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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 194$^{\rm th}$ issue of the AGB Newsletter, with plenty for you to find out or remind you of.

The Fizeau programme continues to accept requests for support of work visits within the interferometry theme, so do consider it as a way of becoming involved in this field.

The third Vienna AGB conference is announced, to take place in the Summer of 2014. It promises to become just as interesting and pleasant as the previous two editions.

The next issue is planned to be distributed around the 1$^{\rm st}$ of October.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

What is the most sensitive and reliable way of quantifying the AGB contribution to the integrated light of galaxies?

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

Kinematic distance study of the planetary nebulæ–supernova remnant–H II region complex at G35.6–0.5

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Two possible planetary nebulæ (PN G035.5−00.4 and IRAS 18551+0159), one newly re-identified supernova remnant (SNR G35.6−0.4), and one H II region (G35.6−0.5) form a line-of-sight-overlapped complex known as G35.6−0.5. We analyze 21 cm H I absorption spectra towards the complex to constrain their kinematic distances. PN G035.5−00.4 has a distance from 3.8 ± 0.4 kpc to 5.4 ± 0.7 kpc. IRAS 18551+0159 is at 4.3 ± 0.5 kpc. We discuss the distance for SNR G35.6−0.4, for which the previous estimate was 10.5 kpc, and find plausible for it to be 3.6 ± 0.4 kpc. The new distance of SNR G35.6−0.4 and the derived mass for the ~ 55 km s^{-1} CO molecular cloud can accommodate an association with HESS J1858+020. We also conclude that SNR G35.6−0.4 is unlikely associated with PSR J1857+0210 or PSR J1857+0212, which are projected into the SNR area.

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An exoplanet's response to anisotropic stellar mass-loss during birth and death

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The birth and death of planets may be affected by mass outflows from their parent stars during the T Tauri or post-main-sequence phases of stellar evolution. These outflows are often modelled to be isotropic, but this assumption is not realistic for fast rotators, bipolar jets and supernovæ. Here we derive the general equations of motion for the time evolution of a single planet, brown dwarf, comet or asteroid perturbed by anisotropic mass loss in terms of a complete set of planetary orbital elements, the ejecta velocity, and the parent star's co-latitude and longitude. We restrict our application of these equations to 1) rapidly rotating giant stars, and 2) arbitrarily-directed jet outflows. We conclude that the isotropic mass-loss assumption can safely be used to model planetary motion during giant branch phases of stellar evolution within distances of hundreds of au. In fact, latitudinal mass-loss variations anisotropically affect planetary motion only if the mass loss is asymmetric about the stellar equator. Also, we demonstrate how constant-velocity, asymmetric bipolar outflows in young systems incite orbital inclination changes. Consequently, this phenomenon readily tilts exoplanetary orbits external to a nascent disc on the order of degrees.

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The age and the mass of the α Herculis triple-star system from a MESA grid of rotating stars with $1.3 \leq M/\mathrm{M}_{\odot} \leq 8.0$

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α^1 Her is the second closest Asymptotic Giant Branch (AGB) star to the Sun, and the variable luminous M5 Ib–II member of a triple stellar system containing G8 III and A9 IV–V components. However, the mass of this important star was previously uncertain with published values ranging from $\sim$ 2–15 $\mathrm{M}_{\odot}$. As shown by this study, its fortuitous membership in a nearby resolved triple star system, makes it possible to determine its fundamental properties including its mass and age. We present over twenty years of VRI photometry of α^1 Her as well as Wing intermediate-band near-IR TiO and NIR continuum photometry. We introduce a new photometry-based calibration technique, and extract the effective temperature and luminosity of α^1 Her, in agreement with recent interferometric measures. We find, $T_{\rm eff} = 3280 \pm 87$ K and $\log(L/\mathrm{L}_{\odot}) = 3.92 \pm 0.14$.

With the MESA code, we calculate a dense grid of evolutionary tracks for Galactic low- to intermediate-mass (1.3 to 8 $\mathrm{M}_{\odot}$) rotating stars from the pre-main sequence phase to the advanced AGB phase. We include atomic diffusion and rotation mechanisms to treat the effects of extra elemental mixing. Based on the observed properties of the α Herculis stars, we constrain the age of the system to lie in the range 0.41 to 1.25 Gyr. Thus, the mass of α^1 Her lies in the range $2.175 \leq M/\mathrm{M}_{\odot} \leq 3.250$. We compare our model-based age inference with recent tracks of the Geneva and STAREVOL codes, and show their agreement. In the prescribed mass range for α^1 Her, the observed $^{12}\mathrm{C}/^{13}\mathrm{C}$ and $^{16}\mathrm{O}/^{17}\mathrm{O}$ ratios are consistent (within 2σ) with the ratios predicted by the MESA, Geneva and STAREVOL codes.

