $+1$, with [α/Fe] = 0.0 and 0.4 and different choices of C and N abundances to also represent stars of types R, S and N, and with microturbulence parameters from 1 to 5 km s^{-1}. We also list fluxes in approximately 108,000 wavelength points. Underlying assumptions in addition to 1D stratification include hydrostatic equilibrium, MLT convection and LTE. A number of general properties of the models are discussed, in relation to the effects of changing blanketing and sphericity. Models are compared with other available grids and excellent agreement is found with plane-parallel models of Castelli and Kurucz within the overlapping parameter range. Although there are departures from the spherically symmetric NextGen models, the agreement with more recent PHOENIX models is gratifying. The models of the grid show regularities, but some interesting departures from general patterns occur for the coolest models due to the molecular opacities. We have tested rules of thumb concerning effects of blanketing and sphericity and found them to often be astonishingly accurate. Some interesting new phenomena have been discovered, such as the intricate coupling between blanketing and sphericity, and the strong effects of carbon enhancement on metal-poor models. We give further details of models and comparisons with observations in subsequent papers.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:0805.0554

Emission line profiles as a probe of physical conditions in planetary nebulae

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We present an analysis of physical conditions in planetary nebulae (PNe) in terms of collisionally-excited line (CEL) and optical-recombination line (ORL) profiles. We aim to investigate whether line profiles could be used to study the long-standing CEL/ORL abundance-discrepancy problem in nebular astrophysics. Using 1D photoionization models and their assumed velocity fields, we simulate the line profiles of various ionic species. We attempt to use our model to account for the observed CEL and ORL profiles. As a case study we present a detailed study of line profiles of the low-excitation planetary nebula (PN) IC 418. Our results show that the profiles of classical temperature and density diagnostic lines, such as [O III] 4363,5007, [S II] 6716,6731, and [Ar IV] 4711,4740, provide a powerful tool to study nebular temperature and density variations. The method enables the CEL/ORL abundance-discrepancy problem to be studied more rigorously than before. A pure photoionization model of a chemically-homogeneous nebula seems to explain the observed disagreements in the profiles for the [O III] 4363 and the 5007 lines, but cannot account for the differences between the [O III] CELs and the O II ORLs. We also investigate the temperature and density variations in the velocity space of a sample of PNe, which are found to be insignificant.

Accepted for publication in A&A
Available from arXiv:0805.2198

AGB stars of the intermediate-age LMC cluster NGC 1846. II. Dredge up along the AGB

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Aims: We investigate the change in the surface abundance of ^{12}C during the evolution along the AGB, aiming to constrain third dredge-up models.
Methods: High-resolution, near-infrared spectra of a sample of AGB stars in the LMC cluster NGC 1846 were obtained. A cluster sample ensures a high level of homogeneity with respect to age, metallicity, and distance. The C/O ratio and the ratio of ^{12}C/^{13}C were measured and compared with our evolutionary models.
Results: For the first time, we show the evolution of the C/O and ^{12}C/^{13}C ratios along a cluster AGB. Our findings allow us to check the reliability of the evolutionary models and, in particular, the efficiency of the third dredge up. The increase in both C/O and ^{12}C/^{13}C in the observed O-rich stars is reproduced by the models well. However, the low carbon isotopic ratios of the two C-stars in our sample indicate the late occurrence of moderate extra mixing. The extra mixing affects the most luminous AGB stars and is capable of increasing the abundance of ^{13}C, while leaving unchanged the C/O ratio, which has been fixed by the cumulative action of several third dredge-up episodes. We find indications that the F abundance also increases along the AGB, supporting an in situ production of this element.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:0805.3242

A latitude-dependent wind model for Mira's cometary head

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We present a 3D numerical simulation of the recently discovered cometary structure produced as Mira travels through the galactic ISM. In our simulation, we consider that Mira ejects a steady, latitude-dependent wind, which interacts with a homogeneous, streaming environment. The axisymmetry of the problem is broken by the lack of alignment between the direction of the relative motion of the environment and the polar axis of the latitude-dependent wind. With this model, we are able to produce a cometary head with a "double bow shock" which agrees well with the structure of the head of Mira's comet. We therefore conclude that a time-dependence in the ejected wind is not required for reproducing the observed double bow shock.

