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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 168$^{\rm th}$ issue of the AGB Newsletter. There are in particular a lot of *Spitzer*, *Herschel*, and other mid-IR results, abundances and nucleosynthesis, and results on pulsating variables, dust, symbiotic binaries and the progenitors of SNe of type Ia, and some (other) weird classes of objects. And more. Bowshocks, surprising results about nearby galaxies and important results on the most distant ones...

To celebrate Dr. Shuji Deguchi's achievements, a very interesting meeting on evolved stars and astrophysical masers is organised to take place in Hong Kong later this year.

The next issue is planned to be distributed in early August 2011.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

What happens when the pulsation period approaches the thermal timescale?

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)

Refereed Journal Papers

Chemical composition of the RS CVn-type star 33 Piscium

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Abundances of 22 chemical elements, including the key elements and isotopes such as ^{12}C, ^{13}C, N and O, are investigated in the spectrum of 33 Psc, a single-lined RS CVn-type binary of low magnetic activity. The high resolution spectra were observed on the Nordic Optical Telescope and analyzed with the MARCS model atmospheres. The following main parameters have been determined: $T_{\rm eff}$ = 4750 K, $\log g$ = 2.8, [Fe/H] = −0.09, [C/Fe] = −0.04, [N/Fe] = 0.23, [O/Fe] = 0.05, C/N = 2.14, ^{12}C/^{13}C = 30, which show the first-dredge-up mixing signatures and no extra-mixing.

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Imaging the circumstellar dust around AGB stars with PolCor

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Aims. The aim of this paper is to investigate how the new imaging Polarimeter and Coronograph (PolCor) at the Nordic Optical Telescope (NOT) can be used in the study of circumstellar structures around AGB stars. The purpose is to prepare for a study of a larger sample.
Methods. We have observed two types of AGB stars using the PolCor instrument on the NOT: the binary S-type star W Aql and two carbon stars with detached shells, U Cam and DR Ser. The polarized light traces the dust distribution around the stars. From the polarimeter images the polarized intensity, the polarization degree, and the polarization angle over the images are calculated. The location and extent of dust structures are examined in the images. The total dust mass and the dust-to-gas ratios of the detached shells are also calculated.
Results. The images of the circumstellar envelope of W Aql show what seems to be an elongated structure in the south–west direction. The detached shells of U Cam and DR Ser are clearly seen in the images. This is the first time the detached shell around DR Ser has been imaged. The radii ($R_{\rm sh}$) and widths ($\Delta R_{\rm sh}$) of the shells are determined and found to be $R_{\rm sh}$ = 7.9″ and 7.6″, and $\Delta R_{\rm sh}$ = 0.9″ and 1.2″, for U Cam and DR Ser, respectively. This is consistent with previous results. The dust masses of the feature south–west of W Aql, and in the shells of U Cam and DR Ser are also estimated and found to be 1×10^{-6}, 5×10^{-7}, and 2×10^{-6} $M_\odot$, respectively.
Conclusions. W Aql is a known binary and the shape of the circumstellar envelope seems to be in line with what could be expected from binary interaction on these scales. For the shells, the results are in agreement with previous investigations. Ages and formation time-scales are also estimated for the detached shells and found to be consistent with the thermal-pulse-formation scenario.

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IRAS 18113−2503: the water fountain with the fastest jet?

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We present Expanded Very Large Array (EVLA) water maser observations at 22 GHz toward the source IRAS 18113−2503. Maser components span over a very high velocity range of $\simeq 500$ km s^{-1}, the second largest found in a Galactic maser, only surpassed by the high-mass star forming region W49 N. Maser components are grouped into a blue and a redshifted cluster, separated by $0.12''$. Further mid-IR and radio data suggest that IRAS 18113−2503 is a post-AGB star, thus a new bona fide member of the rare class of "water fountains". It is the evolved object with the largest total velocity spread in its water masers, and with the highest velocity dispersion within its red- and blue-shifted lobes ($\simeq 170$ km s^{-1}). The large total velocity range of emission probably indicates that IRAS 18113−2503 has the fastest jet among the known water fountain stars. On the other hand, the remarkably high velocity dispersion within each lobe may be interpreted in terms of shocks produced by an episode of mass ejection whose velocity increased up to very high values or, alternatively, by projection effects in a jet with a large opening angle and/or precessing motions.

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Revised classification of the SBS carbon star candidates including the discovery of a new emission line dwarf carbon star

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Faint high latitude carbon stars are rare objects commonly thought to be distant, luminous giants. For this reason they are often used to probe the structure of the Galactic halo; however more accurate investigation of photometric and spectroscopic surveys has revealed an increasing percentage of nearby objects with luminosities of main sequence stars. Aiming at clarifying the nature of the ten carbon star candidates present in the General Catalog of the Second Byurakan Survey we analyzed new optical spectra and photometry and used astronomical databases available on the web. We verified that two stars are N-type giants already confirmed by other surveys. We found that four candidates are M type stars and confirmed the carbon nature of the remaining four stars; the characteristics of three of them are consistent with an early CH giant type. The fourth candidate, SBS 1310+561 identified with a high proper motion star, is a rare type of dwarf carbon showing emission lines in its optical spectrum. We estimated absolute magnitudes and distances to the dwarf carbon and the three CH stars. Our limited sample confirmed the increasing evidence that spectroscopy or colour alone are not conclusive luminosity discriminants for CH-type carbon stars.

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DASCH on KU Cyg: a ~ 5 year dust accretion event in ~ 1900

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KU Cyg is an eclipsing binary consisting of a F-type star accreting through a large accretion disk from a K5 III red giant. Here we present the discovery of a 5-yr dip around 1900 found from its 100 yr DASCH (Digital Access to a Sky Century at Harvard) light curve. It showed a ~ 0.5 mag slow fading from 1899 to 1903, and brightened back around 1904 on a relatively shorter timescale. The light curve shape of the 1899–1904 fading–brightening event differs from the dust production and dispersion process observed in R Coronae Borealis (RCB) stars, which usually has a faster fading and slower recovery, and for KU Cyg is probably related to the accretion disk surrounding the F star. The slow fading in KU Cyg is probably caused by increases in dust extinction in the disk, and the subsequent quick brightening may be due to the evaporation of dust transported inwards through the disk. The extinction excess which caused the fading may arise from increased mass transfer rate in the system, or from dust clump ejections from the K giant.

