THE AGB NEWSLETTER

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

Official publication of the IAU Working Group on Red Giants and Supergiants

No. 282 — 4 January 2021

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

Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

Happy New Year! It is a pleasure to present you the 282nd issue of the AGB Newsletter.

The migration of the editorial office to Outlook e-mail and the regular (thankfully temporal) ban from accessing e-mails on arXiv has caused some delays in inviting authors to post their work. We are now catching up, but please be reminded that you do not need an invitation to post something. Also, we welcome unconventional contributions such as requests for collaboration, discussion of a scientific questions, illustrations, et cetera (in most cases it is probably most appropriate to submit them as an "announcement", though pictures are best e-mailed).

If you are looking for an opportunity to develop your research in a vibrant multi-disciplinary institute then the announcements of (advanced) postdoctoral positions in Madrid couldn't have been timed better.

The next issue is planned to be distributed around the 1st of February. Have a great 2021!

Editorially Yours,
Jacco van Loon, Ambra Nanni and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

If we want to understand pulsation driven mass loss we need to understand convection

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

Refereed Journal Papers

The formation of ultra-massive carbon–oxygen core white dwarfs and their evolutionary and pulsational properties

Leandro G. Althaus[1,2], Pilar Gil Pons[3], Alejandro H. Córsico[1,2], Marcelo M. Miller Bertolami[1,2], Francisco C. De Gerónimo[1,2], María E. Camisassa[1,2,3], Santiago Torres[3,4], Jordi Guterrez[3] and Alberto Rebassa-Mansergas[3,4]

[1]Grupo de Evolución Estelar y Pulsaciones. Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata,Paseo del Bosque s/n, 1900 La Plata, Argentina

[2]Instituto de Astrofísica La Plata, IALP (CCT La Plata), CONICET–UNLP, Argentina

[3]Departament de Física, Universitat Politècnica de Catalunya, c/Esteve Terrades 5, 08860 Castelldefels, Spain

[4]Institute for Space Studies of Catalonia, c/Gran Capita 2–4, Edif. Nexus 104, 08034 Barcelona, Spain

The existence of ultra-massive white dwarf stars, $M_{\rm WD} \gtrsim 1.05\ {\rm M}_\odot$, has been reported in several studies. These white dwarfs are relevant for the role they play in type Ia supernova explosions, the occurrence of physical processes in the asymptotic giant-branch phase, the existence of high-field magnetic white dwarfs, and the occurrence of double white dwarf mergers. We explore the formation of ultra-massive, carbon–oxygen core white dwarfs resulting from single stellar evolution. We also study their evolutionary and pulsational properties and compare them with those of the ultra-massive white dwarfs with oxygen–neon cores resulting from carbon burning in single progenitor stars, and with binary merger predictions. The aim is to provide a theoretical basis that can eventually help to discern the core composition of ultra-massive white dwarfs and the scenario of their formation. We consider two single-star evolution scenarios for the formation of ultra massive carbon–oxygen core white dwarfs that involve rotation of the degenerate core after core helium burning and reduced mass-loss rates in massive asymptotic giant-branch stars. We find that reducing standard mass- loss rates by a factor larger than 5–20 yields the formation of carbon-oxygen cores more massive than 1.05 $M_\odot$ as a result of the slow growth of carbon–oxygen core mass during the thermal pulses. We also performed a series of evolutionary tests of solar-metallicity models with initial masses between 4 and 9.5 $M_\odot$, and with different core rotation rates. We find that ultra-massive carbon–oxygen core white dwarfs are formed even for the lowest rotation rates we analyzed, and that the range of initial masses leading to these white dwarfs widens as the rotation rate of the core increases, whereas the initial mass range for the formation of oxygen–neon core white dwarfs decreases significantly. Finally, we compare our findings with the predictions from ultra-massive white dwarfs resulting from the merger of two equal-mass carbon–oxygen core white dwarfs, by assuming complete mixing between them and a carbon–oxygen core for the merged remnant. These two single evolution scenarios produce ultra-massive white dwarfs with different carbon–oxygen profiles and different helium contents, thus leading to distinctive signatures in the period spectrum and mode-trapping properties of pulsating hydrogen-rich white dwarfs. The resulting ultra-massive carbon–oxygen core white dwarfs evolve markedly slower than their oxygen–neon counterparts. Our study strongly suggests the formation of ultra-massive white dwarfs with carbon–oxygen core from single stellar evolution. We find that both the evolutionary and pulsation properties of these white dwarfs are markedly different from those of their oxygen–neon core counterparts and from those white dwarfs with carbon–oxygen core that might result from double degenerate mergers. This can eventually be used to discern the core composition of ultra-massive white dwarfs and their formation scenario.