Accepted for publication in ApJL
Available from arXiv:0805.0549

Spatially resolved spectroscopy of planetary nebulae and their halos I. Five galactic disk objects

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Strong mass loss off stars at the tip of the asymptotic giant branch (AGB) profoundly affects properties of these stars and their surroundings, including the subsequent planetary nebula (PN) stage. With this study we wanted to determine physical properties of mass loss by studying weakly emitting halos, focusing on objects in the galactic disk. Halos surround the, up to several thousand times, brighter central regions of PNe. Young halos, specifically, still contain information of the preceeding final mass loss stage on the AGB. In the observations we used the method of integral field spectroscopy with the PMAS instrument. This is the first committed study of halos of PNe that uses this technique. We improved our data analysis by a number of steps. In a study of the influence of scattered light we found that a moderate fraction of intensities in the inner halo originate in adjacent regions. As we combine line intensities of distant wavelengths, and because radial intensity gradients are steep, we corrected for effects of differential atmospheric refraction. In order to increase the signal-to-noise of weak emission lines we introduced a dedicated method to bin spectra of individual spatial elements. We also developed a general technique to part the temperature-sensitive oxygen line [O III] λ4363 from the adjacent telluric mercury line Hg λ4358 — without using separate sky exposures. By these steps we avoided introducing errors of several thousand Kelvin to our temperature measurements in the halo. For IC 3568 we detected a halo. For M 2-2 we found a halo radius that is 2.5 times larger than reported earlier. We derived radially densely sampled temperature and density structures for four nebulae, which all extend from the central regions and out into the halo. NGC 7662, IC 3568, and NGC 6826 show steep radially increasing temperatures and a hot halo, indicating that the gas in the halo is not in thermal equilibrium. M 2-2 shows a larger temperature in the central region and an otherwise constant value. From the density structures we made estimates of core and halo masses and — for the first time reliable – mass loss rates at the tip of the AGB. All four objects show inwards radially increasing mass loss rate structures, which represent a rise by a factor of about 4–7, during the final mass loss phase, that covers a time period of approximately 10^4 years. Within a factor of two, the average of the maximum mass loss rates, which are distance dependent, is $\dot{M}_{\rm max} \simeq 10^{-4}$ M$_\odot$ yr^{-1}.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:0802.3813

The core helium flash revisited: I. One and two-dimensional hydrodynamic simulations

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We investigate the hydrodynamics of the core helium flash near its peak. Past research concerned with the dynamics of this event is inconclusive. However, the most recent multidimensional hydrodynamic studies suggest a quiescent behavior and seem to rule out an explosive scenario. Previous work indicated, that depending on initial conditions, employed turbulence models, grid resolution, and dimensionality of the simulation, the core helium flash leads either to the disruption of a low-mass star or to a quiescent quasi-hydrostatic evolution. We try to clarify this issue by simulating the evolution with advanced numerical methods and detailed microphysics. Assuming spherical or axial symmetry, we simulate the evolution of the helium core of a 1.25 $M_\odot$ star with a metallicity $Z = 0.02$ during the core helium flash at its peak with a grid-based hydrodynamics code. We find that the core helium flash neither rips the star apart, nor that it significantly alters its structure, as convection plays a crucial role in keeping the star in hydrostatic equilibrium. In addition, our simulations show the presence of overshooting, which implies new predictions concerning mixing of chemical species in red giants.

Submitted to Astronomy and Astrophysics
Available from arXiv:0805.1355

Bright Planetary Nebulae and their Progenitors in Galaxies Without Star Formation

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We present chemical abundances for planetary nebulae in M 32, NGC 185, and NGC 205 based upon spectroscopy obtained at the Canada-France-Hawaii Telescope using the Multi-Object Spectrograph. From these and similar data compiled from the literature for bright planetary nebulae in other Local Group galaxies, we consider the origin and evolution of the stellar progenitors of bright planetary nebulae in galaxies where star formation ceased long ago. The ratio of neon to oxygen abundances in bright planetary nebulae is either identical to that measured in the interstellar medium of star-forming dwarf galaxies or at most changed by a few percent, indicating that neither abundance is significantly altered as a result of the evolution of their stellar progenitors. Several planetary nebulae appear to have dredged up oxygen, but these are the exception, not the rule. The progenitors of bright planetary nebulae typically enhance their original helium abundances by less than 50%. In contrast, nitrogen enhancements can reach factors of 100. However, nitrogen often shows little or no enhancement, without any relation between the level of enrichment and other parameters studied here, suggesting that nitrogen enrichment is a random process. The helium, oxygen, and neon abundances argue that the typical bright planetary nebulae in all of the galaxies considered here are the progeny of stars with initial masses of approximately 1.5 $M_\odot$ or less, based upon the nucleosynthesis predictions of current theoretical models. These models, however, are unable to explain the nitrogen enrichment or its scatter. Similar conclusions hold for the bright planetary nebulae in galaxies with ongoing star formation. Thus, though composition varies significantly, there is unity in the sense that the progenitors of typical bright planetary nebulae appear to have undergone similar physical processes.