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Empirical determination of the integrated red giant and horizontal branch stellar mass loss in ω Centauri

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We herein determine the average integrated mass loss from stars stars belonging to the dominant metal-poor population ([Fe/H] ~ -1.7) of the Galactic globular cluster ω Centauri (NGC 5139) during their red giant and horizontal branch evolution. Masses are empirically calculated from spectroscopic measurements of surface gravity and photometric measurements of temperature and luminosity. Systematic uncertainties prevent an absolute measurement of masses at a phase of evolution. However, the relative masses of early asymptotic giant branch stars and central red giant branch stars can be measured, and used to derive the mass loss between these two phases. This can then be used as a physical check of models of horizontal branch (HB) stars. For ω Cen, the average difference is found to be $26 \pm 4\%$. Assuming initial and final masses of 0.83 and 0.53 $M_\odot$, we determine that 0.21 ± 0.03 $M_\odot$ is lost on the RGB and $0.09\pm \sim 0.05$ $M_\odot$ is lost on the AGB. The implied HB stellar mass of 0.62 ± 0.04 $M_\odot$ is commensurate with literature determinations of the masses of the cluster's HB stars. The accuracy of this measurement can be improved through better selection of stars and spectral coverage, and applied to other clusters where horizontal branch models do not currently agree.

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Multiple populations in ω Centauri: a cluster analysis of spectroscopic data

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ω Cen is composed of several stellar populations. Their history might allow us to reconstruct the evolution of this complex object. We performed a statistical cluster analysis on the large data set provided by Johnson and Pilachowski

(2010). Stars in ω Cen divide into three main groups. The metal-poor group includes about a third of the total. It shows a moderate O–Na anticorrelation, and similarly to other clusters, the O-poor second generation stars are more centrally concentrated than the O-rich first generation ones. This whole population is La-poor, with a pattern of abundances for n-capture elements which is very close to a scaled r-process one. The metal-intermediate group includes the majority of the cluster stars. This is a much more complex population, with an internal spread in the abundances of most elements. It shows an extreme O–Na anticorrelation, with a very numerous population of extremely O-poor and He-rich second generation stars. This second generation is very centrally concentrated. This whole population is La-rich, with a pattern of the abundances of n-capture elements that shows a strong contribution by the s-process. The spread in metallicity within this metal-intermediate population is not very large, and we might attribute it either to non uniformities of an originally very extended star forming region, or to some ability to retain a fraction of the ejecta of the core collapse SNe that exploded first, or both. As previously noticed, the metal-rich group has an Na–O correlation, rather than anticorrelation. There is evidence for the contribution of both massive stars ending their life as core-collapse SNe, and intermediate/low mass stars, producing the s-capture elements. Kinematics of this population suggests that it formed within the cluster rather than being accreted.

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Iron abundance in the prototype PG 1159 star, GW Vir pulsator PG 1159−035, and related objects

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We performed an iron abundance determination of the hot, hydrogen deficient post-AGB star PG1159−035, which is the prototype of the PG 1159 spectral class and the GW Vir pulsators, and of two related objects (PG 1520+525, PG 1144+005), based on the first detection of Fe VIII lines in stellar photospheres. In another PG 1159 star, PG 1424+535, we detect Fe VII lines. In all four stars, each within $T_{\rm eff}$ =110 000–150 000 K, we find a solar iron abundance. This result agrees with our recent abundance analysis of the hottest PG 1159 stars ($T_{\rm eff}$ =150 000–200 000 K) that exhibit Fe X lines. On the whole, we find that the PG 1159 stars are not significantly iron deficient, in contrast to previous notions.

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Opportunities to constrain astrophysical reaction rates for the s-process through determination of the ground state cross sections

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Modern models of s-process nucleosynthesis in stars require stellar reaction rates with high precision. Most of the neutron capture cross sections in the s-process have been measured and for an increasing number of reactions the required precision is achieved. This does not necessarily mean, however, that the stellar rates are constrained equally

well because only capture on the ground state of a target is measured in the laboratory. Captures on excited states can considerably contribute to stellar rates already at typical s-process temperatures. We show that the ground state contribution X to a stellar rate is the relevant measure to identify reactions which are or could be well constrained by experiments and apply it to (n,γ) reactions in the s-process. It is further shown that the maximally possible reduction in uncertainty of a rate through determination of the g.s. cross section is directly given by X. An error analysis of X is presented and it is found that X is a robust measure with overall small uncertainties. Several specific examples (neutron capture on ^{79}Se, ^{95}Zr, ^{121}Sn, ^{187}Os, and ^{193}Pt) are discussed in detail. The results for a full set of 411 reactions in the s-process path are presented in a table to identify reactions to be better constrained by experiments and such which cannot be improved by only measuring ground state cross sections (and thus require supplementary studies). General trends and implications are discussed.

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Type Ia supernovae as sites of p-process: two-dimensional models coupled to nucleosynthesis