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A *Herschel* study of NGC 650

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As part of the *Herschel* Guaranteed Time Key Project MESS (Mass loss of Evolved StarS) we have imaged a sample of planetary nebulæ. In this paper we present the PACS and SPIRE images of the classical bipolar planetary nebula NGC 650. We used these images to derive a temperature map of the dust. We also constructed a photoionization and dust radiative transfer model using the spectral synthesis code CLOUDY. To constrain this model, we used the PACS and SPIRE fluxes and combined these with hitherto unpublished IUE and *Spitzer* IRS spectra as well as various other data from the literature. The temperature map combined with the photoionization model were used to study various aspects of the central star, the nebula, and in particular the dust grains in the nebula. The central star parameters are determined to be $T_{\rm eff} = 208$ kK and $L = 261$ $\mathrm{L}_{\odot}$ assuming a distance of 1200 pc. The stellar temperature is much higher than previously published values. We confirm that the nebula is carbon-rich with a C/O ratio of 2.1. The nebular abundances are typical for a type IIa planetary nebula. With the photoionization model we determined that

the grains in the ionized nebula are large (assuming single-sized grains, they would have a radius of 0.15 μm). Most likely these large grains were inherited from the asymptotic giant branch phase. The PACS 70/160 μm temperature map shows evidence for two radiation components heating the grains. The first component is direct emission from the central star, while the second component is diffuse emission from the ionized gas (mainly Lyα). We show that previous suggestions that there is a photo-dissociation region surrounding the ionized region are incorrect. The neutral material resides in dense clumps inside the ionized region. These may also harbor stochastically heated very small grains in addition to the large grains.

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Planetary nebulæ after common-envelope phases initiated by low-mass red giants

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It is likely that at least some planetary nebulæ are composed of matter which was ejected from a binary star system during common-envelope (CE) evolution. For these planetary nebulae the ionizing component is the hot and luminous remnant of a giant which had its envelope ejected by a companion in the process of spiralling-in to its current short-period orbit. A large fraction of CE phases which end with ejection of the envelope are thought to be initiated by low-mass red giants, giants with inert, degenerate helium cores. We discuss the possible end-of-CE structures of such stars and their subsequent evolution to investigate for which structures planetary nebulae are formed. We assume that a planetary nebula forms if the remnant reaches an effective temperature greater than 30 kK within 10^4 yr of ejecting its envelope. We assume that the composition profile is unchanged during the CE phase so that possible remnant structures are parametrized by the end-of-CE core mass, envelope mass and entropy profile. We find that planetary nebulæ are expected in post-CE systems with core masses greater than about 0.3 $M_\odot$ if remnants end the CE phase in thermal equilibrium. We show that whether the remnant undergoes a pre-white dwarf plateau phase depends on the prescribed end-of-CE envelope mass. Thus, observing a young post-CE system would constrain the end-of CE envelope mass and post-CE evolution.

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The PTI carbon star angular size survey: effective temperatures and non-sphericity

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We report new interferometric angular diameter observations of 41 carbon stars observed with the Palomar Testbed Interferometer (PTI). Two of these stars are CH carbon stars and represent the first such measurements for this subtype. Of these, 39 have Yamashita (1972, 1975b) spectral classes and are of sufficiently high quality that we may determine the dependence of effective temperature on spectral type. We find that there is a tendency for the effective temperature to increase with increasing temperature index by$\sim$ 120 K per step, starting at $T_{\rm eff} \sim 2500$ K for C3,y,

although there is a large amount of scatter about this relationship. Overall, the median effective temperature for the carbon star sample is found to be 2800 ± 270 K, and the median linear radius is 360 ± 100 $R_{\odot}$. We also find agreement on average within 15 K with the T_{eff} determinations of Bergeat et al. (2001, 2002b,a), and a refinement of carbon star angular size prediction based on V & K magnitudes is presented that is good to an r.m.s. of 12%. A subsample of our stars have sufficient *uv* coverage to permit non-spherical modeling of their photospheres, and a general tendency for detection of statistically significant departures from sphericity with increasing signal-to-noise of the interferometric data is seen. The implications of most – and potentially all – carbon stars being non-spherical is considered in the context of surface inhomogeneities and a rotation-mass loss connection.

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Grids of stellar models with rotation – III. Models from 0.8 to 120 $M_{\odot}$ at a metallicity $Z = 0.002$

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Aims: We study the impact of a subsolar metallicity on various properties of non-rotating and rotating stars, such as surface velocities and abundances, lifetimes, evolutionary tracks and evolutionary scenarios.
Methods: We provide a grid of single star models covering a mass range from 0.8 to 120 $M_{\odot}$ with an initial metallicity $Z = 0.002$ with and without rotation. We discuss the impact of a change in the metallicity by comparing the current tracks with models computed with exactly the same physical ingredients but with a metallicity $Z = 0.014$ (solar).
Results: We show that the width of the main-sequence (MS) band in the upper part of the Hertzsprung–Russell diagram (HRD), for luminosity above $\log(L/L_{\odot}) > 5.5$, is very sensitive to rotational mixing. Strong mixing significantly reduces the MS width. We confirm, but here for the first time on the whole mass range, that surface enrichments are stronger at low metallicity provided that comparisons are made for equivalent initial mass, rotation and evolutionary stage. We show that the enhancement factor due to a lowering of the metallicity (all other factors kept constant) increases when the initial mass decreases. Present models predict an upper luminosity for the red supergiants (RSG) of $\log(L/L_{\odot}) \sim 5.5$ at $Z = 0.002$ in agreement with the observed upper limit of RSG in the Small Magellanic Cloud. We show that models using shear diffusion coefficient calibrated to reproduce the surface enrichments observed for MS B-type stars at $Z = 0.014$ can also reproduce the stronger enrichments observed at low metallicity. In the framework of the present models, we discuss the factors governing the timescale of the first crossing of the Hertzsprung gap after the MS phase. We show that any process favouring a deep localisation of the H-burning shell (steep gradient at the border of the H-burning convective core, low CNO content) and/or the low opacity of the H-rich envelope favour a blue position in the HRD for the whole or at least a significant fraction of the core He-burning phase.

