THE AGB NEWSLETTER

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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 146$^{\rm th}$ issue of the AGB Newsletter. The structure of the mantles of red giants is being simulated with 3-D numerical codes (Brun & Palacios) and probed by astero-seismology experiments (Miglio et al.). Several other works presented in this newsletter also deal directly with the mantles of red giants, so this is all very encouraging and makes one look forward to many exciting new results to be presented at the ESO workshop on the evolution of solar-mass stars in March next year (see the announcement at the end of this newsletter).

Our congratulations go to Marcelino Agúndez, for his thesis on the circumstellar envelope of IRC +10 216.

The next issue will be distributed on the 3$^{\rm rd}$ of October 2009; the deadline for contributions is the 2$^{\rm nd}$ of October.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

How typical is IRC +10 216?

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)

Probing populations of red giants in the galactic disk with CoRoT

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The detection with CoRoT of solar-like oscillations in nearly 800 red giants in the first 150-days long observational run paves the way for detailed studies of populations of galactic-disk red giants. We investigate which information on the observed population can be recovered by the distribution of the observed seismic constraints: the frequency of maximum oscillation power ($\nu_{\rm max}$) and the large frequency separation ($\Delta\nu$). We propose to use the observed distribution of $\nu_{\rm max}$ and of $\Delta\nu$ as a tool for investigating the properties of galactic red-giant stars through comparison with simulated distributions based on synthetic stellar populations. We can clearly identify the bulk of the red giants observed by CoRoT as red-clump stars, i.e. post-flash core-He-burning stars. The distribution of $\nu_{\rm max}$ and of $\Delta\nu$ gives us access to the distribution of the stellar radius and mass, and thus represent a most promising probe of the age and star formation rate of the disk, and of the mass-loss rate during the red-giant branch. CoRoT observations are supplying seismic constraints for the most populated class of He-burning stars in the galactic disk. This opens a new access gate to probing the properties of red-giant stars that, coupled with classical observations, promises to extend our knowledge of these advanced phases of stellar evolution and to add relevant constraints to models of composite stellar populations in the Galaxy.

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Available from arXiv:0908.0210

Spitzer detection of PAH and silicate features in post-AGB stars and young Planetary Nebulae

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We have observed a small sample of hot post-AGB stars with the InfraRed Array Camera (IRAC) and the InfraRed Spectrograph (IRS) on-board the *Spitzer Space Telescope*. The stars were selected from the literature on the basis of their far-Infrared excess (i.e., post-AGB candidates) and B spectral type (i.e., close to the ionization of the envelope). The combination of our IRAC observations with 2MASS and IRAS catalog data, along with previous radio observations in the cm range (where available) allowed us to model the SEDs of our targets and find that in almost all of them at least two shells of dust at different temperatures must be present, the hot dust component ranging up to 1000 K. In several targets grains larger than 1 μm are needed to match the far-IR data points. In particular, in IRAS 17423-1755 grains up to 100 μm must be introduced to match the emission in the mm range. We obtained IRS spectra to identify the chemistry of the envelopes and found that more than $^1/_3$ of the sources in our sample have mixed chemistry, showing both mid-IR bands attributed to Polycyclic Aromatic Hydrocarbons (PAH) and silicate features.

The analysis of the PAH features indicates that these molecules are located in the outflows, far away from the central stars. We consider the larger than expected percentage of mixed-chemistry targets as a selection bias towards stars with a disk or torus around them. Our results strengthen the current picture of mixed chemistry being due to the spatial segregation of different dust populations in the envelopes.

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Available from arXiv:0908.0638

Planetary Nebulae in Face-On Spiral Galaxies. II. Planetary Nebula Spectroscopy

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As the second step in our investigation of the mass-to-light ratio of spiral disks, we present the results of a spectroscopic survey of planetary nebulae (PNe) in five nearby, low-inclination galaxies: IC 342, M 74 (NGC 628), M 83 (NGC 5236), M 94 (NGC 4736), and M 101 (NGC 5457). Using 50 setups of the WIYN/Hydra and Blanco/Hydra spectrographs, and 25 observations with the Hobby-Eberly Telescope's Medium Resolution Spectrograph, we determine the radial velocities of 99, 102, 162, 127, and 48 PNe, respectively, to a precision better than 15 km s^{-1}. Although the main purpose of this data set is to facilitate dynamical mass measurements throughout the inner and outer disks of large spiral galaxies, our spectroscopy has other uses as well. Here, we co-add these spectra to show that to first order, the [O III] and Balmer line ratios of planetary nebulae vary little over the top ∼1.5 mag of the planetary nebula luminosity function. The only obvious spectral change occurs with [N II], which increases in strength as one proceeds down the luminosity function. We also show that typical [O III]-bright planetaries have $E(B-V) \sim 0.2$ mag of circumstellar extinction, and that this value is virtually independent of [O III] luminosity. We discuss the implications this has for understanding the population of PN progenitors.