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Beyond Fe, there is a class of 35 proton-rich nuclides, between ^{74}Se and ^{196}Hg, called p-nuclei. They are bypassed by the s and r neutron capture processes, and are typically 10–1000 times less abundant than the s- and/or r-isotopes in the Solar System. The bulk of p isotopes is created in the 'γ processes' by sequences of photodisintegrations and β decays in explosive conditions in both core collapse supernovae (SNII) and in Type Ia supernovae (SN Ia). SNII contribute to the production of p-nuclei through explosive neon and oxygen burning. However, the major problem in SNII ejecta is a general underproduction of the light p-nuclei, for $A < 120$. We explore SNe Ia as p-process sites in the framework of two-dimensional SN Ia delayed detonation model as well as pure deflagration models. The WD precursor is assumed to have reached the Chandrasekhar mass in a binary system by mass accretion from a giant/main sequence companion. We use enhanced s-seed distributions, with seeds directly obtained from a sequence of thermal pulse instabilities both in the AGB phase and in the accreted material. We apply the tracer-particle method to reconstruct the nucleosynthesis by the thermal histories of Lagrangian particles, passively advected in the hydrodynamic calculations. For each particle we follow the explosive nucleosynthesis with a detailed nuclear reaction network for all isotopes up to ^{209}Bi. We select tracers within the typical temperature range for p-process production, 1.5−3.7 10^9K, and analyse in detail their behavior, exploring the influence of different s-process distributions on the p-process nucleosynthesis. In addition, we discuss the sensitivity of p-process production to parameters of the explosion mechanism, taking into account the consequences on Fe and α elements. We find that SNe Ia can produce a large amount of p-nuclei, both the light p-nuclei below $A = 120$ and the heavy-p nuclei, at quite flat average production factors, tightly related to the s-process seed distribution. For the first time, we find a stellar source able to produce both, light and heavy p-nuclei almost at the same level as ^{56}Fe, including the very debated neutron magic ^{92,94}Mo and ^{96,98}Ru. We also find that there is an important contribution from p-process nucleosynthesis to the s-only nuclei ^{80}Kr, ^{86}Sr, to the neutron magic ^{90}Zr, and to the neutron-rich ^{96}Zr. Finally, we investigate the metallicity effect on p-process production in our models. Starting with different s-process seed distributions, for two metallicities $Z = 0.02$ and $Z = 0.001$, running two-dimensional SNe Ia models with different initial composition, we estimate that SNe Ia can contribute to, at least, 50% of the solar p-process composition. A more detailed analysis of the role of SNe Ia in Galactic chemical evolution of p-nuclei is in preparation.

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Central stars of Galactic planetary nebulae II – New OB-type and emission-line stars

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Context. There are more than 3000 confirmed and probable known Galactic planetary nebulae, but central star spectroscopic information is available for only 13% of them.
Aims. We undertook a spectroscopic survey of central stars of PNe to identify their spectral types. Methods. We performed spectroscopic observations, at low resolution, with the 2-m telescope at CASLEO, Argentina.
Results. We present the spectra of 46 central stars of PNe, most of them are OB-type and emission-line stars.

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Tidally enhanced stellar wind: a way to make the symbiotic channel to Type Ia supernova viable

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In the symbiotic (or WD+RG) channel of the single degenerate scenario for type Ia supernovae (SNe Ia) the explosions occur a relatively long time after star formation. The birthrate from this channel would be too low to account for all observed SNe Ia were it not for some mechanism to enhance the rate of accretion on to the white dwarf. A tidally enhanced stellar wind, of the type which has been postulated to explain many phenomena related to giant star evolution in binary systems, can do this. Compared to mass-stripping this model extends the space of SNe Ia progenitors to longer orbital periods and hence increases the birthrate to about 0.0069 yr^{-1} for the symbiotic channel. Two symbiotic stars, T CrB and RS Oph, considered to be the most likely progenitors of SNe Ia through the symbiotic channel, are well inside the period–companion mass space predicted by our models.

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Planet engulfment by ~ 1.5–$3\ \mathrm{M}_\odot$ red giants

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Recent radial-velocity surveys for GK clump giants have revealed that planets also exist around ~ 1.5–$3\ \mathrm{M}_\odot$ stars. However, no planets have been found inside 0.6 AU around clump giants, in contrast to solar-type main-sequence stars, many of which harbor short-period planets such as hot Jupiters. In this study we examine the possibility that planets were engulfed by host stars evolving on the red-giant branch (RGB). We integrate the orbital evolution of planets in the RGB and helium burning (HeB) phases of host stars, including the effects of stellar tide and stellar mass loss. Then we derive the critical semimajor axis (or the survival limit) inside which planets are eventually engulfed by their host stars after tidal decay of their orbits. Especially, we investigate the impact of stellar mass and other stellar parameters on the survival limit in more detail than previous studies. In addition, we make detailed comparison with measured semimajor axes of planets detected so far, which no previous study did. We find that the critical semimajor axis is quite sensitive to stellar mass in the range between 1.7 and 2.1 $\mathrm{M}_\odot$, which suggests a need for careful comparison between theoretical and observational limits of existence of planets. Our comparison demonstrates that

all those planets are beyond the survival limit, which is consistent with the planet-engulfment hypothesis. However, on the high-mass side (> 2.1 $M_\odot$), the detected planets are orbiting significantly far from the survival limit, which suggests that engulfment by host stars may not be the main reason for the observed lack of short-period giant planets. To confirm our conclusion, the detection of more planets around clump giants, especially with masses > 2.5 $M_\odot$, is required.

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The mass-loss return from evolved stars to the Large Magellanic Cloud V. The GRAMS carbon-star model grid

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Outflows from asymptotic giant branch (AGB) and red supergiant (RSG) stars inject dust into the interstellar medium. The total rate of dust return provides an important constraint to galactic chemical evolution models. However, this requires detailed radiative transfer (RT) modeling of individual stars, which becomes impractical for large data sets. An alternative approach is to select the best-fit spectral energy distribution (SED) from a grid of dust shell models, allowing for a faster determination of the luminosities and mass-loss rates for entire samples. We have developed the Grid of RSG and AGB ModelS (GRAMS) to measure the mass-loss return from evolved stars. The models span the range of stellar, dust shell and grain properties relevant to evolved stars. The GRAMS model database will be made available to the scientific community. In this paper we present the carbon-rich AGB model grid and compare our results with photometry and spectra of Large Magellanic Cloud (LMC) carbon stars from the SAGE (Surveying the Agents of Galaxy Evolution) and SAGE-Spec programs. We generate models for spherically symmetric dust shells using the 2Dust code, with hydrostatic models for the central stars. The model photospheres have effective temperatures between 2600 and 4000 K and luminosities from $\sim$ 2000 $L_\odot$ to $\sim$ 40000 $L_\odot$. Assuming a constant expansion velocity, we explore five values of the inner radius $R_{\rm in}$ of the dust shell (1.5, 3, 4.5, 7 and 12 $R_\star$). We fix the outer radius at 1000 $R_{\rm in}$. Based on the results from our previous study, we use amorphous carbon dust mixed with 10% silicon carbide by mass. The grain size distribution follows a power-law and an exponential falloff at large sizes. The models span twenty-six values of 11.3 μm optical depth, ranging from 0.001 to 4. For each model, 2Dust calculates the output SED from 0.2 to 200 μm. Results. Over 12 000 models have dust temperatures below 1800 K. For these, we derive synthetic photometry in optical, near- infrared and mid-infrared filters for comparison with available data. We find good agreement with magnitudes and colors observed for LMC carbon-rich and extreme AGB star candidates from the SAGE survey, as well as spectroscopically confirmed carbon stars from the SAGE-Spec study. Our models reproduce the IRAC colors of most of the extreme AGB star candidates, consistent with the expectation that a majority of these enshrouded stars have carbon-rich dust. Finally, we fit the SEDs of some well-studied carbon stars and compare the resulting luminosities and mass-loss rates with those from previous studies.