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Time variation of the O/H radial gradient in the Galactic Disk based on planetary nebulæ

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The controversy on the time variation of the radial abundance gradients can in principle be settled by estimating the gradients from planetary nebulæ (PN) ejected by central stars (CSPN) with different ages. In this work, we consider four samples of CSPN whose lifetimes have been estimated using three different methods and estimate the oxygen abundance gradients for these objects. The results suggest some small differences between the younger and older CSPN. The younger objects have similar or slightly higher oxygen abundances compared with the older objects, and the gradients of both groups are similar within the uncertainties. Therefore, the O/H radial gradient has not changed appreciably during the lifetime of the objects considered, so that PN gradients are not expected to be very different from the gradients observed in younger objects, which seems to be supported by recent observational data.

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Formulation of non-steady-state dust formation process in astrophysical environments

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The non-steady-state formation of small clusters and the growth of grains accompanied by chemical reactions are formulated under the consideration that the collision of key gas species (key molecule) controls the kinetics of dust formation process. The formula allows us to evaluate the size distribution and condensation efficiency of dust formed in astrophysical environments. We apply the formulation to the formation of C and $MgSiO_3$ grains in the ejecta of supernovæ, as an example, to investigate how the non-steady effect influences the formation process, condensation efficiency $f_{\rm con,\infty}$, and average radius $a_{\rm ave,\infty}$ of newly formed grains in comparison with the results calculated with the steady-state nucleation rate. We show that the steady-state nucleation rate is a good approximation if the collision timescale of key molecule $\tau_{\rm coll}$ is much smaller than the timescale $\tau_{\rm sat}$ with which the supersaturation ratio increases; otherwise the effect of the non-steady state becomes remarkable, leading to a lower $f_{\rm con,\infty}$ and a larger $a_{\rm ave,\infty}$. Examining the results of calculations, we reveal that the steady-state nucleation rate is applicable if the cooling gas satisfies $\Lambda \equiv \tau_{\rm sat}/\tau_{\rm coll} \gtrsim 30$ during the formation of dust, and find that $f_{\rm con,\infty}$ and $a_{\rm ave,\infty}$ are uniquely determined by $\Lambda_{\rm on}$ at the onset time $t_{\rm on}$ of dust formation. The approximation formulæ for $f_{\rm con,\infty}$ and $a_{\rm ave,\infty}$ as a function of $\Lambda_{\rm on}$ could be useful in estimating the mass and typical size of newly formed grains from observed or model-predicted physical properties not only in supernova ejecta but also in mass-loss winds from evolved stars.

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A study of two high-velocity red horizontal branch stars

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High-velocity Halo stars provide important information about the properties of the extreme Galactic Halo. The study

of Population II unbound and bound stars enables us better estimate the mass of the halo.
We carried out a detailed spectroscopic and kinematic study of two red horizontal branch stars, CD −41°15048 and HD 214362.
The atmospheric parameters, chemical abundances, and kinematical properties were determined using high-resolution optical spectroscopy and employing the local thermodynamic equilibrium model atmospheres of Kurucz and the spectral analysis code MOOG.
We found that CD −41°15048 and HD 214362 are metal-poor red horizontal branch stars. Their abundance patterns are similar to other metal-poor Halo stars already investigated. Our kinematic analysis of the 3D space motions shows that HD 214362 has a highly eccentric ($e = 0.95$) orbit and passes at 2 kpc from the Galactic Center. CD −41°15048, for an adopted distance of 1.3 kpc, has an extreme retrograde motion and travels with very high velocity relative to the Galactocentric reference frame ($v_{\rm GRF} = 583$ km s^{-1}).
CD −41°15048 is a bound or an unbound star, depending on the adopted Galactic potential. We also show that the red horizontal branch star BD +09°3223 is another example of a hypervelocity star. Whether it is bound or unbound to the Galaxy depends on the assumed mass and adopted Galactic potential. Possible origins of these two high-velocity stars are briefly discussed. CD −41°15048 and BD +09°3223 are further examples of evolved stars to join the restricted group of hypervelocity stars. Finally, our results seem to contradict the idea that a passage of a star very close to the Galactic Center is the only possible origin of the hypervelocity stars.

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VISTA's view of the Sagittarius dwarf spheroidal galaxy and southern Galactic Bulge