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Available from arXiv:0908.0531

What can we learn about the kinematics of bright extragalactic planetary nebulae?

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We present high resolution spectroscopy in the [O III]λ5007 and Hα lines of bright planetary nebulae in the Milky Way bulge and the dwarf galaxies M 32, Fornax, Sagittarius, and NGC 6822 obtained at the Observatorio Astronómico Nacional in the Sierra San Pedro Mártir using the Manchester Echelle Spectrograph. We use the high signal-to-noise (S/N) observations of Milky Way bulge planetary nebulae to explore what kinematic information can be determined reliably when observing extragalactic planetary nebulae in the [O III]λ5007 line at modest S/N. We find that the intrinsic line widths measured in [O III]λ5007 and Hα are very similar. Over the range of S/N available in this sample, the line width we measure is independent of the S/N. Finally, deviations from a Gaussian line shape are small. Thus, the line width of the [O III]λ5007 line in bright extragalactic planetary nebulae should reflect the kinematics of most of the mass in the ionized nebular shell.

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Analysis of the Schmidt, Cohen & Margon (1980) features in the Red Rectangle nebula

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This study investigates the relationship between atmospheric extinction and the spectrum of the Red Rectangle nebula on scales of a few to a few tens of Å. It is found that the fine structure of the nebula's continuum short-ward of 6700 Å is similar to background spectra, and is thus determined either by atmospheric absorption or by light from HD 44179 scattered in the earth atmosphere.

Published in The Open Astronomy Journal
Available from arXiv:0908.3297

The expanding nebular remnant of the recurrent nova RS Ophiuchi (2006): II. Modeling of combined *Hubble Space Telescope* imaging and ground-based spectroscopy

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We report *Hubble Space Telescope* imaging, obtained 155 and 449 days after the 2006 outburst of the recurrent nova RS Ophiuchi, together with ground-based spectroscopic observations, obtained from the Observatorio Astronómico Nacional en San Pedro Mártir, Baja California, México and at the Observatorio Astrofísico Guillermo Haro, at Cananea, Sonora, México. The observations at the first epoch were used as inputs to model the geometry and kinematic structure of the evolving RS Oph nebular remnant. We find that the modeled remnant comprises two distinct co-aligned bipolar components; a low-velocity, high-density innermost (hour glass) region and a more extended, high-velocity (dumbbell) structure. This overall structure is in agreement with that deduced from radio observations and optical interferometry at earlier epochs. We find that the asymmetry observed in the west lobe is an instrumental effect caused by the profile of the *HST* filter and hence demonstrate that this lobe is approaching the observer. We then conclude that the system has an inclination to the line of sight of 39^{+1}_{-10} degrees. This is in agreement with the inclination of the binary orbit and lends support to the proposal that this morphology is due to the interaction of the outburst ejecta with either an accretion disk around the central white dwarf and/or a pre-existing red giant wind that is significantly denser in the equatorial regions of the binary than at the poles. The second epoch *HST* observation was also modeled. However, as no spectra were taken at this epoch, it is more difficult to constrain any model. Nevertheless, we demonstrate that between the two *HST* epochs the outer dumbbell structure seems to have expanded linearly. For the central (hour glass) region there may be evidence of deceleration, but it is harder to draw firm conclusions in this case.

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HD 77361: A new case of super Li-rich K giant with anomalous low $^{12}C/^{13}C$ ratio

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Results from high resolution spectroscopic analysis of HD 77361 are reported. The LTE analysis shows that HD 77361 is a K giant of atmospheric parameters: $T_{\rm eff} = 4580 \pm 75$ K, $\log g = 2.5 \pm 0.1$, and $\xi_{\rm t} = 1.40 \pm 0.5$ km s^{-1}. We found that the atmosphere of HD 77361 is highly enriched in Li with $\log \epsilon({\rm Li}) = 3.82 \pm 0.1$. With this finding the total number of super Li-rich K giants ($\log \epsilon({\rm Li}) \geq 3.3$ ISM value) known till date reached six. Contrary to first dredge-up, extra-deep mixing and the associated cool bottom processing, and other recent predictions for K giants on the RGB luminosity bump phase, HD 77361 shows very low value of $^{12}C/^{13}C = 4.3 \pm 0.5$ having, simultaneously, very large amount of Li. Also, HD 77361 is the only population I low luminosity ($\log L/L_{\odot} = 1.66 \pm 0.1$) low mass K giant ($M = 1.5 \pm 0.2$ M$_{\odot}$) among the known super Li-rich K giants that has a very low $^{12}C/^{13}C$ ratio. Results of HD 77361 further constrain our theoretical understanding of Li enhancement in the atmospheres of RGB stars.

