Dear Colleagues,

It is a pleasure to present you the 180th issue of the AGB Newsletter. Those who are interested in the use of AGB stars, planetary nebulae and white dwarfs to determine the structures and histories of galaxies will enjoy the many related works that were posted this month. There are also a couple of fundamental works, such as the molecular data presented by the UCL group and the reaction rate of the $\alpha$ capture by neon which provides the neutrons for s-process synthesis, as well as some evidence for the (already suspected) composite nature of dust grains. Some more unusual contributions include the use of a solar observatory to find and characterise long-period variables, and amateurs finding the largest planetary nebula in the sky; but there are also those "good old" CW Leo and Betelgeuse.

There seem to be lots of jobs going around in Belgium these days: this time it concerns a post-doctoral position in Brussels and a Ph.D. place in Leuven.

The next issue is planned to be distributed on the 1st of August.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month’s thought-provoking statement is:

*If we sat inside an old planetary nebula, would we notice it?*

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)
Near-infrared spectroscopy of post-starburst galaxies: a limited impact of TP-AGB stars on galaxy SED

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We present VLT–ISAAC NIR spectro-photometric observations of 16 post-starburst (PSB) galaxies aimed at constraining the debated influence of TP-AGB stars on the SED of galaxies with stellar ages between 0.5 and 2 Gyr, hence critical for high-redshift studies. PSB galaxies have negligible current star formation and a SED dominated by the stellar population formed in a recent (< 2 Gyr) burst. By spectroscopically selecting PSB galaxies with mean luminosity-weighted ages between 0.5 and 1.5 Gyr and a broad range of metallicities, we explore the parameter space over which the relative energy output of TP-AGB stars peaks. A key feature of the present study is that we target galaxies at $z \sim 0.2$, so that two main spectral features of TP-AGB stars (C-molecule band-head drops at 1.41 and 1.77 $\mu$m, blended with strong telluric absorption features, hence hardly observable from the ground at $z \sim 0$) move inside the H and K atmospheric windows and can be constrained for the first time to high accuracy. Our observations provide key constraints to stellar population synthesis models. Our main results are: i) the NIR regions around 1.41 and 1.77 $\mu$m (rest-frame) are featureless for all galaxies in our sample at variance with the Maraston (2005) ”TP-AGB heavy” models, which exhibit marked drops there; ii) no flux boosting is observed in the NIR: the optical-NIR SEDs of our PSB galaxies are generally consistent with Bruzual & Charlot (2003) simple stellar populations (SSP) of corresponding light-weighted ages and metallicities, but cannot be reproduced using Maraston (2005) SSPs. Possible systematic effects, including biases due to finite and different spectroscopic apertures, dust attenuation and, more importantly, the mixing of the pure post-burst stellar population with an old underlying component, are analysed and shown not to be able to reconcile observations and ”TP-AGB heavy” models.

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CD$-62^\circ$1346: an extreme halo or hypervelocity CH star?

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Context: High-velocity halo stars provide important information about the properties of the extreme Galactic halo. The study of unbound and bound Population II stars permits us to better estimate the mass of the halo.

Aims: We carried out a detailed spectroscopic and kinematic study and have significantly refined the distance and the evolutionary state of the star.

Methods: Its 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.

Results: We found that CD$-62^\circ$1346 is a metal-poor ([Fe/H] = −1.6) evolved giant star with $T_{\text{eff}} = 5300$ K and $\log g = 1.7$. The star exhibits high carbon and s-element abundances typical of CH stars. It is also a lead star. Our kinematic analysis of its 3D space motions shows that this star has a highly eccentric ($e = 0.91$) retrograde orbit with
an apogalactic distance of \( \sim 100 \text{ kpc} \), exceeding by a factor of two the distance to the Magellanic Clouds. The star travels with very high velocity relative to the Galactocentric reference frame \( (v_{\text{GRF}} = 570 \text{ km s}^{-1}) \).

**Conclusions:** CD − 62°1346 is an evolved giant star and not a subgiant star, as was considered earlier. Whether it is bound or unbound to the Galaxy depends on the assumed mass and on the adopted Galactic potential. We also show that the star HD 5223 is another example of a high-velocity CH star that exceeds the Galactic escape velocity. Possible origins of these two high-velocity stars are briefly discussed. CD − 62°1346 and HD 5223 are the first red giant stars to join the restricted group of hypervelocity stars.

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**The rovibrational spectrum of BeH, MgH and CaH at high temperatures in the \( X^2\Sigma^+ \) state: a theoretical study**

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Accurate line lists for three molecules, BeH, MgH and CaH, in their ground electronic states are presented. These line lists are suitable for temperatures relevant to exoplanetary atmospheres and cool stars (up to 2000 K). A combination of empirical and ab initio methods is used. The rovibrational energy levels of BeH, MgH and CaH are computed using the programs Level and DPotFit in conjunction with ‘spectroscopic’ potential energy curves (PECs). The PEC of BeH is taken from the literature, while the PECs of CaH and MgH are generated by fitting to the experimental transition energy levels. Both spin-rotation interactions (except for BeH, for which it is negligible) and non-adiabatic corrections are explicitly taken into account. Accurate line intensities are generated using newly computed ab initio dipole moment curves for each molecule using high levels of theory. Full line lists of rotation-vibration transitions for \(^9\)BeH, \(^24\)MgH, \(^25\)MgH, \(^26\)MgH and \(^40\)CaH are made available in an electronic form as supplementary data to this article and at www.exomol.com.