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The dust properties of two hot R Coronae Borealis stars and a Wolf–Rayet central star of a planetary nebula: in search of a possible link

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We present new *Spitzer*/IRS spectra of two hot R Coronae Borealis (RCB) stars, one in the Galaxy, V348 Sgr, and one lying in the Large Magellanic Cloud, HV 2671. These two objects may constitute a link between the RCB stars and the late Wolf–Rayet ([WCL]) class of central stars of planetary nebula (CSPNe) such as CPD -56° 8032 that has little

or no hydrogen in their atmospheres. HV 2671 and V348 Sgr are members of a rare subclass that has significantly higher effective temperatures than most RCB stars, but sharing the traits of hydrogen deficiency and dust formation that define the cooler RCB stars. The [WC] CSPNe star, CPD −56° 8032, displays evidence for dual-dust chemistry showing both PAHs and crystalline silicates in its mid-IR spectrum. HV 2671 shows strong PAH emission but shows no sign of having crystalline silicates. The spectrum of V348 Sgr is very different from those of CPD −56° 8032 and HV 2671. The PAH emission seen strongly in the other two stars is not present. Instead, the spectrum is dominated by a broad emission centered at about 8.2 μm. This feature is not identified with either PAHs or silicates. Several other cool RCB stars, novae and post-asymptotic giant branch stars show similar features in their IR spectra. The mid-IR spectrum of CPD −56° 8032 shows emission features that may be associated with C_{60}. The other two stars do not show evidence for C_{60}. The different nature of the dust around these stars does not help us in establishing further links that may indicate a common origin.
HV 2671 has also been detected by *Herschel*/PACS and SPIRE. V348 Sgr and CPD −56° 8032 have been detected by AKARI/FIS. These data were combined with *Spitzer*, IRAS, 2MASS and other photometry to produce their spectral energy distributions from the visible to the far-IR. Monte Carlo radiative transfer modeling was used to study the circumstellar dust around these stars. HV 2671 and CPD −56° 8032 require both a flared inner disk with warm dust and an extended diffuse envelope with cold dust to to fit their SEDs. The SED of V348 Sgr can be fit with a much smaller disk and envelope. The cold dust in the extended diffuse envelopes inferred around HV 2671 and CPD −56° 8032 may consist of interstellar medium swept up during mass-loss episodes.

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The halo and rings of the planetary nebula NGC 40 in the mid-infrared

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We present imaging and spectroscopy of NGC 40 acquired using the *Spitzer* Space Telescope (*Spitzer*), and the Infrared Space observatory (ISO). These are used to investigate the nature of emission from the central nebular shell, from the nebular halo, and from the associated circumnebular rings. It is pointed out that a variety of mechanisms may contribute to the mid-infrared (MIR) fluxes, and there is evidence for a cool dust continuum, strong ionic transitions, and appreciable emission by polycyclic aromatic hydrocarbons (PAHs). Prior observations at shorter wavelengths also indicate the presence of warmer grains, and the possible contribution of H_2 transitions. It is suggested that an apparent jet-like structure to the NE of the halo represents one of the many emission spokes that permeate the shell. The spokes are likely to be caused by the percolation of UV photons through a clumpy interior shell, whilst the jet-like feature is enhanced due to locally elevated electron densities; a result of interaction between NGC 40 and the interstellar medium. It is finally noted that the presence of the PAH, 21 μm and 30 μm spectral features testifies to appreciable C/O ratios within the main nebular shell. Such a result is consistent with abundance determinations using collisionally excited lines, but not with those determined using optical recombination lines.

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IRAS 12556−7731: a "chamaeleonic" lithium-rich M-giant

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In this letter we characterise IRAS 12556−7731 as the first lithium-rich M-type giant. Based on its late spectral

type and high lithium content, and because of its proximity in angular distance to the Chamaeleon II star-forming region, the star was misclassified as a young low-mass star in a previous work. Based on HARPS data, synthetic spectral modelling, and proper motions, we derive the astrophysical parameters and kinematics of the star and discuss its evolutionary status. This solar-mass red giant ($T_{\rm eff}$ = 3460 ± 60 K and $\log g$ = 0.6 ± 0.2) is characterised by a relatively fast rotation ($v \sin i \sim 8$ km s^{-1}), slightly subsolar metallicity and a high-lithium abundance, A(Li)= 2.4±0.2 dex. We discuss IRAS 12556−7731 within the context of other known lithium-rich K-type giants. Because it is close to the tip of the red giant branch, IRAS 12556−7731 is the coolest lithium-rich giant known so far, and it is among the least massive and most luminous giants where enhancement of lithium has been detected. Among several possible explanations, we cannot preclude the possibility that the lithium enhancement and rapid rotation of the star were triggered by the engulfment of a brown dwarf or a planet.