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The impact of systematic uncertainties in stellar parameters on integrated spectra of stellar populations

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In this paper we investigate a hitherto unexplored source of potentially significant error in stellar population synthesis (SPS) models, caused by systematic uncertainties associated with the three fundamental stellar atmospheric parameters; effective temperature $T_{\rm eff}$, surface gravity g, and iron abundance [Fe/H]. All SPS models rely on calibrations of $T_{\rm eff}$, $\log g$ and [Fe/H] scales, which are implicit in stellar models, isochrones and synthetic spectra, and are explicitly adopted for empirical spectral libraries. We assess the effect of a mismatch in scales between isochrones and spectral libraries (the two key components of SPS models) and quantify the effects on 23 commonly used diagnostic line indices. We find that typical systematic offsets of 100 K in $T_{\rm eff}$, 0.15 dex in [Fe/H] and/or 0.25 dex in $\log g$ significantly alter inferred absolute ages of simple stellar populations (SSPs) and that in some circumstances, relative ages also change. Offsets in $T_{\rm eff}$, $\log g$ and [Fe/H] scales for a scaled-solar SSP produce deviations from the model which can mimic the effects of altering abundance ratios to non-scaled-solar chemical compositions, and could also be spuriously interpreted as evidence for a more complex population, especially when multiple-index or full-SED fitting methods are used. We stress that the behavior we find can potentially affect any SPS models, whether using full integrated spectra or fitting functions to determine line strengths. We present measured offsets in 23 diagnostic line indices and urge caution in the over-interpretation of line-index data for stellar populations.

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Long-term photometry and periods for 261 nearby pulsating M giants

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We present the results of a 5.5-year CCD photometric campaign that monitored 261 bright, southern, semi-regular

variables with relatively precise Hipparcos parallaxes. The data are supplemented with independent photoelectric observations of 34 of the brightest stars, including 11 that were not part of the CCD survey, and a previously unpublished long time-series of VZ Cam. Pulsation periods and amplitudes are established for 247 of these stars, the majority of which have not been determined before. All M giants with sufficient observations for period determination are found to be variable, with 87% of the sample (at $S/N \geq 7.5$) exhibiting multi-periodic behaviour. The period ratios of local SRVs are in excellent agreement with those in the Large Magellanic Cloud. Apparent K-band magnitudes are extracted from multiple NIR catalogues and analysed to determine the most reliable values. We review the effects of interstellar and circumstellar extinction and calculate absolute K-band magnitudes using revised Hipparcos parallaxes.

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The origin of the supersoft X-ray–optical/UV flux anticorrelation in the symbiotic binary AG Draconis

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Context: AG Draconis produces a strong supersoft X-ray emission. The X-ray and optical/UV fluxes are in a strict anticorrelation throughout the active and quiescent phases.
Aims: To identify the source of the X-ray emission and reveal the nature of the observed flux anticorrelation.
Methods: The X-ray and UV observations with XMM-Newton, far-UV spectroscopy from FUSE, low- and high-resolution IUE spectra and optical/near-IR spectroscopic and/or photometric observations. Modeling the spectral energy distribution and broad wings of the O VI 1032, 1038 and He II 1640 lines by the electron-scattering during the maximum of the 2003 burst, the following transition and quiescent phase.
Results: The X-ray–near-IR energy distribution at different levels of the star's brightness confirmed quantitatively the observed flux anticorrelation and showed that the optical bursts are associated to an increase of the nebular component of radiation. The profile-fitting analysis revealed a significant increase in the mean particle density around the hot star from $\sim 2.6 \times 10^{10}$ cm^{-3} during quiescent phase to $\sim 1.1 \times 10^{12}$ cm^{-3} during the burst.
Conclusion: The supersoft X-ray emission is produced by the white dwarf photosphere. The X-ray and far-UV fluxes make it possible to determine its temperature unambiguously. The supersoft X-ray–optical/UV flux anticorrelation is caused by the variable wind from the hot star. The enhanced hot star wind gives rise to the optical bursts by reprocessing high-energy photons from the Lyman continuum to the optical/UV.