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**The age of the Milky Way inner Halo**

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The Milky Way galaxy is observed to have multiple components with distinct properties, such as the Bulge, Disk, and Halo. Unraveling the assembly history of these populations provides a powerful test to the theory of galaxy formation and evolution, but is often restricted due to difficulties in measuring accurate stellar ages for low mass, hydrogen-burning stars. Unlike these progenitors, the "cinders" of stellar evolution, white dwarf stars, are remarkably simple objects and their fundamental properties can be measured with little ambiguity from spectroscopy. Here I report observations of newly formed white dwarf stars in the Halo of the Milky Way, and a separate analysis of archival data on white dwarfs in the well-studied 12.5 billion year old globular cluster Messier 4. From this, I measure the mass distribution of the remnants and invert the stellar evolution process to develop a new relation that links this final stellar mass to the mass of their immediate progenitors, and therefore to the age of the parent population. By applying this technique to a small sample of four nearby and kinematically-confirmed Halo white dwarfs, I measure the age of local field Halo stars to be \( 11.4 \pm 0.7 \) billion years. This age is directly tied to the globular cluster age scale, on which the oldest clusters formed 13.5 billion years ago. Future (spectroscopic) observations of newly formed white dwarfs in the Milky Way Halo can be used to reduce the present uncertainty, and to probe relative differences between the formation time of the last clusters and the inner Halo.

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ExoMol: molecular line lists for exoplanet and other atmospheres

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The discovery of extrasolar planets is one of the major scientific advances of the last two decades. Hundreds of planets have now been detected and astronomers are beginning to characterise their composition and physical characteristics. To do this requires a huge quantity of spectroscopic data most of which is not available from laboratory studies. The ExoMol project will offer a comprehensive solution to this problem by providing spectroscopic data on all the molecular transitions of importance in the atmospheres of exoplanets. These data will be widely applicable to other problems and will be used for studies on cool stars, brown dwarfs and circumstellar environments. This paper lays out the scientific foundations of this project and reviews previous work in this area. A mixture of first principles and empirically-tuned quantum mechanical methods will be used to compute comprehensive and very large rotation-vibration and rotation-vibration-electronic (rovibronic) line lists. Methodologies will be developed for treating larger molecules such as methane and nitric acid. ExoMol will rely on these developments and the use of state-of-the-art computing.

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Temperature-dependent molecular absorption cross sections for exoplanets and other atmospheres

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Exoplanets, and in particular hot ones such as hot Jupiters, require a very significant quantities of molecular spectroscopic data to model radiative transport in their atmospheres or to interpret their spectra. This data is commonly provided in the form of very extensive transition line lists. The size of these line lists is such that constructing a single model may require the consideration of several billion lines. We present a procedure to simplify this process based on the use of cross sections. Line lists for water, H⁺³, HCN /HNC and ammonia have been turned into cross sections on a fine enough grid to preserve their spectroscopic features. Cross sections are provided at a fixed range of temperatures and an interpolation procedure which can be used to generate cross sections at arbitrary temperatures is described. A web-based interface (www.exomol.com/xsec) has been developed to allow astronomers to download cross sections at specified temperatures and spectral resolution. Specific examples are presented for the key water molecule.

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and from www.exomol.com/xsec

Is Mira a magneto-dusty rotator?

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We investigate the possibility that a magnetic field may be present in the star oCeti (hereafter, Mira) and that the field plays a role in the star’s mass loss. The model presented here is an application of an earlier derived theory that has been successfully employed for intermediate and high-mass evolved stars, and is now extended to the low-mass end. The modelling shows that it is possible to obtain a hybrid magnetohydrodynamic-dust-driven wind scenario for Mira, in which the role of a magnetic field in the equatorial plane of the star is dynamically important for producing a stellar wind. The wind velocity and the temperatures obtained from the model appear consistent with findings elsewhere.

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We build a sample of distant ($D > 80$ kpc) stellar Halo stars with measured radial velocities. Faint ($20 < g < 22$) candidate blue horizontal branch (BHB) stars were selected using the deep, but wide, multi-epoch Sloan Digital Sky Survey photometry. Follow-up spectroscopy for these A-type stars was performed using the VLT–FORS2 instrument. We classify stars according to their Balmer line profiles, and find 7 are bona fide BHB stars and 31 are blue stragglers (BS). Owing to the magnitude range of our sample, even the intrinsically fainter BS stars can reach out to $D \sim 90$ kpc. We complement this sample of A-type stars with intrinsically brighter, intermediate-age, asymptotic giant branch stars. A set of 4 distant cool carbon stars is compiled from the literature and we perform spectroscopic follow-up on a further 4 N-type carbon stars using the WHT–ISIS instrument. Altogether, this provides us with the largest sample to date of individual star tracers out to $r \sim 150$ kpc. We find that the radial velocity dispersion of these tracers falls rapidly at large distances and is surprisingly cold ($\sigma_r \approx 50–60$ km s$^{-1}$) between 100–150 kpc. Relating the measured radial velocities to the mass of the Milky Way requires knowledge of the (unknown) tracer density profile and anisotropy at these distances. Nonetheless, by assuming the stellar Halo stars between 50–150 kpc have a moderate density fall-off (with power-law slope $\alpha < 5$) and are on radial orbits ($\sigma_{\tau}/\sigma_r < 1$), we infer that the mass within 150 kpc is less than $10^{12} M_\odot$ and suggest it probably lies in the range $(5–10) \times 10^{11} M_\odot$. We discuss the implications of such a low mass for the Milky Way.