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3-D photoionization structure and distances of planetary nebulae IV. NGC 40

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Continuing our series of papers on the 3-D structure and accurate distances of Planetary Nebulae (PNe), we present here the results obtained for the planetary nebula NGC 40. Using data from different sources and wavelengths, we construct 3-D photoionization models and derive the physical quantitities of the ionizing source and nebular gas. The procedure, discussed in detail in the previous papers, consists of the use of 3-D photoionization codes constrained by observational data to derive the three-dimensional nebular structure, physical and chemical characteristics and ionizing star parameters of the objects by simultaneously fitting the integrated line intensities, the density map, the temperature map, and the observed morphologies in different emission lines. For this particular case we combined hydrodynamical simulations with the photoionization scheme in order to obtain self-consistent distributions of density and velocity of the nebular material. Combining the velocity field with the emission line cubes we also obtained the synthetic position–velocity plots that are compared to the observations. Finally, using theoretical evolutionary tracks of intermediate and low mass stars, we derive the mass and age of the central star of NGC 40 as (0.567 ± 0.06) $M_\odot$ and (5810 ± 600) yr, respectively. The distance obtained from the fitting procedure was (1150 ± 120) pc.

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Optical and mid-infrared observations of the planetary nebula NGC 6781

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Although the planetary nebula NGC 6781 appears to possess an elliptical morphology, its kinematic and emission characteristics are in many ways unusual, and it is possible that it may represent a bipolar source oriented close to the line of sight. We shall present deep imaging of this nebula in [O III], Hα and [N II], and using broad-band (F555W and F814W) filters. These were taken with the 2.56-m Nordic Optical Telescope and *Hubble* Space Telescope. This is combined with mid-infrared (MIR) imaging and spectroscopy acquired with the *Spitzer* Space Telescope (Spitzer), and near-infrared spectroscopy deriving from the Infrared Space Observatory (ISO). These reveal details of the complex

[N II] structure associated with extended shell emission, perhaps associated with highly inclined bipolar lobes. We also note the presence of narrow absorbing filaments and clumps projected against the surface of the envelope, components which may be responsible for much of the molecular emission. We point out that such clumps may be responsible for complex source structure in the MIR, and give rise to asymmetries in emission along the major axis of the source.

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Metal accretion onto white dwarfs caused by Poynting–Robertson drag on their debris disks

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Recent discoveries of compact (sizes $\lesssim R_\odot$) debris disks around more than a dozen of metal-rich white dwarfs (WDs) suggest that pollution of these stars with metals may be caused by accretion of high-Z material from the disk. But the mechanism responsible for efficient transfer of mass from a particulate disk to the WD atmosphere has not yet been identified. Here we demonstrate that radiation of the WD can effectively drive accretion of matter through the disk towards the sublimation radius (located at several tens of WD radii), where particles evaporate, feeding a disk of metal gas accreting onto the WD. We show that, contrary to some previous claims, Poynting–Robertson (PR) drag on the debris disk is effective at providing metal accretion rate $\dot{M}_{\rm PR} \sim 10^8$ g s^{-1} and higher, scaling quadratically with WD effective temperature. We compare our results with observations and show that, as expected, no WD hosting a particulate debris disk shows evidence of metal accretion rate below that produced by the PR drag. Existence of WDs accreting metals at rates significantly higher than $\dot{M}_{\rm PR}$ suggests that another mechanism in addition to PR drag drives accretion of high-Z elements in these systems.

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A population of accreted Small Magellanic Cloud stars in the Large Magellanic Cloud

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We present an analysis of the stellar kinematics of the Large Magellanic Cloud based on '*sim*5900 new and existing velocities of massive red supergiants, oxygen-rich and carbon-rich AGB stars, and other giants. After correcting the line-of-sight velocities for the LMC's space motion and accounting for asymmetric drift in the AGB population, we derive a rotation curve that is consistent with all of the tracers used, as well as that of published H I data. The amplitude of the rotation curve is $v_0 = 87 \pm 5$ km s^{-1} beyond a radius $R_0 = 2.4 \pm 0.1$ kpc, and has a position angle of the kinematic line of nodes of $\theta = 142° \pm 5°$. By examining the outliers from our fits, we identify a population of 376 stars, or $\gtrsim$5% of our sample, that have line-of-sight velocities that apparently oppose the sense of rotation of the LMC disk. We find that these kinematically distinct stars are either counter-rotating in a plane closely aligned with the LMC disk, or rotating in the same sense as the LMC disk, but in a plane that is inclined by $54° \pm 2°$ to the LMC. Their kinematics clearly link them to two known H I arms, which have previously been interpreted as being pulled out from the LMC. We measure metallicities from the Ca triplet lines of ~ 1000 LMC field stars and 30 stars in the kinematically distinct population. For the LMC field, we find a median [Fe/H] $= -0.56 \pm 0.02$ with dispersion of 0.5 dex, while for the kinematically distinct stars the median [Fe/H] is -1.25 ± 0.13 with a dispersion of 0.7 dex. The

metallicity differences provide strong evidence that the kinematically distinct population originated in the SMC. This interpretation has the consequence that the H I arms kinematically associated with the stars are likely falling into the LMC, instead of being pulled out.

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Herschel's view into Mira's head

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Herschel's PACS instrument observed the environment of the binary system Mira Ceti in the 70 and 160 μm bands. These images reveal bright structures shaped as five broken arcs and fainter filaments in the ejected material of Mira's primary star. The overall shape of the IR emission around Mira deviates significantly from the expected alignment with Mira's exceptionally high space velocity. The observed broken arcs are neither connected to each other nor are they of a circular shape; they stretch over angular ranges of 80 to 100 degrees. By comparing *Herschel* and GALEX data, we found evidence for the disruption of the IR arcs by the fast outflow visible in both Hα and the far UV. Radial intensity profiles are derived, which place the arcs at distances of 6–85″ (550–8000 AU) from the binary. Mira's IR environment appears to be shaped by the complex interaction of Mira's wind with its companion, the bipolar jet, and the ISM.