Accepted for publication in Astrophysical Journal
Available from arXiv:0805.3669

High resolution infrared spectra of NGC 6440 and NGC 6441: two massive Bulge Globular Clusters

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Using the NIRSPEC spectrograph at Keck II, we have obtained infrared echelle spectra covering the 1.5-1.8 μm range for giant stars in the massive bulge globular clusters NGC 6440 and NGC 6441. We report the first high dispersion abundance for NGC 6440, [Fe/H]$= -0.56 \pm 0.02$ and we find [Fe/H]$= -0.50 \pm 0.02$ for the blue HB cluster NGC 6441. We measure an average α-enhancement of $\sim +0.3$ dex in both clusters, consistent with previous measurements of other metal rich bulge clusters, and favoring the scenario of a rapid bulge formation and chemical enrichment. We also measure very low ^{12}C/^{13}C isotopic ratios ($\sim 5 \pm 1$), suggesting that extra-mixing mechanisms are at work during evolution along the Red Giant Branch also in the high metallicity regime. We also measure Al abundances, finding average [Al/Fe]$= 0.45 \pm 0.02$ and [Al/Fe]$= 0.52 \pm 0.02$ in NGC 6440 and NGC 6441, respectively, and some Mg-Al anti-correlation in NGC 6441. We also measure radial velocities $v_{\rm r} = -76 \pm 3$ km s^{-1} and $v_{\rm r} = +14 \pm 3$ km s^{-1} and velocity dispersions $\sigma = 9 \pm 2$ km s^{-1} and $\sigma = 10 \pm 2$ km s^{-1}, in NGC 6440 and NGC 6441, respectively.

Accepted for publication in MNRAS
Available from arXiv:0805.3442

Dust-driven winds and mass loss of C-rich AGB stars with subsolar metallicities

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We investigate the mass loss of highly evolved, low- and intermediate mass stars and stellar samples with subsolar metallicity. We give a qualitative as well as quantitative description which can be applied to LMC/SMC-type stellar populations. For that purpose we apply the same approach as we did for solar metallicity stars and calculate hydrodynamical wind models including dust formation with LMC and SMC abundances under consideration of an adapted model assumption. In particular, we improved the treatment of the radiative transfer problem in order to accommodate larger non-local contributions occurring with smaller opacities. For each wind model we determine an averaged mass-loss rate. The resulting, approximate mass-loss formulae are then applied to well-tested and calibrated stellar evolution calculations in order to quantify the stellar mass loss. The dynamical models for LMC and SMC metallicity result in mass-loss rates of the same order of magnitude as the solar metallicity models which is in this basic approach in agreement with observations. The hydrodynamical properties like e.g. the outflow velocity differ (for fixed C/O abundance ratio) noticeably, though. While critical luminosities of LMC and solar metallicity models fairly coincide, the SMC models need higher luminosities to develop dust-driven winds.

Accepted for publication in A&A
Available from arXiv:0805.3656

First VLTI infrared spectro-interferometry on GCIRS 7 — Characterizing the prime reference source for Galactic center observations at highest angular resolution

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Context. The massive black hole Sgr A* at the very center of the Galaxy, and its immediate stellar and non-stellar environment, have been studied in the past decade with increasing intensity and wavelength coverage, revealing surprising results. This research requires the highest angular resolution available to avoid source confusion and to study the physical properties of the objects.

Aims. GCIRS 7 is the dominating star of the central cluster in the NIR, so it has been used as wavefront and astrometric reference. Our studies investigate, for the first time, its properties at 2 and 10 μm using the VLTI.We aim at analyzing the suitability of GCIRS 7 as an interferometric phase-reference for the upcoming generation of dual-field facilities at optical interferometers.

Methods. VLTI-AMBER and MIDI instruments were used to spatially resolve GCIRS 7 and to measure the wavelength dependence of the visibility using the low spectral resolution mode ($R \sim 30$) and projected baseline lengths of about 50 m, resulting in an angular resolution of about 9 mas and 45 mas for the NIR and MIR, respectively.

Results. The first K-band fringe detection of a GC star suggests that GCIRS 7 could be marginally resolved at 2 μm, which would imply that the photosphere of the supergiant is enshrouded by a molecular and dusty envelope. At 10 μm, GCIRS 7 is strongly resolved with a visibility of approximately 0.2. The MIR is dominated by moderately warm (200 K), extended dust, mostly distributed outside of a radius of about 120 AU (15 mas) around the star. A deep 9.8 μm-silicate absorption in excess of the usual extinction law with respect to the NIR extinction has been found.