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We present the deepest near-infrared (ZJK_s) photometry yet obtained of the Sagittarius dwarf spheroidal (Sgr dSph), using VISTA to survey 11 square degrees centred on its core. We list locations and ZJK_s-band magnitudes for over 2.9 million sources in the field. We discuss the isolation of the Sgr dSph from the foreground and Galactic Bulge populations, identify the Sgr dSph's horizontal branch in the near-infrared for the first time, and map the density of the galaxy's stars. We present isochrones for the Sgr dSph and Bulge populations. These are consistent with the previously-reported properties of the Sgr dSph core: namely that it is dominated by a population between [Fe/H] ~ -1 dex and solar, with a significant [α/Fe] versus [Fe/H] gradient. While strong contamination from the Galactic Bulge prevents accurate measurement of the (Galactic) north side of the Sgr dSph, the dwarf galaxy can be well-approximated by a roughly ovaloid projection of characteristic size 4×2 degrees, beyond which the projected stellar density is less than half that of the region surrounding the core. The galaxy's major axis is perpendicular to the Galactic Plane, as in previous studies. We find slight evidence to confirm a metallicity gradient in the Sgr dSph and use isochrones to fit a distance of 24.3 ± 2.3 kpc. We were unable to fully constrain the metallicity distribution of the Sgr dSph due to the Bulge contamination and strong correlation of [alpha/Fe] with metallicity, however we find that metal-poor stars ([Fe/H] $\lesssim -1$) make up $\lesssim$29 per cent of the Sgr dSph's upper-RGB population. The Bulge population is best fit by a younger population with [Fe/H] ~ 0 and [α/Fe] ~ 0 or slightly higher. We find no evidence for a split, peanut- or X-shaped Bulge population in this line of sight ($l = 5.6 \pm 1$ deg, $b = -14.1 \pm 3$ deg).

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Evidence of a binary-induced spiral from an incomplete ring pattern of CIT 6

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With the advent of high-resolution high-sensitivity observations, spiral patterns have been revealed around several asymptotic giant branch (AGB) stars. Such patterns can provide possible evidence for the existence of central binary stars embedded in outflowing circumstellar envelopes. Here, we suggest the viability of explaining the previously observed incomplete ring-like patterns with the spiral-shell structure due to the motion of (unknown) binary components viewed at an inclination with respect to the orbital plane. We describe a method of extracting such spiral-shells from an incomplete ring-like pattern to place constraints on the characteristics of the central binary stars. The use of gas kinematics is essential in facilitating a detailed modeling for the three-dimensional structure of the circumstellar pattern. We show that a hydrodynamic radiative transfer model can reproduce the structure of the HC_3N molecular line emission of the extreme carbon star, CIT 6. This method can be applied to other sources in the AGB phase and to the outer ring-like patterns of pre-planetary nebulæ for probing the existence of embedded binary stars, which are highly anticipated with future observations using the Atacama Large Millimeter/submillimeter Array.

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SS 383: a new S-type yellow symbiotic star?

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Symbiotic stars are key objects to understand the formation and evolution of interacting binary systems, and probably the progenitors of type Ia supernovæ. However, the number of known symbiotic stars is much lower than the predicted one. We aim to search for new symbiotic stars, with particular emphasis on the S-type yellow simbiotic stars, in order to determine their total population, evolutionary timescales, and physical properties. The 2MASS (J–H) vs. (H–K_s) colour–colour diagram has been previously used to identify new symbiotic star candidates and show that yellow symbiotics are located in a particular region of that diagram. Candidate symbiotic stars are selected on the basis of their locus in the 2MASS (J–H) vs. (H–K_s) diagram and presence of Hα line emission in the Stephenson & Sanduleak (1977) Hα survey. This diagram separates S-type yellow symbiotic stars from the rest of S-type symbiotic stars, allowing us to select candidates to yellow symbiotics. To establish the true nature of the candidates, intermediate-resolution spectroscopy is obtained. We have identified the Hα emission line source SS 383 as a S-type yellow symbiotic candidate by its position in the 2MASS colour–colour diagram. The optical spectrum of SS 383 shows Balmer, He I, He II, and [O III] emission lines, in combination with TiO absorption bands that confirm its symbiotic nature. The derived electron density ($\sim 10^{8-9}$ cm^{-3}), He I emission line intensity ratios, and position in the [O III]5007/Hβ vs. [O III]4363/Hγ diagram indicate that SS 383 is an S-type symbiotic star, with a probable spectral type of K7–M0 is deduced for its cool component based on TiO indices. The spectral type and the position of SS 383 (corrected for reddening) in the 2MASS colour–colour diagram strongly suggest that SS 383 is an S-type yellow symbiotic. Our result points out that the 2MASS colour–colour diagram is a powerful tool to identify new S-type yellow symbiotics.

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A wind-shell interaction model for multipolar planetary nebulæ

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We explore the formation of multipolar structures in planetary and pre-planetary nebulæ from the interaction of a fast post-AGB wind with a highly inhomogeneous and filamentary shell structure assumed to form during the final phase of the high density wind. The simulations were performed with a new hydrodynamics code integrated in the interactive framework of the astrophysical modeling package SHAPE. In contrast to conventional astrophysical hydrodynamics software, the new code does not require any programming intervention by the user for setting up or controlling the code. Visualization and analysis of the simulation data has been done in SHAPE without external software. The key conclusion from the simulations is that secondary lobes in planetary nebulæ, such as Hubble 5 and K 3-17, can be formed through the interaction of a fast low-density wind with a complex high density environment, such as a filamentary circumstellar shell. The more complicated alternative explanation of intermittent collimated outflows that change direction, in many cases may therefore not be necessary. We consider that the wind-shell interaction scenario is more likely since the bow-shock shape expected from a strongly cooling bow-shock from jets is different from that of the observed bubbles. Furthermore, the timescales of the wind–wind interaction suggest that the progenitor star was rather massive.