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STEREO observations of long period variables

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Observations from the Heliospheric Imagers (HI-1) on both the STEREO spacecraft have been analysed to search for very long period large amplitude stellar variability, finding 6 new candidates. A total of 85 objects, mostly previously known Mira variables, were found to show convincing variability on time scales of over a hundred days. These objects range in peak brightness from about 4th magnitude to 10th magnitude in $R$ and have periods between about 170 days and 490 days. There is a period gap between 200 and 300 days where no objects were found and this is discussed. 15 of the Miras in the sample are previously recorded as having variable periods and the possibility for these and 2 other stars to have undergone a period change or to be irregular is discussed. In addition to the 6 stars in the sample not previously recorded as variable, another 7 are recorded as variable but with no classification. Our period determination is the first to be made for 19 of these 85 stars. The sample represents a set of very long period variables that would be challenging to monitor from the Earth, or even from Earth orbit, owing to their position on the Ecliptic Plane and that their periods are often close to a year or an integer fraction thereof. The possibility for the new candidates to possess circumstellar shells is discussed.

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The structure of the planetary nebula NGC 2371 in the visible and mid-infrared

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We investigate the structure of the planetary nebula (PN) NGC 2371 using [O\textsc{iii}] 5007 imaging taken with the Jacobus Kapteyn 1.0 m telescope, and [N\textsc{ii}] 6584, [O\textsc{iii}] 5007 and H\textalpha{} results acquired with the Hubble Space Telescope (HST). These are supplemented with archival mid-infrared (MIR) observations taken with the Spitzer Space Telescope (Spitzer). We note the presence of off-axis low-ionization spokes along a PA of 65°, and associated collars of enhanced [O\textsc{iii}] emission. The spokes appear to consist of dense condensations having low-excitation tails, possibly arising due to UV shadowing and/or ram-pressure stripping of material. Line ratios imply that most of the emission arises through photo-ionisation, and is unlikely to derive from post-shock cooling regions. An analysis of these features in the MIR suggests that they may also be associated with high levels of emission from polycyclic aromatic hydrocarbons (PAHs), together with various permitted and forbidden line transitions. Such high levels of PAH emission, where they are confirmed, may develop as a result of preferentially enhanced FUV pumping of the molecules, or shattering of larger grains within local shocks. Although H\textsubscript{2} emission may also contribute to these trends, it is argued that shock-excited transitions would lead to markedly differing results. We finally note that thin filaments and ridges of [O\textsc{iii}] emission may indicate the presence of shock activity at the limits of the interior envelope, as well as at various positions within the shell itself. We also note that radially increasing fluxes at 3.6, 5.8 and 8.0 \(\mu\)m, relative to the emission at 4.5 \(\mu\)m, may arise due to enhanced PAH emission in external photo-dissociative regions (PDRs).

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The size, luminosity and motion of the extreme carbon star IRC +10\textdegree{}216 (CW Leonis)

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Very Large Array observations of the extreme carbon star IRC +10\textdegree{}216 at 7 mm wavelength with 40 milli-arcsecond resolution resolve the object’s radio emission, which forms an almost round uniform disk of 83 milli arcseconds diameter, corresponding to 11 AU (for an assumed distance of 130 pc). We find a brightness temperature of 1635 K for the radio photosphere. Since the emission is optically thick, we can directly estimate IRC +10\textdegree{}216’s average luminosity, which is 8640 L\textsubscript{\odot}. This value is in excellent agreement with what is predicted from the period–luminosity relation for carbon-rich Miras. Assuming an effective temperature of 2750 K for IRC +10\textdegree{}216, it implies an optical photospheric diameter of 3.8 AU. Our precise determination of IRC +10\textdegree{}216’s proper motion fits the picture presented by far-ultraviolet and far-infrared wavelength observations of its interaction region with the interstellar medium (its "astrosphere"): the star moves roughly in the direction expected from the morphology of the termination shock and its astrotail structures. Calculation of its three dimensional velocity and an analysis of the kinematics of its surrounding interstellar medium (ISM) suggest an appreciable relative velocity of 42 km s\textsuperscript{–1}, which is about half the value discussed in recent studies. This suggests a lower (time-averaged) mass-loss rate and/or a higher ISM density than previously assumed.