Accepted for publication in Astronomy and Astrophysics
Available from https://arxiv.org/abs/2011.10439

Pulsating hydrogen-deficient white dwarfs and pre-white dwarfs observed with TESS – I. Asteroseismology of the GW Vir stars RX J2117+3412, HS 2324+3944, NGC 6905, NGC 1501, NGC 2371, and K 1−16

Alejandro H. Córsico[1,2], *Murat Uzundag*[3,4], *S.O. Kepler*[5], *Leandro G. Althaus*[1,2], *Roberto Silvotti*[6], *Andrzej S. Baran*[7,8,9], *Maja Vučković*[3], *Klaus Werner*[10], *Keaton J. Bell*[11,12] *and Michael Higgins*[13]

[1]Grupo de Evolución Estelar y Pulsaciones. Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata,Paseo del Bosque s/n, 1900 La Plata, Argentina

[2]Instituto de Astrofísica La Plata, IALP (CCT La Plata), CONICET–UNLP, Argentina

[3]Instituto de Física y Astronomía, Universidad de Valparaíso, Gran Bretaña 1111, Playa Ancha, Valparaíso 2360102, Chile

[4]European Southern Observatory, Alonso de Córdova 3107, Santiago, Chile

[5]Instituto de Física, Universidade Federal do Rio Grande do Sul, 91501-970, Porto-Alegre, RS, Brazil

[6]INAF–Osservatorio Astrofisico di Torino, strada dell'Osservatorio 20, 10025 Pino Torinese, Italy

[7]Uniwersytet Pedagogiczny, Obserwatorium na Suhorze, ul. Podchorążych 2, 30-084 Kraków, Polska

[8]Embry-Riddle Aeronautical University, Department of Physical Science, Daytona Beach, FL 32114, USA

[9]Department of Physics, Astronomy, and Materials Science, Missouri State University, Springfield, MO 5897, USA

[10]Institute for Astronomy and Astrophysics, Kepler Center for Astro and Particle Physics, Eberhard Karls University, Sand 1,72076 Tübingen, Germany

[11]DIRAC Institute, Department of Astronomy, University of Washington, Seattle, WA-98195, USA

[12]NSF Astronomy and Astrophysics Postdoctoral Fellow

[13]Department of Physics, Duke University, Durham, NC-27708, USA

The recent arrival of continuous photometric observations of unprecedented quality from space missions has largely fueled the study of pulsating stars, bringing the area to an unprecedented interest in stellar astrophysics. In the particular case of pulsating white dwarfs, the TESS mission is taking asteroseismology of these compact stars to a higher level, emulating or even surpassing the performance of its predecessor, the *Kepler* mission. In this paper, we present a detailed asteroseismological analysis of six GW Vir stars including the observations collected by the TESS mission. We processed and analyzed TESS observations of RX J2117+3412 (TIC 117070953), HS 2324+3944 (TIC 352444061), NGC 6905 (TIC 402913811), NGC 1501 (TIC 084306468), NGC 2371 (TIC 446005482), and K 1−16 (TIC 233689607). We carried out a detailed asteroseismological analysis of these stars on the basis of PG 1159 evolutionary models that take into account the complete evolution of the progenitor stars. We constrained the stellar mass of these stars by comparing the observed period spacing with the average of the computed period spacings, and, when possible, we employed the individual observed periods to search for a representative seismological model. In total, we extracted 58 periodicities from the TESS light curves of these GW Vir stars using a standard pre-whitening procedure to derive the potential pulsation frequencies. All the oscillation frequencies that we found are associated with g-mode pulsations with periods spanning from $\sim$ 817 s to $\sim$ 2682 s. We find constant period spacings for all but one star (K 1−16), which allowed us to infer their stellar masses and constrain the harmonic degree ℓ of the modes. Based on rotational frequency splittings, we derive the rotation period of RX J2117+3412, obtaining a value in agreement with previous determinations. We performed period-to-period fit analyses on five of the six analyzed stars. For four stars (RX J2117+3412, HS 2324+3944, NGC 1501, and NGC 2371), we were able to find an asteroseismological model with masses in agreement with the stellar-mass values inferred from the period spacings, and generally compatible with the spectroscopic masses. Obtaining seismological models allowed us to estimate the seismological distance and compare it with the precise astrometric distance measured with Gaia. Finally, we find that the period spectrum of K 1−16 exhibits dramatic changes in frequency and amplitude which, together with the scarcity of modes, prevented us from making a meaningful seismological modeling. The high-quality data collected by the TESS space mission, considered simultaneously with ground-based observations, are able to provide a very valuable input to the asteroseismology of GW Vir stars, similar to the case of other classes of pulsating white-dwarf stars. The TESS mission, in conjunction with future space missions and upcoming surveys, will make impressive progress in white-dwarf asteroseismology.