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ALMA observations of the variable ^{12}CO/^{13}CO ratio around the asymptotic giant branch star R Sculptoris

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The ^{12}CO/^{13}CO ratio is often used as a measure of the ^{12}C/^{13}C ratio in the circumstellar environment, carrying important information about the stellar nucleosynthesis. External processes can change the ^{12}CO and ^{13}CO abundances, and spatially resolved studies of the ^{12}CO/^{13}CO ratio are needed to quantify the effect of these processes on the globally determined values. Additionally, such studies provide important information on the conditions in the circumstellar environment. The detached-shell source R Scl, displaying CO emission from recent mass loss, in a binary-induced spiral structure as well as in a clumpy shell produced during a thermal pulse, provides a unique laboratory for studying the differences in CO isotope abundances throughout its recent evolution. We observed both the ^{12}CO($J = 3 \rightarrow 2$) and the ^{13}CO($J = 3 \rightarrow 2$) line using ALMA. We find significant variations in the ^{12}CO/^{13}CO intensity ratios and consequently in the abundance ratios. The *average* CO isotope abundance ratio is at least a factor three lower in the shell (~ 19) than that in the present-day ($\lesssim$300 years) mass loss (> 60). Additionally, variations in the ratio of more than an order of magnitude are found in the shell itself. We attribute these variations to the competition between

selective dissociation and isotope fractionation in the shell, of which large parts cannot be warmer than ~ 35 K. However, we also find that the $^{12}CO/^{13}CO$ ratio in the present-day mass loss is significantly higher than the $^{12}C/^{13}C$ ratio determined in the stellar photosphere from molecular tracers (~ 19). The origin of this discrepancy is still unclear, but we speculate that it is due to an embedded source of UV-radiation that is primarily photo-dissociating ^{13}CO. This radiation source could be the hitherto hidden companion. Alternatively, the UV-radiation could originate from an active chromosphere of R Scl itself. Our results indicate that caution should be taken when directly relating the $^{12}CO/^{13}CO$ intensity and $^{12}C/^{13}C$ abundance ratios for specific asymptotic giant branch stars, in particular binaries or stars that display signs of chromospheric stellar activity.

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The peculiar light curve of the symbiotic star AX Per of the last 125 years

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We analyze the last 125 years optical light curve of the symbiotic star AX Per through some remarkable correlations that we discovered in its power spectrum. The data were assembled from the literature and from the AAVSO database. A series of 6 major outbursts dominate the light curve. They are presented in the power spectrum as 13 harmonics of the fundamental frequency $f_a = 1/P_a = 1/23172$ d^{-1}. We refer to them as the "red" frequencies. Oscillations with the binary periodicity of the system $P_b = 1/f_b = 681.48$ d are also seen in the light curve, with particularly large amplitudes during outbursts. The f_b peak in the power spectrum is accompanied by 13 other peaks on each side, to which we refer as the "blue" frequencies. A distinct structure in the frequency distribution of the blue peaks, as well as in their peak power are best interpreted as reflecting beating of the 13 "red" frequencies with the binary one. We suggest, following others, that the major outbursts of the system result from events of intense mass loss from the giant star. Mass accretion onto the hot component, partially through the L1 point of the system, took place in the last 125 years at a rate that oscillated with the 13 first harmonics of the fa frequency. The binary orbit is slightly eccentric and periastron passages induced modulation of the L1 accretion at the binary frequency. Hence the f_b oscillations in the brightness of the star of amplitude that is modulated by the "red" frequencies of the system.

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GYRE: An open-source stellar oscillation code based on a new Magnus Multiple Shooting Scheme

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We present a new oscillation code, GYRE, which solves the stellar pulsation equations (both adiabatic and non-adiabatic) using a novel Magnus Multiple Shooting numerical scheme devised to overcome certain weaknesses of the usual relaxation and shooting schemes appearing in the literature. The code is accurate (up to $6^{\rm th}$ order in the number of grid points), robust, efficiently makes use of multiple processor cores and/or nodes, and is freely available in source form for use and distribution. We verify the code against analytic solutions and results from other oscillation codes, in all cases finding good agreement. Then, we use the code to explore how the asteroseismic observables of a 1.5 $M_\odot$ star change as it evolves through the red-giant bump.

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The bow-shock and high-speed jet in the faint, 40 arcmin diameter, outer halo of the evolved Helix planetary nebula (NGC 7293)

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In previous, very deep, optical images of NGC 7293 both a feature that has the morphology of a bow-shock and one with that of a jet were discovered in the faint 40′ diameter halo of the nebula. Spatially resolved longslit profiles of the Hα and [N II] 6548, 6584 Å nebular emission lines from both features have now been obtained.
The bow-shaped feature has been found to have Hα radial velocities close to the systemic heliocentric radial velocity, -27 km s^{-1}, of NGC 7293 and is faint in the [N II] 6548, 6584 Å lines. Furthermore, the full width of these profiles matches the relative motion of NGC 7293 with its ambient interstellar medium consequently it is deduced that the feature is a real bow-shock caused by the motion of NGC 7293 as it ploughs through this medium.The proper motion of the central star also points towards this halo feature which substantiates this interpretation of its origin.
Similarly [N II] 6584 Å line profiles reveal that the jet-like filament is indeed a collimated outflow, as suggested by its morphology, at around 300 km s^{-1} with turbulent widths of around 50 km s^{-1}. It's low Hα/[N II] 6548, 6584 Å ratio suggests collisional ionization as expected in a high-speed jet.