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Reaction rates for the s-process neutron source $^{22}$Ne+$\alpha$

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The $^{22}$Ne($\alpha$,n)$^{25}$Mg reaction is an important source of neutrons for the s-process. In massive stars responsible for the weak component of the s-process, $^{22}$Ne($\alpha$,n)$^{25}$Mg is the dominant source of neutrons, both during core helium burning and in shell carbon burning. For the main s-process component produced in Asymptotic Giant Branch (AGB) stars, the $^{13}$C($\alpha$,n)$^{16}$O reaction is the dominant source of neutrons operating during the interpulse period, with the $^{22}$Ne+\alpha source affecting mainly the s-process branchings during a thermal pulse. Rate uncertainties in the competing $^{22}$Ne($\alpha$,n)$^{25}$Mg and $^{22}$Ne($\alpha$,\gamma)$^{26}$Mg reactions result in large variations of s-process nucleosynthesis. Here, we present up-to-date and statistically rigorous $^{22}$Ne+$\alpha$ reaction rates using recent experimental results and Monte Carlo sampling. Our new rates are used in post-processing nucleosynthesis calculations both for massive stars and AGB stars. We demonstrate that the nucleosynthesis uncertainties arising from the new rates are dramatically reduced in comparison to previously published results, but several ambiguities in the present data must still be addressed. Recommendations for further study to resolve these issues are provided.

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A phenomenological model for the X-ray spectrum of nova V2491 Cygni

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The X-ray flux of nova V2491 Cyg reached a maximum some forty days after optical maximum. The X-ray spectrum at that time, obtained with the RGS of XMM–Newton, shows deep, blue-shifted absorption by ions of a wide range of ionization. We show that the deep absorption lines of the X-ray spectrum at maximum, and those observed nine days later, are well described by a phenomenological model with emission from a central blackbody and from a collisionally ionized plasma (CIE). The blackbody spectrum (BB) is absorbed by three main highly ionized expanding shells; the CIE and BB are absorbed by cold circumstellar and interstellar matter that includes dust. The outflow density does not decrease monotonically with distance. The abundances of the shells indicate that they were ejected from an O–Ne white dwarf. We show that the variations on time scales of hours in the X-ray spectrum are caused by a combination of variation in the central source and in the column density of the ionized shells. Our phenomenological model gives the best description so far of the supersoft X-ray spectrum of nova V2491 Cyg, but underpredicts, by a large factor, the optical and ultraviolet flux. The X-ray part of the spectrum must originate from a very different layer in the expanding envelope, presumably much closer to the white dwarf than the layers responsible for the optical/ultraviolet spectrum. This is confirmed by the absence of any correlation between the X-ray and UV/optical observed fluxes.

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The A–X infrared bands of aluminum oxide in stars: search and new detections

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We describe a search for the A–X infrared bands of AlO with a view to better understand the characteristics of this radical. These bands are infrequently encountered in astronomical sources but surprisingly were very prominent in the spectra of two well-known, nova-like variables (V838 Mon and V4332 Sgr) thereby motivating us to explore the physical conditions necessary for their excitation. In this study, we present the detection of A–X bands in the spectra of 13 out of 17 stars, selected on the basis of their J–K colors as potential candidates for detection of these bands. The majority of the AlO detections are in AGB stars viz. 9 OH/IR stars, 2 Mira variables and 2 bright infrared sources. Our study shows that the A–X bands are fairly prevalent in sources with low temperature and O-rich environments. Interesting variation in strength of the AlO bands in one of the sources (IRAS18530+0817) is reported and the cause for this is examined. Possible applications of the present study are discussed in terms of the role of AlO in alumina dust formation, the scope for estimating the radioactive $^{26}\text{Al}$ content in AGB stars from the A–X bands, and providing possible targets for further mm/radio studies of AlO which has recently been discovered at millimeter wavelengths.

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Discovery of a new faint Northern Galactic planetary nebula

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We present the discovery of 6 nebular objects made by amateur astronomers. Four of these discoveries are clearly planetary nebulae (PNe), one is a possible PN, and another is a likely H II region. The bipolar nebula Ou 4 presents the largest angular extent ever found: over one degree on the sky! We consider various scenarios that could explain such a nebula. Ou 4 could be one of the nearest PNe known, though its possible PN nature will need confirmation.

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Elemental abundances in the ejecta of old classical novae from late-epoch Spitzer spectra

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We present \textit{Spitzer} Space Telescope mid-infrared IRS spectra, supplemented by ground-based optical observations, of the classical novae V1974 Cyg, V382 Vel, and V1494 Aql more than 11, 8, and 4 years after outburst respectively. The spectra are dominated by forbidden emission from neon and oxygen, though in some cases, there are weak signatures of magnesium, sulfur, and argon. We investigate the geometry and distribution of the late time ejecta by examination of the emission line profiles. Using nebular analysis in the low density regime, we estimate lower limits on the abundances in these novae. In V1974 Cyg and V382 Vel, our observations confirm the abundance estimates presented by other authors and support the claims that these eruptions occurred on ONe white dwarfs. We report the first detection of neon emission in V1494 Aql and show that the system most likely contains a CO white dwarf.