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X Her and TX Psc: Two cases of ISM interaction with stellar winds observed by ıHerschel

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The asymptotic giant branch (AGB) stars X Her and TX Psc have been imaged at 70 and 160 μm with the PACS instrument onboard the *Herschel* satellite, as part of the large MESS (Mass loss of Evolved StarS) Guaranteed Time Key Program. The images reveal an axisymmetric extended structure with its axis oriented along the space motion of the stars. This extended structure is very likely to be shaped by the interaction of the wind ejected by the AGB star

with the surrounding interstellar medium (ISM). As predicted by numerical simulations, the detailed structure of the wind–ISM interface depends upon the relative velocity between star+wind and the ISM, which is large for these two stars (108 and 55 km s^{-1} for X Her and TX Psc, respectively). In both cases, there is a compact blob upstream whose origin is not fully elucidated, but that could be the signature of some instability in the wind–ISM shock. Deconvolved images of X Her and TX Psc reveal several discrete structures along the outermost filaments, which could be Kelvin–Helmholtz vortices. Finally, TX Psc is surrounded by an almost circular ring (the signature of the termination shock?) that contrasts with the outer, more structured filaments. A similar inner circular structure seems to be present in X Her as well, albeit less clearly.

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Long-period variables in NGC 147 and NGC 185

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Previous studies on the stellar content of the two nearby dwarf galaxies NGC 147 and NGC 185 reveal a rich population of late-type giants in both systems, including a large number of carbon-rich objects. These stars are known to show pronounced photometric variability, which can be used for a more detailed characterisation of these highly evolved stars. Owing to their well-studied parameters, these Local Group members are ideal candidates for comparative studies. Trough photometric monitoring, we attempt to provide a catalogue of long-period variables (LPVs), including Mira variables, semi-regular variables, and even irregular variables in NGC 147 and NGC 185. We investigate the light variations and compare the characteristics of these two LPV populations with the results found for other galaxies such as the LMC. We carried out time-series photometry in the i-band of the two target galaxies with the Nordic Optical Telescope (NOT), covering a time span of $\sim$ 2.5 years. These data were then combined with single-epoch K-band photometry, also obtained with the NOT. Narrow-band photometry data from the literature was used to distinguish between O-rich and C-rich stars. We report the detection of 513 LPVs in NGC 185 and 213 LPVs in NGC 147, showing i-amplitudes of up to $\sim$ 2 mag and periods ranging between 90 and 800 days. The period–luminosity diagram for each of our target galaxies exhibits a well populated sequence of fundamental mode pulsators. The resulting period–luminosity relations we obtained are compared to relations from the literature. We discuss the universality of those relations because of which, as a side result, a correction of the distance modulus of NGC 185 may be necessary. Only one of our two galaxies, namely NGC 185, has a significant fraction of possibly first overtone pulsators. An interpretation of this finding in terms of differences in the star-formation histories is suggested.

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Identification of three new proto-Planetary Nebulae exhibiting the unidentified feature at 21 μm

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Among its great findings, the IRAS mission showed the existence of an unidentified mid-IR feature around 21 μm.

Since its discovery, this feature has been detected in all C-rich proto-PNe of intermediate spectral type (A–G) and – weakly – in a few PNe and AGB stars, but the nature of its carriers remains unknown. In this paper, we show the detection of this feature in the spectra of three new stars transiting from the AGB to the PN stage obtained with the *Spitzer* Space Telescope. Following a recent suggestion, we try to model the SEDs of our targets with amorphous carbon and FeO, which might be responsible for the unidentified feature. The fit thus obtained is not completely satisfactory, since the shape of the feature is not well matched. In the attempt to relate the unidentified feature to other dust features, we retrieved mid-IR spectra of all the 21-μm sources currently known from ISO and *Spitzer* on-line archives and noticed a correlation between the flux emitted in the 21-μm feature and that emitted at 7 and 11 μm (PAH bands and HAC broad emission). Such a correlation may point to a common nature of the carriers.

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Spitzer 24 μm survey for dust disks around hot white dwarfs

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Two types of dust disks around white dwarfs (WDs) have been reported: small dust disks around cool metal-rich WDs consisting of tidally disrupted asteroids, and a large dust disk around the hot central WD of the Helix planetary nebula (PN) possibly produced by collisions among *Kuiper* Belt-like objects. To search for more dust disks of the latter type, we have conducted a *Spitzer* MIPS 24 μm survey of 71 hot WDs or pre-WDs, among which 35 are central stars of PNe (CSPNs). Nine of these evolved stars are detected and their 24 μm flux densities are at least two orders of magnitude higher than their expected photospheric emission. Considering the bias against detection of distant objects, the 24 μm detection rate for the sample is $\gtrsim$15%. It is striking that seven, or $\sim$ 20%, of the WD and pre-WDs in known PNe exhibit 24 μm excesses, while two, or 5–6%, of the WDs not in PNe show 24 μm excesses and they have the lowest 24 μm flux densities. We have obtained follow-up *Spitzer* IRS spectra for five objects. Four show clear continuum emission at 24 μm, and one is overwhelmed by a bright neighboring star but still show a hint of continuum emission. In the cases of WD 0950+139 and CSPN K 1-22, a late-type companion is present, making it difficult to determine whether the excess 24 μm emission is associated with the WD or its red companion. High-resolution images in the mid-IR are needed to establish unambiguously the stars responsible for the 24 μm excesses.

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Inhomogeneities in molecular layers of Mira atmospheres

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We investigate the structure and shape of the photospheric and molecular layers of the atmospheres of four Mira variables. We obtained near-infrared K-band spectro-interferometric observations of the Mira variables R Cnc, X Hya, W Vel, and RW Vel with a spectral resolution of about 1500 using the AMBER instrument at the VLTI. We obtained concurrent JHKL photometry using the the Mk II instrument at the SAAO. The Mira stars in our sample are found to have wavelength-dependent visibility values that are consistent with earlier low-resolution AMBER observations of S Ori and with the predictions of dynamic model atmosphere series based on self-excited pulsation models. The corresponding wavelength-dependent uniform disk (UD) diameters show a minimum near the near-continuum bandpass at 2.25 μm. They then increase by up to 30% toward the H_2O band at 2.0 μm and by up to 70% at the CO bandheads between 2.29 μm and 2.48 μm. The dynamic model atmosphere series show a consistent wavelength-dependence, and their parameters such as the visual phase, effective temperature, and distances are consistent with independent estimates. The closure phases have significantly wavelength-dependent and non-zero values at all wavelengths indicating deviations from point symmetry. For example, the R Cnc closure phase is $110° \pm 4°$ in the 2.0 μm H_2O band, corresponding for instance to an additional unresolved spot contributing 3% of the total flux at a separation of ~ 4 mas. Our observations are consistent with the predictions of the latest dynamic model atmosphere series based on self-excited pulsation models. The wavelength-dependent radius variations are interpreted as the effect of molecular layers lying above the photosphere. The wavelength-dependent closure phase values are indicative of deviations from point symmetry at all wavelengths, thus a complex non-spherical stratification of the extended atmosphere. In particular, the significant deviation from point symmetry in the H_2O band is interpreted as a signature on large scales (there being a few across the stellar disk) of inhomogeneities or clumps in the water vapor layer. The observed inhomogeneities might possibly be caused by pulsation- and shock-induced chaotic motion in the extended atmosphere.