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The abundances of hydrocarbon functional groups in the interstellar medium inferred from laboratory spectra of hydrogenated and methylated polycyclic aromatic hydrocarbons

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Infrared (IR) absorption spectra of individual polycyclic aromatic hydrocarbons (PAHs) containing methyl (–CH_3), methylene (>CH_2), or diamond-like ⋆CH groups and IR spectra of mixtures of methylated and hydrogenated PAHs prepared by gas phase condensation were measured at room temperature (as grains in pellets) and at low temperature (isolated in Ne matrices). In addition, the PAH blends were subjected to an in-depth molecular structure analysis by means of high-performance liquid chromatography (HPLC), nuclear magnetic resonance (NMR) spectroscopy, and matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI–TOF). Supported by calculations at the density functional theory (DFT) level, the laboratory results were applied to analyze in detail the aliphatic absorption complex of the diffuse interstellar medium (ISM) at 3.4 μm and to determine the abundances of hydrocarbon functional groups. Assuming that the PAHs are mainly locked in grains, aliphatic CH_x groups ($x = 1, 2, 3$) would contribute approximately in equal quantities to the 3.4-μm feature ($N_{CH_x}/N_H \approx 10^{-5}$–$2 \times 10^{-5}$). The abundances, however, may be two to four times lower if a major contribution to the 3.4-μm feature comes from molecules in the gas phase. Aromatic =CH groups seem to be almost absent from some lines of sight, but can be nearly as abundant as each of the aliphatic components in other directions ($N_{=CH}/N_H < 2 \times 10^{-5}$; upper value for grains). Due to comparatively low binding energies, IR emission sources, on the other side, do not display such heavy excess hydrogenation. At best, especially in proto-planetary nebulæ, >CH_2 groups bound to aromatic molecules, i.e., excess hydrogens on the molecular periphery only, can survive the presence of a nearby star.

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Hunting for extremely faint planetary nebulæ in the SDSS spectroscopic database

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Using $\sim 1,700,000$ target- and sky-fiber spectra from the SDSS, we have carried out a systematic search for Galactic planetary nebulæ (PNe) via detections of the [O III] 4959, 5007 lines. Thanks to the excellent sensitivity of the SDSS spectroscopic surveys, this is by far the deepest search for PNe ever taken, reaching a surface brightness of the [O III] 5007 line down to about 29.0 mag/arcsec^2. The search recovers 13 previously known PNe in the Galactic Caps. In total, 44 new PN candidates are identified, including 7 candidates of multiple detections and 37 candidates of single detection. The 7 candidates of multiple detections are all extremely large (between $21'$–$154'$) and faint, located mostly in the low Galactic latitude region and with a kinematics similar to Disk stars. After checking their images in Hα and other bands, three of them are probably H II regions, one is probably associated with a new supernova remnant, another one is possibly a true PN, and the remaining two could be either PNe or supernova remnants. Based on sky positions and kinematics, 7 candidates of single detection probably belong to the Halo population. If confirmed, they will increase the number of known PNe in the Galactic Halo significantly. All the newly identified PN candidates are very faint, with a surface brightness of the [O III] 5007 line between 27.0–30.0 mag/arcsec^2, very challenging to be discovered with previous techniques and thus may greatly increase the number of "missing" faint PNe. Our results demonstrate the power of large scale fiber spectroscopy in hunting for ultra-faint PNe and other types of emission line nebulæ. Combining the large spectral databases provided by the SDSS and other on-going projects (e.g., the LAMOST Galactic surveys), it is possible to build a statistically meaningful sample of ultra-faint, large, evolved PNe, thus improving the census of Galactic PNe.

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The insidious boosting of TP-AGB stars in intermediate-age Magellanic Cloud clusters

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In the recent controversy about the role of TP-AGB stars in evolutionary population synthesis (EPS) models of galaxies, one particular aspect is puzzling: TP-AGB models aimed at reproducing the lifetimes and integrated fluxes of the TP-AGB phase in Magellanic Cloud (MC) clusters, when incorporated into EPS models, are found to overestimate, to various extents, the TP-AGB contribution in resolved star counts and integrated spectra of galaxies. In this paper, we call attention to a particular evolutionary aspect, linked to the physics of stellar interiors, that in all probability is the main cause of this conundrum. As soon as stellar populations intercept the ages at which RGB stars first appear, a sudden and abrupt change in the lifetime of the core He-burning phase causes a temporary "boost" in the production rate of subsequent evolutionary phases, including the TP-AGB. For a timespan of about 0.1 Gyr, triple TP-AGB branches develop at slightly different initial masses, causing their frequency and contribution to the integrated luminosity of the stellar population to increase by a factor of ~ 2. The boost occurs for turn-off masses of ~ 1.75 M$_\odot$, just in the proximity of the expected peak in the TP-AGB lifetimes (for MC metallicities), and for ages of ~ 1.6 Gyr. Coincidently, this relatively narrow age interval happens to contain the few very massive MC clusters that host most of the TP-AGB stars used to constrain stellar evolution and EPS models. This concomitance makes the AGB-boosting particularly insidious in the context of present EPS models. As we discuss in this paper, the identification of this evolutionary effect brings about three main consequences. First, we claim that present estimates of the TP-AGB contribution to the integrated light of galaxies derived from MC clusters, are biased towards too

large values. Second, the relative TP-AGB contribution of single-burst populations falling in this critical age range cannot be accurately derived by approximations such as the fuel consumption theorem, that ignore, by construction, the above evolutionary effect. Third, a careful revision of AGB star populations in intermediate-age MC clusters is urgently demanded, promisingly with the aid of detailed sets of stellar isochrones.