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Dust formation history of galaxies: a critical role of metallicity for the dust mass growth by accreting materials in the interstellar medium

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This paper investigate what is the main driver of the dust mass growth in the interstellar medium (ISM) by using a chemical evolution model of galaxy with metals (elements heavier than helium) in dust phase in addition to the total amount of metals. We consider asymptotic giant branch (AGB) stars, type II supernovae (SNe II) and the dust mass growth in the ISM as the sources of dust, and SN shocks as the destruction mechanism of dust. Further, to describe the dust evolution precisely, our model takes into account the age and metallicity (the ratio of metal mass to ISM mass) dependence of the sources of dust. We particularly focused on the dust mass growth, and found that the dust mass growth in the ISM is regulated by the metallicity. To quantify this aspect, we introduce a "critical metallicity", which is a metallicity at which the contribution of stars (AGB stars and SNe II) equals that of the dust mass growth in the ISM. If the star formation timescale is shorter, the value of the critical metallicity is higher, but the galactic age at which the metallicity reaches the critical metallicity is shorter. From observations, it was expected that the dust mass growth was the dominant source of dust in the Milky Way and dusty QSOs at high redshifts. By introducing the critical metallicity, it is clearly shown that the dust mass growth is the main source of dust in such galaxies with various star formation timescales and ages. The dust mass growth in the ISM is regulated by metallicity, and we stress that the critical metallicity works as an indicator to judge whether the grain growth in the ISM is dominant source of dust in a galaxy, especially because of the strong and nonlinear dependence on the metallicity.

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Seismic evidence for a rapidly rotating core in a lower-giant-branch star observed with *Kepler*

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Rotation is expected to have an important influence on the structure and the evolution of stars. However, the mechanisms of angular momentum transport in stars remain theoretically uncertain and very complex to take into account in stellar models. To achieve a better understanding of these processes, we desperately need observational constraints on the internal rotation of stars, which until very recently were restricted to the Sun. In this paper, we report the detection of mixed modes – i.e. modes that behave both as g modes in the core and as p modes in the envelope – in the spectrum of the early red giant KIC 7341231, which was observed during one year with the *Kepler* spacecraft. By performing an analysis of the oscillation spectrum of the star, we show that its non-radial modes are clearly split by stellar rotation and we are able to determine precisely the rotational splittings of 18 modes. We then find a stellar model that reproduces very well the observed atmospheric and seismic properties of the star. We use this model to perform inversions of the internal rotation profile of the star, which enables us to show that the core of the star is rotating at least five times faster than the envelope. This will shed new light on the processes of transport of angular momentum in stars. In particular, this result can be used to place constraints on the angular momentum coupling between the core and the envelope of early red giants, which could help us discriminate between the theories that have been proposed over the last decades.

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Constraining the structure and formation of the Galactic Bulge from a field in its outskirts. FLAMES–GIRAFFE spectra of \( \sim 400 \) red giants around \( (l, b) = (0^\circ, -10^\circ) \)

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\textbf{Context:} The presence of two stellar populations in the Milky Way bulge has been reported recently, based on observations of giant and dwarf stars in the inner and intermediate bulge.

\textbf{Aims:} We aim at studying the abundances and kinematics of stars in the outer Galactic Bulge, thereby providing additional constraints on formation models of the Bulge.

\textbf{Methods:} Spectra of 401 red giant stars in a field at \( (l, b) = (0^\circ, -10^\circ) \) were obtained with the FLAMES–GIRAFFE spectrograph at the VLT. Stars of luminosities down to below the two bulge redclumps are included in the data set. From these spectra we measure general metallicities, abundances of iron and the \( \alpha \)-elements, and radial velocities of the stars. The abundances are derived from an interpolation and fitting procedure within a grid of COMARCS model atmospheres and spectra. These measurements as well as photometric data are compared to simulations with the Besançon and TRILEGAL models of the Galaxy.

\textbf{Results:} We confirm the presence of two populations among our sample stars: i) a metal-rich one at \([M/H] \sim +0.3\), comprising about 30\% of the sample, with low velocity dispersion and low \( \alpha \)-abundance, and ii) a metal-poor population at \([M/H] \sim -0.6\) with high velocity dispersion and high \( \alpha \)-abundance. The metallicity difference between the two populations, a systematically and statistically robust figure, is \( \Delta[M/H] = 0.87 \pm 0.03 \). The metal-rich population could be connected to the Galactic Bar. We identify this population as the carrier of the double red clump feature. We do not find a significant difference in metallicity or radial velocity between the two red clumps, a small difference in metallicity being probably due to a selection effect and contamination by the metal-poor population. The velocity dispersion agrees well with predictions of the Besançon Galaxy model, but the metallicity of the “thick Bulge” model component should be shifted to lower metallicity by 0.2 to 0.3 dex to well reproduce the observations. We present evidence that the metallicity distribution function depends on the evolutionary state of the sample stars, suggesting that enhanced mass loss preferentially removes metal-rich stars. The enhancement in \( \alpha \)-elements decreases with increasing metallicity, a plateau at low metallicity is however lacking in our data.

\textbf{Conclusions:} Our sample is consistent with the existence of two populations, one being a metal-rich bar, the second one being more like a metal-poor classical bulge with larger velocity dispersion.