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Numerical simulations of a rotating red giant star. I. Three-dimensional models of turbulent convection and associated mean flows

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With the development of one-dimensional stellar evolution codes including rotation and the increasing number of observational data for stars of various evolutionary stages, it becomes more and more possible to follow the evolution of the rotation profile and angular momentum distribution in stars. In this context, understanding the interplay between rotation and convection in the very extended envelopes of giant stars is very important considering that

all low- and intermediate-mass stars become red giants after the central hydrogen burning phase. In this paper, we analyze the interplay between rotation and convection in the envelope of red giant stars using three-dimensional numerical experiments. We make use of the Anelastic Spherical Harmonics code to simulate the inner 50% of the envelope of a low-mass star on the red giant branch. We discuss the organization and dynamics of convection, and put a special emphasis on the distribution of angular momentum in such a rotating extended envelope. To do so, we explore two directions of the parameter space, namely, the bulk rotation rate and the Reynolds number with a series of four simulations. We find that turbulent convection in red giant stars is dynamically rich, and that it is particularly sensitive to the rotation rate of the star. Reynolds stresses and meridional circulation establish various differential rotation profiles (either cylindrical or shellular) depending on the convective Rossby number of the simulations, but they all agree that the radial shear is large. Temperature fluctuations are found to be large and in the slowly rotating cases, a dominant $e_{\|} = 1$ temperature dipole influences the convective motions. Both baroclinic effects and turbulent advection are strong in all cases and mostly oppose one another.

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Available from http://www.iop.org/EJ/abstract/0004-637X/702/2/1078/

Conference Papers

IRSF/SIRIUS JHK$_s$ Near-Infrared Variable Star Survey in the Magellanic Clouds

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We carried out a NIR variable star survey toward the Large and Small Magellanic Clouds using the InfraRed Survey Facility (IRSF) at Sutherland, South African Astronomical Observatory. This survey project was initiated in December 2000, and since then, we kept monitoring a total area of 3 square degrees along the LMC bar and also an area of 1 square degree around the center of the SMC, sufficiently large to do statistical analysis and to make complete catalog of variable red giants in the Magellanic Clouds. The detection limits ($S/N = 10$) of the survey are 17.0, 16.5 and 15.5 mag at J, H and K$_s$, respectively. In this article, we present some results on infrared variables that are not detected by the previous optical surveys. We show that they do not fall on the standard period–K$_s$ magnitude relation for Mira-type variables pulsating in the fundamental mode.

Poster contribution, published in "Stellar Pulsation: Challenges for Theory and Observation", Eds. J. Guzik & P. Bradley
Available from arXiv:0907.5244

$T_{\rm eff}$ and $\log g$ dependence of velocity fields in M-stars

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We present an investigation of velocity fields in early to late M-type hydrodynamic stellar atmosphere models. These velocities will be expressed in classical terms of micro- and macro-turbulent velocities for usage in 1D spectral synthesis. The M-star model parameters range between $\log g$ of 3.0–5.0 and $T_{\rm eff}$ of 2500–4000 K. We characterize the $T_{\rm eff}$- and $\log g$-dependence of the hydrodynamical velocity fields in these models with a binning method, and for the determination of micro-turbulent velocities, the Curve of Growth method is used. The macro-turbulent velocities are

obtained by convolutions with Gaussian profiles. Velocity fields in M-stars strongly depend on $\log g$ and $T_{\rm eff}$. Their velocity amplitudes increase with decreasing $\log g$ and increasing $T_{\rm eff}$. The 3D hydrodynamical and 1D macro-turbulent velocities range from ~ 100 m s^{-1} for cool high gravity models to ~ 800–1000 m s^{-1} for hot models or models with low $\log g$. The micro-turbulent velocities range in the order of ~ 100 m s^{-1} for cool models, to ~ 600 m s^{-1} for hot or low $\log g$ models. Our M-star structure models are calculated with the 3D radiative-hydrodynamics (RHD) code CO5BOLD. The spectral synthesis on these models is performed with the line synthesis code LINFOR3D.