Accepted for publication in Astronomy and Astrophysics
Available from https://arxiv.org/abs/2011.03629

Infrared interferometric imaging of the compact dust disk around the AGB star HR 3126 with the bipolar Toby Jug Nebula

Keiichi Ohnaka[1], *Dieter Schertl*[2], *Karl-Heinz Hofmann*[2] *and Gerd Weigelt*[2]

[1]Universidad Católica del Norte, Antofagasta, Chile

[2]Max-Planck-Institut für Radioastronomie, Bonn, Germany

The asymptotic giant branch (AGB) star HR 3126, associated with the arcminute-scale bipolar Toby Jug Nebula, provides a rare opportunity to study the emergence of bipolar structures at the end of the AGB phase. Our goal is to image the central region of HR 3126 with high spatial resolution. We carried out long-baseline interferometric observations with AMBER and GRAVITY (2–2.45 μm) at the Very Large Telescope Interferometer (VLTI) with spectral resolutions of 1500 and 4500, speckle interferometric observations with VLT/NACO (2.24 μm), and imaging with SPHERE-ZIMPOL (0.55 μm) and VISIR (7.9–19.5 μm). The images reconstructed in the continuum at 2.1–2.29 μm from the AMBER+GRAVITY data reveal the central star surrounded by an elliptical ring-like structure with a semimajor and semiminor axis of 5.3 and 3.5 mas, respectively. The ring is interpreted as the inner rim of an equatorial dust disk viewed from an inclination angle of $\sim 50°$, and its axis is approximately aligned with the arcminute-scale bipolar nebula. The disk is surprisingly compact, with an inner radius of a mere 3.5 stellar radii (2 au). Our 2-D radiative transfer modeling shows that an optically thick flared disk with silicate grains as large as ~ 4 μm can simultaneously reproduce the observed continuum images and the spectral energy distribution. The images reconstructed in the CO first overtone bands reveal elongated extended emission around the central star, suggesting the oblateness of the star's atmosphere or the presence of a CO gas disk inside the dust cavity. The object is unresolved with SPHERE-ZIMPOL, NACO, and VISIR. If the disk formed together with the bipolar nebula, the grain growth from sub-micron to a few microns should have taken place over the nebula's dynamical age of $\sim$ 3900 yrs. The non-detection of a companion in the reconstructed images implies that either its 2.2-μm brightness is more than $\sim$ 30 times lower than that of the red giant or it might have been shredded due to binary interaction.

Published in Astronomy & Astrophysics
Available from https://arxiv.org/abs/2012.00768
and from https://www.aanda.org/articles/aa/abs/2020/11/aa38577-20/aa38577-20.html

Long-term photospheric instabilities and envelopes dynamics in the post-AGB binary system 89 Herculis

M. Gangi[1], *M. Giarrusso*[2], *M. Munari*[3], *C. Ferrara*[4,3], *C. Scalia*[3] *and F. Leone*[4,3]

[1]INAF – Osservatorio Astronomico di Roma, Via Frascati 33, I-00078 Monte Porzio Catone, Italy

[2]INFN – Laboratori Nazionali del Sud, Via S. Sofia 62, I-95123 Catania, Italy

[3]INAF – Osservatorio Astrofisico di Catania, Via S. Sofia 78, I-95123 Catania, Italy

[4]Università di Catania, Dipartimento di Fisica e Astronomia, Sezione Astrofisica, Via S. Sofia 78, I-95123 Catania, Italy

We present a long-term optical spectroscopic study of the post-asymptotic giant branch (AGB) binary system 89 Herculis, with the aim to characterize the relationship between photospheric instabilities and dynamics in the close circumstellar environment of the system. This study is based on spectra acquired with the high-resolution Catania Astrophysical Observatory Spectropolarimeter and archive data, covering a time interval between 1978 and 2018. We find long-term changes in the radial velocity curve of the system, occurring mostly in amplitude, which correlate with the variability observed in the blueshifted absorption component of the P Cygni-like Hα profile. Two possible scenarios are discussed. We also find strong splitting in the s-process elements of Ba II 6141.713- and 6496.898-Å lines, with short-term morphological variations. A Gaussian decomposition of such profiles allows us to distinguish four shell components, two expanding and two infalling toward the central star, which are subject to the orbital motion of the system and are not affected by the long-term instabilities. Finally, we find that the numerous metal lines in emission could originate in regions of a structured circumbinary disc that have sizes proportional to the energy of the corresponding upper level transition $E_{\rm up}$. This study demonstrates the potential of long-term high-resolution spectroscopy in linking together the instability processes occurring during the late evolutionary stages of post-AGBs and the subsequent phase of PNe.