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The origin of dust in high-redshift quasars: the case of SDSS J1148+5251

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We present a semi-analytical model for the formation and evolution of a high redshift quasar (QSO). We reconstruct a set of hierarchical merger histories of a 10^{13} $M_\odot$ dark matter halo and model the evolution of the corresponding galaxy and of its central super massive black hole. The code GAMETE/QSODUST consistently follows: (i) the black

hole assembly via both coalescence with other black holes and gas accretion; (ii) the build up and star formation history of the quasar host galaxy, driven by binary mergers and mass accretion; (iii) the evolution of gas, stars, metals in the interstellar medium (ISM), accounting for mass exchanges with the external medium (infall and outflow processes); (iv) dust formation in Supernova (SN) ejecta and in the stellar atmosphere of Asymptotic Giant Branch (AGB) stars, dust destruction by interstellar shocks and grain growth in molecular clouds; (v) the AGN feedback which powers a galactic-scale wind, self-regulating the black hole growth and eventually halting star formation. We use this model to study the case of SDSS J1148+5251 observed at redshift 6.4. We explore different star formation histories for the QSO host galaxy and find that Population III stars give a negligible contribution to the final metal and dust masses due to rapid enrichment of the ISM to metallicities $> Z_{\rm cr} = [10^{-6}$–$10^{-4}]$ $\rm Z_\odot$ in progenitor galaxies at redshifts > 10. If Population II/I stars form with a standard initial mass function (IMF) and with a characteristic stellar mass of $m_{\rm ch} = 0.35$ $\rm M_\odot$, a final stellar mass of $[1$–$5]\times10^{11}$ $\rm M_\odot$ is required to reproduce the observed dust mass and gas metallicity of J1148. This is a factor 3 to 10 higher than the stellar mass inferred from observations and would shift the QSO closer or onto the stellar-bulge–black-hole relation observed in the local Universe; alternatively, the observed chemical properties can be reconciled with the inferred stellar mass assuming that Population II/I stars form according to a top-heavy IMF with $m_{\rm ch} = 5$ $\rm M_\odot$. We find that SNe dominate the early dust enrichment and that, depending on the shape of the star formation history and on the stellar IMF, AGB stars contribute at redshift $z < 8$–10. Yet, a dust mass of $[2$–$6]\times10^8$ $\rm M_\odot$ estimated for J1148 cannot be reproduced considering only stellar sources and the final dust mass is dominated by grain growth in molecular clouds. This conclusion is independent of the stellar initial mass function and star formation history.

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Thermohaline mixing and the photospheric composition of low-mass giant stars

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We compute full evolutionary sequences of red giant branch stars close to the luminosity bump by including state of the art composition transport prescriptions for the thermohaline mixing regimes. In particular we adopt a self-consistent double-diffusive convection theory, that allows to handle the instabilities that arise when thermal and composition gradients compete against each other, and a very recent empirically motivated and parameter free asymptotic scaling law for thermohaline composition transport. In agreement with previous works, we find that during the red giant stage, a thermohaline instability sets in shortly after the hydrogen burning shell (HBS) encounters the chemical discontinuity left behind by the first dredge-up. We also find that the thermohaline unstable region, initially appearing at the exterior wing of the HBS, is unable to reach the outer convective envelope, with the consequence that no mixing of elements that produces a non-canonical modification of the stellar surface abundances occurs. Also in agreement with previous works, we find that by artificially increasing the mixing efficiency of thermohaline regions it is possible to connect both unstable regions, thus affecting the photospheric composition. However, we find that in order to reproduce the observed abundances of red giant branch stars close to the luminosity bump, thermohaline mixing efficiency has to be artificially increased by about 4 orders of magnitude from that predicted by recent 3D numerical simulations of thermohaline convection close to astrophysical environments. From this we conclude the chemical abundance anomalies of red giant stars cannot be explained on the basis of thermohaline mixing alone.

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Mid-infrared interferometric monitoring of evolved stars – The dust shell around the Mira variable RR Aql at 13 epochs

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We present a unique multi-epoch infrared interferometric study of the oxygen-rich Mira variable RR Aql in comparison to radiative transfer models of the dust shell. We investigate flux and visibility spectra at 8–13 μm with the aim of better understanding the pulsation mechanism and its connection to the dust condensation sequence and mass-loss process. We obtained 13 epochs of mid-infrared interferometry with the MIDI instrument at the VLTI between April 2004 and July 2007, covering minimum to pre-maximum pulsation phases (0.45–0.85) within four cycles. The data are modeled with a radiative transfer model of the dust shell where the central stellar intensity profile is described by a series of dust-free dynamic model atmospheres based on self-excited pulsation models. We examined two dust species, silicate and Al_2O_3 grains. We performed model simulations using variations in model phase and dust shell parameters to investigate the expected variability of our mid-infrared photometric and interferometric data. The observed visibility spectra do not show any indication of variations as a function of pulsation phase and cycle. The observed photometry spectra may indicate intracycle and cycle-to-cycle variations at the level of 1–2 standard deviations. The photometric and visibility spectra of RR Aql can be described well by the radiative transfer model of the dust shell that uses a dynamic model atmosphere describing the central source. The best-fitting model for our average pulsation phase of 0.64 ± 0.15 includes the dynamic model atmosphere M21n ($T_{\rm model} = 2550$ K) with a photospheric angular diameter of 7.6 ± 0.6 mas, and a silicate dust shell with an optical depth of 2.8 ± 0.8, an inner radius of 4.1 ± 0.7 $R_{\rm Phot}$, and a power-law index of the density distribution of 2.6 ± 0.3. The addition of an Al_2O_3 dust shell did not improve the model fit. However, our model simulations indicate that the presence of an inner Al_2O_3 dust shell with lower optical depth than for the silicate dust shell cannot be excluded. The photospheric angular diameter corresponds to a radius of 520^{+230}_{-140} $R_\odot$ and an effective temperature of $\sim 2420 \pm 200$ K. Our modeling simulations confirm that significant intracycle and cycle-to-cycle visibility variations are not expected for RR Aql at mid-infrared wavelengths within our uncertainties. We conclude that our RR Aql data can be described by a pulsating atmosphere surrounded by a silicate dust shell. The effects of the pulsation on the mid-infrared flux and visibility values are expected to be less than about 25% and 20%, respectively, and are too low to be detected within our measurement uncertainties.