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\begin{center}
\textbf{CARMA CO(\( J = 2–1 \)) observations of the circumstellar envelope of Betelgeuse}
\end{center}

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We report radio interferometric observations of the \( ^{12}\text{C}^{16}\text{O} \) 1.3-mm \( J = 2–1 \) emission line in the circumstellar envelope of the M supergiant \( \alpha \) Ori and have detected and separated both the S1 and S2 flow components for the first time.
Observations were made with the Combined Array for Research in Millimeter-wave Astronomy (CARMA) interferometer in the C, D, and E antenna configurations. We obtain good $u - v$ coverage (5–280 k$\lambda$) by combining data from all three configurations allowing us to trace spatial scales as small as 0".9 over a 32" field of view. The high spectral and spatial resolution C configuration line profile shows that the inner S1 flow has slightly asymmetric outflow velocities ranging from $-9.0$ km s$^{-1}$ to $+10.6$ km s$^{-1}$ with respect to the stellar rest frame. We find little evidence for the outer S2 flow in this configuration because the majority of this emission has been spatially-filtered (resolved out) by the array. We also report a SOFIA–GREAT CO($J=12-11$) emission line profile which we associate with this inner higher excitation S1 flow. The outer S2 flow appears in the D and E configuration maps and its outflow velocity is found to be in good agreement with high resolution optical spectroscopy of K i obtained at the McDonald Observatory. We image both S1 and S2 in the multi-configuration maps and see a gradual change in the angular size of the emission in the high absolute velocity maps. We assign an outer radius of 4" to S1 and propose that S2 extends beyond CARMA’s field of view (32" at 1.3 mm) out to a radius of 17" which is larger than recent single-dish observations have indicated. When azimuthally averaged, the intensity fall-off for both flows is found to be proportional to $R^{-1}$, where $R$ is the projected radius, indicating optically thin winds with $\rho \propto R^{-2}$.

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BD $+48^\circ740$ – Li overabundant giant star with a planet. A case of recent engulfment?

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We report the discovery of a unique object, BD $+48^\circ740$, a lithium overabundant giant with $A$(Li) = 2.33 ± 0.04 (where $A$(Li) = $\log n_{Li}/n_{H} + 12$), that exhibits radial velocity (RV) variations consistent with a 1.6 M$\odot$ companion in a highly eccentric, $e = 0.67 \pm 0.17$ and extended, $a = 1.89$ AU ($P = 771$ d), orbit. The high eccentricity of the planet is uncommon among planetary systems orbiting evolved stars and so is the high lithium abundance in a giant star. The ingestion by the star of a putative second planet in the system originally in a closer orbit, could possibly allow for a single explanation to these two exceptional facts. If the planet candidate is confirmed by future RV observations, it might represent the first example of the remnant of a multiple planetary system possibly affected by stellar evolution.

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3-D modelling of the collimated bipolar outflows of compact planetary nebulae with WR-type central stars

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We present high-resolution, long-slit spectroscopic observations of five compact $(\leq 10^\prime\prime)$ planetary nebulae located close to the Galactic Bulge region and for which no high spatial resolution images are available. The data have been drawn from the San Pedro Mártir kinematic catalogue of Galactic planetary nebulae (López et al. 2012). The central star in four of these objects (M1-32, M2-20, M2-31 and M3-15) is of WR type and the fifth object (M2-42) has a wels type nucleus. These observations reveal the presence in all of them of a dense and thick equatorial torus-like component and high-speed, collimated, bipolar outflows. The code SHAPE is used to investigate the main morphokinematic characteristics and reproduce the 3-D structure of these objects assuming a cylindrical velocity field for the
bipolar outflows and a homologous expansion law for the torus/ring component. The deprojected expansion velocities of the bipolar outflows are found to be in the range of 65 to 200 km s\(^{-1}\), whereas the torus/ring component shows much slower expansion velocities, in the range of 15 to 25 km s\(^{-1}\). It is found that these planetary nebulae have very similar structural components and the differences in their emission line spectra derive mostly from their different projections on the sky. The relation of their morpho-kinematic characteristics with the WR-type nuclei deserves further investigation.

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Discovery of a TiO emission band in the infrared spectrum of the S star NP Aurigae

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We report on the discovery of an infrared emission band in the \textit{Spitzer} spectrum of the S-type AGB star NP Aurigae that is caused by TiO molecules in the circumstellar environment. We modeled the observed emission to derive the temperature of the TiO molecules (\(\approx 600\) K), an upper limit on the column density (\(\approx 10^{17.25}\) cm\(^{-2}\)) and a lower limit on the spatial extent of the layer that contains these molecules. (\(\approx 4.6\) stellar radii). This is the first time that this TiO emission band is observed. A search for similar emission features in the sample of S-type stars yielded two additional candidates. However, owing to the additional dust emission, the identification is less stringent. By comparing the stellar characteristics of NP Aur to those of the other stars in our sample, we find that all stars with TiO emission show large-amplitude pulsations, s-process enrichment, and a low C/O ratio. These characteristics might be necessary requirements for a star to show TiO in emission, but they are not sufficient.

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The irregular variable KU Her: The light and period variations

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We present CCD photometric observations of the slow irregular type variable KU Her. We have also used observations from the ASAS Database and the AAVSO International Database. The V-band observations span eight years from August of 2002 to September of 2010. The length and density of the data enable us to look for variations on time scales ranging from days to years. The V-band observations of KU Her are analysed to derive periodicity. This analysis was an approach to find the fundamental periods of the variability of KU Her. Analysis of the KU Her light variation indicates a complex combination of different periods. Five main and three harmonic periods are identified. In addition to the period analysis, we present the colour variations of the star.