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The BaSTI stellar evolution database: models for extremely metal-poor and super-metal-rich stellar populations

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We present an extension of the BaSTI (Bag of Stellar Tracks and Isochrones) stellar evolution database to extremely metal-poor ($Z = 10^{-5}$) and super-metal-rich ($Z = 0.05$) metallicities, with both scaled-solar and α-enhanced ($[\alpha/\mathrm{Fe}] = 0.4$) heavy element distributions. These new tracks (from the pre-main sequence to the early-asymptotic giant branch phase), horizontal branch models, and isochrones will enable the use of the BaSTI database to study the most metal-poor populations found in Local Group faint dwarf galaxies, and the metal-rich component of the Galactic Bulge, for example. An overview of several fundamental predictions of stellar evolution over the full metallicity range of BaSTI is presented, together with comparisons with literature calculations at $Z = 10^{-5}$ and $Z = 0.05$.

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Rubidium abundances in the globular clusters NGC 6752, NGC 1904 and NGC 104 (47 Tuc)

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Large star-to-star variations of the abundances of proton-capture elements, such as Na and O, in globular clusters (GCs) are interpreted as the effect of internal pollution resulting from the presence of multiple stellar populations. To better constrain this scenario we investigate the abundance distribution of the heavy element rubidium (Rb) in NGC 6752, NGC 1904, and NGC 104 (47 Tuc). Combining the results from our sample with those in the literature, we found that Rb exhibits no star-to-star variations, regardless the cluster metallicity, with the possible intriguing, though very uncertain, exception of the metal-rich bulge cluster NGC 6388. If no star-to-star variations will be confirmed for all GCs, it implies that the stellar source of the proton-capture element variations must not have produced significant amounts of Rb. This element is observed to be enhanced at extremely high levels in intermediate-mass AGB (IM-AGB) stars in the Magellanic Clouds (i.e., at a metallicity similar to 47 Tuc and NGC 6388). This may present a challenge to this popular candidate polluter, unless the mass range of the observed IM-AGB stars does not participate in the formation of the second-generation stars in GCs. A number of possible solutions are available to resolve this conundrum, also given that the Magellanic Clouds observations are very uncertain and may need to be revised. The fast rotating massive stars scenario would not face this potential problem as the slow mechanical winds of these stars

during their main-sequence phase do not carry any Rb enhancements; however, these candidates face even bigger issues such as the production of Li and the close over-imposition with core-collapse supernova timescales. Observations of Sr, Rb, and Zr in metal-rich clusters such as NGC 6388 and NGC 6441 are sorely needed to clarify the situation.

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Constraints on common envelope magnetic fields from observations of jets in planetary nebulæ

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The common envelope (CE) interaction describes the swallowing of a nearby companion by a growing, evolving star. CEs that take place during the asymptotic giant branch phase of the primary and may lead to the formation of a planetary nebula (PN) with a post-CE close binary in the middle. We have used published observations of masses and kinematics of jets in four post-CE PN to infer physical characteristics of the CE interaction. In three of the four systems studied, Abell 63, ETHOS 1 and the Necklace PN, the kinematics indicate that the jets were launched a few thousand years before the CE and we favour a scenario where this happened before Roche lobe overflow, although better models of wind accretion and wind Roche lobe overflow are needed. The magnetic fields inferred to launch pre-CE jets are of the order of a few Gauss. In the fourth case, NGC 6778, the kinematics indicate that the jets were launched about 3000 years after the CE interaction. Magnetic fields of the order of a few hundreds to a few thousands Gauss are inferred in this case, approximately in line with predictions of post-CE magnetic fields. However, we remark that in the case of this system, it is impossible to find a reasonable scenario for the formation of the two jet pairs observed: the small orbital separation would preclude the formation of even one accretion disk able to supply the necessary accretion rate to cause the observed jets.

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Multiple fast molecular outflows in the PPN CRL 618

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CRL 618 is a well-studied pre-planetary nebula. It has multiple highly collimated optical lobes, fast molecular outflows along the optical lobes, and an extended molecular envelope that consists of a dense torus in the equator and a tenuous round halo. Here we present our observations of this source in CO $J = 3$–2 and HCN $J = 4$–3 obtained with the Submillimeter Array at up to $\sim 0\farcs3$ resolutions. We spatially resolve the fast molecular-outflow region previously detected in CO near the central star and find it to be composed of multiple outflows that have similar dynamical ages, and are oriented along the different optical lobes. We also detect fast molecular outflows further away from the central star near the tips of the extended optical lobes and a pair of equatorial outflows inside the dense torus. We find that two episodes of bullet ejections in different directions are needed, one producing the fast molecular outflows near the central star, and one producing the fast molecular outflows near the tips of the extended optical lobes. One possibility to launch these bullets is the magneto-rotational explosion of the stellar envelope.