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Conference Papers

Spatio-kinematic modelling: Testing the link between planetary nebulae and close binaries

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It is widely believed that central star binarity plays an important role in the formation and evolution of aspherical planetary nebulae, however observational support for this hypothesis is lacking. Here, we present the most recent results of a continuing programme to model the morphologies of all planetary nebulae known to host a close binary

central star. Initially, this programme allows us to compare the inclination of the nebular symmetry axis to that of the binary plane, testing the theoretical expectation that they will lie perpendicular – to date, all have satisfied this expectation, indicating that each nebula has been shaped by its central binary star.
As a greater sample of nebulae are modelled, it will be possible to search for trends connecting the parameters of both nebula and central binary, strengthening our understanding of the processes at work in these objects. I will discuss some of the more obvious comparisons, and their current statuses, as well as the obvious links to common envelope evolution.

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A PIONIER and incisive look at the interacting binary SS Lep

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Symbiotic stars are eccellent laboratories to study a broad range of poorly understood physical processes, such as mass loss of red giants, accretion onto compact objects, and evolution of nova-like outbursts. As their evolution is strongly influenced by the mass transfer episodes, understanding the history of these systems requires foremost to determine which process is at play: Roche lobe overflow, stellar wind accretion, or some more complex mixture of both. We report here an interferometric study of the symbiotic system SS Leporis, performed with the unique PIONIER instrument. By determining the binary orbit and revisiting the parameters of the two stars, we show that the giant does not fill its Roche lobe, and that the mass transfer most likely occurs via the accretion of an important part of the giant's wind.

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Review Papers

Light-element abundance variations in globular clusters

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Star-to-star variations in abundances of the light elements carbon, nitrogen, oxygen, and sodium have been observed in stars of all evolutionary phases in all Galactic globular clusters that have been thoroughly studied. The data available for studying this phenomenon, and the hypotheses as to its origin, have both co-evolved with observing technology; once high-resolution spectra were available even for main-sequence stars in globular clusters, scenarios involving multiple closely spaced stellar generations enriched by feedback from moderate- and high-mass stars began to gain traction in the literature. This paper briefly reviews the observational history of globular cluster abundance inhomogeneities, discusses the presently favored models of their origin, and considers several aspects of this problem that require further study.

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Reevaluation of the ^{14}O(α,p)^{17}F resonant reaction rate

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The reaction rates of the key stellar reaction of ^{14}O(α,p)^{17}F have been reevaluated. It is thought that the previous 1^- assignment for the 6.15-MeV state is incorrect by a careful reanalysis of the previous experimental data [J. Gómez del Campo et al., Phys. Rev. Lett., 86, 43 (2001)]. Most probably, the 6.286-MeV state is the key 1^- state and the 6.15-MeV state is a 2^- one, and hence the resonance at E_x=6.286 MeV ($J^\pi = ^-$) actually dominates the reaction rates in the temperature region of astrophysical interests. The newly calculated reaction rates for the ^{14}O(α,p)^{17}F reaction are quite different from the previous ones, for instance, it's only about 1/6 of the previous value around 0.4 GK, while it's about 2.4 times larger than the previous value around 2 GK. The astrophysical implications have been briefly discussed based on the present conclusions.

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Announcement

The Hong Kong Workshop on Evolved Stars and Astrophysical Masers: 7–8 November 2011

⟨Date and Location⟩
The workshop is going to take place from 7 to 8 November 2011. The venue will be in The University of Hong Kong; whereas the exact conference room will be confirmed in the final circular.

⟨Focus of the Workshop⟩
We are pleased to announce the Hong Kong Workshop on Evolved Stars and Astrophysical Masers, which will widely cover subjects about the physical and chemical nature of evolved stars (of all mass spectrum) and their circumstellar envelopes/shells as well as astrophysical masers.

Over the past several years, we have seen significant trends in the evolved star field. A notable one must be the release of brand-new, infrared survey data, such as *Spitzer*, AKARI, WISE, and *Herschel*. More to the point, some leading-edge radio telescopes providing distinctive capabilities, such as ALMA and SKA, have recently been put into operation or will soon be constructed. We are about to witness the extremely exciting era with these new capabilities. At the same time, the population of researchers and students in the evolved star field has rapidly grown, in particular, in the East Asian region. Therefore, we would like to have an opportunity to get together and exchange ideas on latest topics and ongoing/forthcoming projects among international colleagues in this field. This workshop is also intended to commemorate the retirement of Dr. Shuji Deguchi, who has been contributing in this field over 40 years.

The topics we would like to discuss are, for example:

- AGB, Post-AGB, PPNe, PNe
- Red supergiants, pre-explosion mass-loss of massive evolved stars
- Circumstellar masers, astrophysical masers
- Circumstellar chemistry, dust formation
- Pulsation, binarity and their effects on dust formation and mass-loss
- Novae and supernovae probed by masers
- New observational approaches with AKARI, VLBA, eVLA, ALMA, SKA etc.

More information is available from the website, or contact LOC at hkws2011@hku.hk

See also http://www.scifac.hku.hk/hkws2011/