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A study of high proper-motion white dwarfs I. Spectropolarimetry of a cool hydrogen-rich sample

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We conducted a spectropolarimetric survey of 58 high proper-motion white dwarfs which achieved uncertainties of \( \gtrsim 2 \) kG in the H\( \alpha \) line and \( \gtrsim 5 \) kG in the upper Balmer line series. The survey aimed at detecting low magnetic fields (\( \lesssim 100 \) kG) and helped identify the new magnetic white dwarfs NLTT 2219, with a longitudinal field \( B_l = -97 \) kG, and NLTT 10480 (\( B_l = -212 \) kG). Also, we report the possible identification of a very low-field white dwarf with \( B_l = -4.6 \) kG. The observations show that \( \approx 5\% \) of white dwarfs harbour low fields (\( \sim 10 \) to \( \sim 10^2 \) kG) and that increased survey sensitivity may help uncover several new magnetic white dwarfs with fields below \( \sim 1 \) kG. A series of observations of the high field white dwarf NLTT 12758 revealed changes in polarity occurring within an hour possibly associated to an inclined, fast rotating dipole. Also, the relative strength of the \( \pi \) and \( \sigma \) components in NLTT 12758 possibly revealed the effect of a field concentration ("spot"), or, most likely, the presence of a non-magnetic white dwarf companion. Similar observations of NLTT 13015 also showed possible polarity variations, but without a clear indication of the timescale. The survey data also proved useful in constraining the chemical composition, age and kinematics of a sample of cool white dwarfs as well as in constraining the incidence of double degenerates.

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Molecular chemistry and the missing mass problem in planetary nebulae

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Detections of molecular lines, mainly from H\( \text{\textsubscript{2}} \) and CO, reveal molecular material in planetary nebulae. Observations of a variety of molecules suggest that the molecular composition in these objects differs from that found in interstellar clouds or in circumstellar envelopes. The success of the models, which are mostly devoted to explain molecular densities in specific planetary nebulae, is still partial however. The present study aims at identifying the influence of stellar and nebular properties on the molecular composition of planetary nebulae by means of chemical models. A comparison of theoretical results with those derived from the observations may provide clues to the conditions that favor the presence of a particular molecule. A self-consistent photoionization numerical code was adapted to simulate cold molecular regions beyond the ionized zone. The code was used to obtain a grid of models and the resulting column densities are compared with those inferred from observations. Our models show that the inclusion of an incident flux of X-rays is required to explain the molecular composition derived for planetary nebulae. We also obtain a more accurate relation for the \( N(\text{CO})/N(\text{H}\text{\textsubscript{2}}) \) ratio in these objects. Molecular masses obtained by previous works in the literature were then recalculated, showing that these masses can be underestimated by up to three orders of magnitude. We conclude that the problem of the missing mass in planetary nebulae can be solved by a more accurate calculation of the molecular mass.

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A unique isolated dwarf spheroidal galaxy at $D = 1.9$ Mpc

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We present a photometric and spectroscopic study of the unique isolated nearby dSph galaxy KKR 25. The galaxy was resolved into stars with HST/WFPC2 including old red giant branch and red clump. We have constructed a model of the resolved stellar populations and measured the star formation rate and metallicity as function of time. The main star formation activity period occurred about 12.6 to 13.7 Gyr ago. These stars are mostly metal-poor, with a mean metallicity $[\text{Fe/H}] \sim −1$ to $−1.6$ dex. About 60 per cent of the total stellar mass was formed during this event. There are indications of intermediate age star formation in KKR 25 between 1 and 4 Gyr with no significant signs of metal enrichment for these stars. Long-slit spectroscopy was carried out using the Russian 6-m telescope of the integrated starlight and bright individual objects in the galaxy. We have discovered a planetary nebula (PN) in KKR 25. This is the first known PN in a dwarf spheroidal galaxy outside the Local Group. We have measured its oxygen abundance $12 + \log(\text{O}/\text{H}) = 7.60 \pm 0.07$ dex and a radial velocity $v_{\text{hel}} = −79 \text{ km s}^{-1}$. We have analysed the stellar density distribution in the galaxy body. The galaxy has an exponential surface brightness profile with a central light depression. We discuss the evolutionary status of KKR 25, which belongs to a rare class of very isolated dwarf galaxies with spheroidal morphology.

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The Penn State–Toruń Centre for Astronomy Planet Search stars. I. Spectroscopic analysis of 348 red giants