Oral contribution, published in "Recent directions in astrophysical quantitative spectroscopy and radiation hydrodynamics" (AiP)
Available from arXiv:0908.0820

Galactic AGB stars from the IPHAS survey

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The INT Photometric H-Alpha Survey (IPHAS) is particular effective in tracing asymptotic giant branch (AGB) stars across the Galactic disk due to its use of broad-band r' and i' filters, and the clear separation of the dwarf and giant branches in the colour–colour diagram. Here we discuss some results from our studies of the Galactic AGB population that has been revealed by IPHAS. This includes a photometric study, our spectroscopic follow-up campaign, and the photometric technique that allows us to separate O-rich, S-type and carbon stars across the entire Galactic disk based on their IPHAS photometry alone. We also discuss the potential impact of this technique on our understanding of the dredge-up process in AGB stars, Galactic chemical evolution, and the structure and properties of the Galactic disk.

Oral contribution, published in The Galactic Plane, in depth and across the spectrum, Special Session 8 at the IAU General Assembly 2009, Highlights of Astronomy Volume 15, eds. Janet Drew & Melvin Hoare
Available from arXiv:0908.3194

Asteroseismology of red-clump stars with CoRoT and Kepler

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The availability of asteroseismic constraints for a large number of red giants with CoRoT and, in the near future with Kepler, paves the way for detailed studies of populations of galactic-disk red giants. We investigate which information on the observed population can be recovered by the distribution of the observed seismic constraints: the frequency of maximum power of solar-like oscillations ($\nu_{\rm max}$) and the large frequency separation ($\Delta\nu$). We use the distribution of $\nu_{\rm max}$ and of $\Delta\nu$ observed by CoRoT in nearly 800 red giants in the first long observational run, as a tool to investigate the properties of galactic red-giant stars through the comparison with simulated distributions based on synthetic stellar populations. We can clearly identify the bulk of the red giants observed by CoRoT as red-clump stars, i.e. post-flash core-He-burning stars. The distribution of $\nu_{\rm max}$ and of $\Delta\nu$ give us access to the distribution of the stellar radius and mass, and thus represent a most promising probe of the age and star formation rate of the disk, and of the mass-loss rate during the red-giant branch. This approach will be of great utility also in the interpretation of forthcoming surveys of variability of red giants with CoRoT and Kepler. In particular, an asteroseismic mass estimate

of clump stars in the old-open clusters observed by Kepler, would represent a most valuable observational test of the poorly known mass-loss rate on the giant branch, and of its dependence on metallicity.

Oral contribution, published in "Stellar Pulsation: Challenges for Theory and Observation", Santa Fe 2009
Available from arXiv:0908.4172

Thesis

A study of the chemistry in the circumstellar envelope of IRC +10 216

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Stars experience during their last evolutionary stages the most drastic changes of all their lifes, the most spectacular is probably the huge increment in the dimensions of the star, which expands until reaching a radius of several astronomical units. Thus, low mass stars (< 8 $M_\odot$) become red giants and start to suffer strong mass-loss processes, which are particularly intense during the phase known as AGB (Asymptotic Giant Branch). The stellar winds associated to the AGB phase produce very extended circumstellar envelopes, composed of gas phase molecules and tiny solid dust particles, and are the main mechanism by means of which the interstellar medium is being recycled of matter. The gas in these circumstellar envelopes show a very rich variety of molecules, specially in the case of carbon-rich envelopes, i.e. those in which the dredge-up processes have brought carbon out to the surface in a selective way making the abundance ratio [C]/[O] > 1. In this thesis we present a study of the chemical composition and processes that occur in the circumstellar envelope of the prototype of carbon-rich AGB star, IRC +10 216. The study of this object allow us to get insight in a very detailed manner into phenomena that are characteristic of carbon-rich circumstellar envelopes and that cannot be studied in other objects of the same type, which due to their larger distances to the Earth only show the most evident processes.

Defended on 28^{th} July 2009 at the Universidad Autónoma de Madrid (Spain). Thesis written in spanish.

Announcement

ESO Workshop on "The Origin and Fate of the Sun"

Evolution of Solar-mass Stars Observed with High Angular Resolution
Garching, Germany, 2–5 March, 2010

Summary: The goal of this workshop is to review recent results on solar-mass stars obtained with infrared and millimeter interferometers, and to discuss their importance for our understanding of stellar evolution from star formation to stellar end products. The workshop will concentrate on the mass range from ≈ 0.5–2 $M_\odot$, will discuss what new results for one stage of stellar evolution mean for the next stage, and will bring interferometric results into context with our knowledge based on other observational techniques and with theory. It will also include prospects with 2^{nd} generation instruments at the VLTI and with ALMA. Interferometry experts and non-interferometrists alike are welcome to attend the workshop and to bring together their different perspectives.

See also http://www.eso.org/sci/meetings/stars2010