Conclusions. Our VLTI observations show that interferometric NIR phase-referencing experiments with mas resolution using GCIRS 7 as phase reference appear to be feasible, but more such studies are required to definitely characterize the close environment around this star. The MIR data confirm recent findings of a relatively enhanced, interstellar 9.8 μm-silicate absorption with respect to the NIR extinction towards another star in the central arc-seconds, suggesting an unusual dust composition in that region. We demonstrate that the resolution and sensitivity of modern large-aperture optical telescope arrays is required to resolve the innermost environment of stars at the Galactic center.

Accepted for publication in A&A

Available from arXiv:0805.4408

Infrared Passbands for Precise Photometry of Variable Stars by Amateur and Professional Astronomers

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The Infrared spectral region is a rich one for variable star work, especially of cooler stars, but it is hard to do IR photometry because of high, variable background, and specialized telescopic equipment that is usually required to obtain meaningful data. Typically telescopes with IR detectors are at high elevations, to minimize water vapor absorption. Nearly all the filters produced for astronomical work at observatories around the world have not been optimized for use at anything other than the highest and driest of observatories. This has made it difficult for amateur astronomers to contribute to this field. Now, however, this is no longer the case. The IAU's Infrared Working Group (IRWG) has designed and tested a set of IR filters less sensitive to water vapor, permitting observations at any site where precise optical photometry can be carried out. Data acquired with these filters can be corrected easily for

atmospheric (water vapor) extinction, unlike the situation with the older IR filters. We demonstrate this with data from the University of Calgary's Rothney Astrophysical Observatory.

Accepted for publication in JAAVSO
Available from arXiv:0805.3739

Enrichment of lead (Pb) in the Galactic halo

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We have determined lead (Pb) abundances for twelve red giants having [Fe/H] between −2.1 and −1.3, and its upper-limits for two lower metallicity objects, as well as the abundances of lanthanum (La) and europium (Eu). The averages of [Pb/Fe] and [Pb/Eu] are −0.3 and −0.6, respectively, and no clear increase of these ratios with increasing metallicity is found. The [La/Eu] values are only slightly higher than that of the r-process component in solar-system material. Combining the previous studies for globular clusters, these results suggest little contribution of the s-process to Pb of the field stars studied here, supporting the estimate of Pb production by the r-process from the solar-system abundances.

Accepted for publication in Publication of Astronomical Society of Japan (PASJ)
Available from arXiv:0804.0952

Conference Papers

Morphologies of the Nebulae around "born-again" Central Stars of Planetary Nebulae

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While in the past spherodicity was assumed, and still is used in modeling of most nebulae, we know now that only a small number of planetary nebulae (PNe) are really spherical or at least nearly round. Round planetary nebulae are the minority of objects. In the case of those objects that underwent a very late helium flash (called VLTP objects or "born-again" PNe) it seems to be different. The first, hydrogen-rich PN, is more or less round. The ejecta from the VLTP event, in contrast, are extremely asymmetrical.

Oral contribution, published in "Hydrogen-Deficient Stars", Sept. 17-21, 2007, Tübingen, Germany
Available from arXiv:0804.4069

Symmetry and Asymmetry in ”born again” Planetary Nebulae

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While in the past spheroidicity was assumed, and still is used in modeling of most nebulae, we know now that only a small number of planetary nebulae (PNe) are really spherical or at least nearly round. Round planetary nebulae are the minority of objects. In case of those objects that underwent a very late helium flash (called VLTP or ”born-again” PNe) it seems to be different. The first, hydrogen rich PN, is more or less round. The ejecta from the VLTP event is extremely asymmetrically. Angular momentum is mostly assumed to be the main reason for the asymmetry in PNe. Thus we have to find processes either changing their behavior within a few hundred to a few thousands of years or change their properties dramatically due to the variation of the abundance. They most likely have a strong link or dependency with the abundance of the ejecta.

Oral contribution, published in ”Asymmetrical Planetary Nebulae IV”, Eds. Romano L.M. Corradi, Arturo Manchado and Noam Soker
Available from arXiv:0804.4058

Review Paper

Detection methods of binary stars with low- and intermediate-mass components

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This paper reviews methods which can be used to detect binaries involving low- and intermediate-mass stars, with special emphasis on systems with Mira or AGB stars. Besides the traditional methods involving radial-velocity or photometric monitoring, the paper discusses as well less known methods involving astrometry or maser (non-)detection. An extensive list of internet resources (mostly catalogues/databases of orbits and individual measurements) for the study of binary stars is provided at the end of the paper.

Published in ”XII Special Courses at the National Observatory of Rio de Janeiro”, ed. S. Pellegrini, AIP Conference Proceedings
Available from arXiv:0804.3720
and from http://www.astro.ulb.ac.be/ps.html#Binaries