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We present basic atmospheric parameters ($T_{\text{eff}}$, log $g$, $v_t$, and [Fe/H]) as well as luminosities, masses, radii and absolute radial velocities for 348 stars, presumably giants, from the ~1000 star sample observed within the Penn State–Toruń Centre for Astronomy Planet Search with the High Resolution Spectrograph of the 9.2-m Hobby–Eberly Telescope. The stellar parameters (luminosities, masses, radii) are key ingredients in proper interpretation of newly discovered low-mass companions while a systematic study of the complete sample will create a basis for future statistical considerations concerning low-mass companions appearance around evolved low and intermediate-mass stars. The atmospheric parameters were derived using a strictly spectroscopic method based on the LTE analysis of equivalent widths of Fe I and Fe II lines. With existing photometric data and the Hipparcos parallaxes we estimated stellar masses and ages via evolutionary tracks fitting. The stellar radii were calculated from either estimated masses and the spectroscopic log $g$ or from the spectroscopic $T_{\text{eff}}$ and estimated luminosities. The absolute radial velocities were obtained by cross-correlating spectra with a numerical template. We completed the spectroscopic analysis for 332 stars of which 327 were found to be giants. For the remaining 16 stars with incomplete data a simplified analysis was applied. The results show that our sample is composed of stars with effective temperatures ranging from 4055 K to 6239 K, and log $g$ between 1.39 and 4.78 (5 dwarfs were identified). The estimated luminosities ranging between log $L/L_\odot = −1.0$ and 3 lead to masses ranging from 0.6 to 3.4 M_⊙. Only 63 stars with masses larger than 2 M_⊙ were found. The radii of our stars range from 0.6 to 52 R_⊙ with vast majority between 9–11 R_⊙. The stars in our sample are generally less metal abundant than the Sun with median [Fe/H] = −0.15. The estimated uncertainties in the atmospheric parameters were found to be comparable to those reached in other studies. However, due to lack of precise parallaxes the stellar luminosities and, in turn, the masses are far less precise, within 0.2 M_⊙ in best cases, and 0.3 M_⊙ on average.

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Observational evidence for composite grains in an AGB outflow: MgS in the extreme carbon star LL Peg

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The broad 30 um feature in carbon stars is commonly attributed to MgS dust particles. However, reproducing the 30 um feature with homogeneous MgS grains would require much more sulfur relative to the solar abundance. Direct gas-phase condensation of MgS occurs at a low efficiency. Precipitation of MgS on SiC precursor grains provides a more efficient formation mechanism, such that the assumption of homogeneous MgS grains may not be correct. Using a Monte Carlo based radiative transfer code, we aim to model the 30 um feature of the extreme carbon star LL Peg with MgS dust particles. We find that for LL Peg this modeling is insensitive to the unknown MgS optical properties at λ < 10 μm. When MgS is allowed to be in thermal contact with amorphous carbon and SiC, the amount of MgS required to reproduce the strength of 30 μm feature is in agreement with the solar abundance of sulfur, thereby resolving the reported MgS mass problem. We conclude that MgS is a valid candidate to be the carrier of the 30 μm feature when it is part of a composite grain population that has optical properties representative of an ensemble of particle shapes.

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Conference Paper

Lithium destruction and production observed in red giant stars

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According to standard stellar evolution, lithium is destroyed throughout most of the evolution of low- to intermediate-mass stars. However, a number of evolved stars on the red giant branch (RGB) and the asymptotic giant branch (AGB) are known to contain a considerable amount of Li, whose origin is not always understood well. Here we present the latest development on the observational side to obtain a better understanding of Li-rich K giants (RGB), moderately Li-rich low-mass stars on the AGB, as well as very Li-rich intermediate-mass AGB stars possibly undergoing the standard hot bottom burning phase. These last ones probably also enrich the interstellar medium with freshly produced Li.

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Postdoctoral position in modelling of interacting binaries  
Institut d’Astronomie et d’Astrophysique, ULB, Brussels, Belgium

Applications are invited for a postdoctoral position at the Institute of Astronomy and Astrophysics (IAA) at the Université Libre de Bruxelles. The successful candidate will be working on the modeling of mass transfer in wide period binary systems. The research will involve 2D and 3D hydrodynamical simulations of mass transfer in wide (likely eccentric) low and intermediate mass binaries. One of the goals is to understand the $e$–log $P$ diagram of barium stars. This project will be done in collaboration with Prof. Alain Jorissen and Dr. Lionel Siess, and with the binary group at the IAA which is actively working on the development of a state-of-the-art Binary Stellar Evolution Code.

The Institute of Astronomy and Astrophysics has a strong expertise on binary evolution, with both theorists and observers working on evolved binaries. The successful candidate will be expected to perform hydrodynamical simulations on the university supercomputer and will be involved in the interpretation of ESA’s Herschel data.

The position can start any time from now and will extend till december 2014. The annual net salary will be in the range 25,000 to 30,000 euros depending on qualifications and experience. There are also funds for travel and computing. Applicants must have been awarded their PhD after 2006 and have strong experience in hydrodynamical calculations. Applicants should send a CV, list of publications, the details of three referees, and a three page research statement by email to lsiess@ulb.ac.be. The position will remain open until a suitable candidate is found.

See also http://www.astro.ulb.ac.be/~siess/Postdoc

PhD position  
Institute for Astronomy K.U. Leuven, Belgium

Description: The final evolutionary stages of stars are largely determined by ejection of mass from the stellar envelope. The mechanisms at work are thought to be understood in broad terms, but several major aspects remain elusive. Among those is the role of different kind of instabilities, which cause the mass outflows to be variable in time. It has now also become clear that the interaction of mass outflows with the pre-existing interstellar medium on the one hand substantially complicate the interpretation of observational data, but on the other hand provide a new tool to study the interstellar medium.

The project focuses on the interpretation of images and spectra obtained with the Herschel satellite of the mass outflows from evolved stars (AGB stars and massive supergiants). The aims are to reconstruct the mass-loss history of these objects and to understand the interaction of the outflows with the interstellar medium. Tools are the analysis of the Herschel data in the framework of the Herschel key program on evolved stars (MESS) and hydrodynamical simulations to be developed.

See also http://www.ster.kuleuven.be/vacancies

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