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K_s-band luminosity evolution of the asymptotic giant branch population based on star clusters in the Large Magellanic Cloud

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We present a study of K_s-band luminosity evolution of the asymptotic giant branch (AGB) population in simple stellar systems using star clusters in the Large Magellanic Cloud (LMC). We determine physical parameters of LMC star clusters including center coordinates, radii, and foreground reddenings. Ages of 83 star clusters are derived from isochrone fitting with the Padova models, and those of 19 star clusters are taken from the literature. The AGB stars in 102 star clusters with log(age) = 7.3–9.5 are selected using near-infrared color magnitude diagrams based on 2MASS photometry. Then we obtain the K_s-band luminosity fraction of AGB stars in these star clusters as a function of ages. The K_s-band luminosity fraction of AGB stars increases, on average, as age increases from log(age) $\sim$ 8.0, reaching a maximum at log(age) $\sim$ 8.5, and it decreases thereafter. There is a large scatter in the AGB luminosity fraction for given ages, which is mainly due to stochastic effects. We discuss this result in comparison with five simple stellar population models. The maximum K_s-band AGB luminosity fraction for bright clusters is reproduced by the models that expect the value of 0.7–0.8 at log(age) = 8.5–8.7. We discuss the implication of our results with regard to the study of size and mass evolution of galaxies.

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A synchrotron jet from a post-AGB star

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The evolution of low- and intermediate-initial-mass stars beyond the asymptotic giant branch (AGB) remains poorly understood. High-velocity outflows launched shortly after the AGB phase are thought to be the primary shaping mechanism of bipolar and multipolar planetary nebulæ (PNe). However, little is known about the launching and driving mechanism for these jets, whose momentum and energy often far exceed the energy that can be provided by radiation pressure alone. Here, we report direct evidence of a magnetically collimated jet shaping the bipolar morphology of the circumstellar envelope of a post-AGB star. We present radio continuum observations of the post-AGB star IRAS 15445−5449 (OH 326.5−0.4) which has water masers tracing a fast bipolar outflow. Our observations confirm the earlier observed steep negative spectral index of the spectral energy distribution (SED) above $\sim$ 3 GHz, and resolve, for the first time, the emission to originate from a radio jet, proving the existence of such jets around a post-AGB star. The SED is consistent with a synchrotron jet embedded in a sheath of thermal electrons. We find a close correspondence between the extent and direction of the synchrotron jet and the bipolar shape of the object observed at other wavelengths, suggesting that the jet is responsible for the source morphology. The jet is collimated by a magnetic field of the order of mG at almost 7000 au from the central star. We recover observations from the ATCA archive that indicate that the emission measure of the thermal component has increased by a factor of three between 1998 and 2005 after which it has remained constant. The short timescale evolution of the radio emission suggests a short lifetime for the jet. The observations of a synchrotron jet from a post-AGB star with characteristics similar to those from protostars and young stellar objects, for instance, suggest that magnetic launching and collimation is a common feature of astrophysical jets.

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Conference Paper

Method of running sines: modeling variability in long-period variables

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We review one of complementary methods for time series analysis – the method of "Running Sines". "Crash tests" of the method include signals with a large period variation and with a large trend. The method is most effective for "nearly period" signals, which exhibit "wavy shape" with a "cycle length" varying within few dozen per cent (i.e. oscillations of low coherence). This is a typical case for brightness variations of long-period pulsating variables and resembles QPO (Quasi-Periodic Oscillations) and TPO (Transient Periodic Oscillations) in interacting binary stars – cataclysmic variables, symbiotic variables, low-mass X-Ray binaries etc. General theory of "running approximations" was described by Andronov (1997, A&AS, 125, 207), one of realizations of which is the method of "running sines". The method is related to Morlet-type wavelet analysis improved for irregularly spaced data (Andronov, 1998, KFNT, 14, 490; 1999, sss conf, 57), as well as to a classical "running mean" (= "moving average"). The method is illustrated by an application to a model signal with strongly variable period, as well as to a semi-regular variable AF Cyg. Some other stars studied with this method are discussed, e.g., RU And (switching between "Mira-type" large amplitude oscillations and time intervals of "constancy"), intermediate polars MU Cam (1RXS J062518.2+733433) and BG CMi, magnetic dwarf nova DO Dra, symbiotic stars UV Aur and V1329 Cyg.

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Available from arXiv:1308.1129

Announcements

Fizeau exchange visitors program in optical interferometry – call for applications

Dear colleagues!

The Fizeau exchange visitors program in optical interferometry funds (travel and accommodation) visits of researchers to an institute of his/her choice (within the European Community) to perform collaborative work and training on one of the active topics of the European Interferometry Initiative. The visits will typically last for one month, and strengthen the network of astronomers engaged in technical, scientific and training work on optical/infrared interferometry. The program is open for all levels of astronomers (Ph.D. students to tenured staff). Applicants are strongly encouraged to seek also partial support from their home or host institutions.

The deadline for applications is September 15. Fellowships can be awarded for missions starting in November 2013.

Further informations and application forms can be found at www.european-interferometry.eu

The program is funded by OPTICON/FP7.

Please distribute this message also to potentially interested colleagues outside of the your community!

Looking forward to your applications,
Josef Hron & Laszlo Mosoni
(for the European Interferometry Initiative)

See also www.european-interferometry.eu

Why Galaxies Care About AGB Stars III
Vienna, July 28 – August 1, 2014

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Hans Olofsson and Franz Kerschbaum on behalf of SOC and LOC

See also http://www.univie.ac.at/galagb/