Published in Monthly Notices of the Royal Astronomical Society, 500, 926 (2021)
Available from https://doi.org/10.1093/mnras/staa3255

Discovery of ground-state absorption line polarization and sub-Gauss magnetic field in the post-AGB binary system 89 Her

Heshou Zhang[1], *Manuele Gangi*[2], *Francesco Leone*[3], *Andrew Taylor*[1] *and Huirong Yan*[1]

[1]Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, D-15738 Zeuthen, Germany; Institut für Physik und Astronomie, Universität Potsdam, Haus 28, Karl-Liebknecht-Str. 24/25, D-14476 Potsdam, Germany

[2]INAF – Osservatorio Astronomico di Roma, Via Frascati 33, I-00078 Monte Porzio Catone, Italy

[3]Università di Catania, Dipartimento di Fisica e Astronomia, Sezione Astrofisica, Via S. Sofia 78, I-95123 Catania, Italy

We report the polarization of ground-state absorption lines from the post-asymptotic giant branch (post-AGB) binary star system 89 Herculis (89 Her). Two ground-state neutral iron lines are found to have counterintuitive high-amplitude polarizations and an unchanged polarization direction through the orbital period. This is contrary to the pattern of polarization of absorption lines from excited states, which are synchronized with the orbital phase due to optical pumping. This can be explained by magnetic realignment of the ground state, whereby the 3D mean magnetic field is separated from the degree and direction of the polarizations of the two iron lines. The field strength is also constrained to be < 100 mG. Our result improves the accuracy by orders of magnitude compared to the previous 10 G upper limit set by non-detection of the Zeeman effect.

Published in The Astrophysical Journal Letters, 902, L7 (2020)
Available from https://iopscience.iop.org/article/10.3847/2041-8213/abb8e1

Wind mass transfer in S-type symbiotic binaries – III. Confirmation of a wind focusing in EG Andromedæ from the nebular [O III] λ5007 line

N. Shagatova[1], *A. Skopal*[1], *S.Yu. Shugarov*[1,2], *R. Komžík*[1], *E. Kundra*[1] *and F. Teyssier*[3]

[1]Astronomical Institute, Slovak Academy of Sciences, 059 60 Tatranská Lomnica, Slovakia

[2]P.K. Sternberg Astronomical Institute, M.V. Lomonosov Moscow State University, Russia

[3]Observatoire Rouen Sud (FR) – ARAS group, 76100 Rouen, France

Context: The structure of the wind from the cool giants in symbiotic binaries carries important information for understanding the wind mass transfer to their white dwarf companions, its fuelling, and thus the path towards different phases of symbiotic-star evolution.
Aims: In this paper, we indicate a non-spherical distribution of the neutral wind zone around the red giant (RG) in the symbiotic binary star, EG And. We concentrate in particular on the wind focusing towards the orbital plane and its asymmetry alongside the orbital motion of the RG.
Methods: We achieved this aim by analysing the periodic orbital variations of fluxes and radial velocities of individual components of the Hα and [O III] λ5007 lines observed on our high-cadence medium ($R \sim 11\,000$) and high-resolution ($R \sim 38\,000$) spectra.
Results: The asymmetric shaping of the neutral wind zone at the near-orbital-plane region is indicated by:
(i) the asymmetric course of the Hα core emission fluxes along the orbit;
(ii) the presence of their secondary maximum around the orbital phase $\varphi = 0.1$, which is possibly caused by the refraction effect; and
(iii) the properties of the Hα broad wing emission originating by Raman scattering on H^0 atoms.
The wind is substantially compressed from polar directions to the orbital plane as constrained by the location of the [O III] λ5007 line emission zones in the vicinity of the RG at/around its poles. The corresponding mass-loss rate from the polar regions of $\lesssim 10^{-8}$ $M_\odot$ yr^{-1} is a factor of $\gtrsim 10$ lower than the average rate of $\approx 10^{-7}$ $M_\odot$ yr^{-1} derived from nebular emission of the ionised wind from the RG. Furthermore, it is two orders of magnitude lower than that measured in the near-orbital-plane region from Rayleigh scattering.
Conclusions: The startling properties of the nebular [O III] λ5007 line in EG And provides an independent indication of the wind focusing towards the orbital plane – the key to understanding the efficient wind mass transfer in symbiotic binary stars.

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/2012.08417

Rise of the Phoenix Giants: a rich history of dusty post-merger stellar remnants

Carl Melis[1]

[1]UC San Diego, USA

Hoadley et al. (2020) present an exceptional star system hosting orbiting dust and gas and a detached shell of material presumably generated in a stellar merger event. While they claim it to be "the only known merger system not enshrouded by dust", the reality is that this system is a new addition to a remarkable collection of stars first recognized decades ago as likely post-merger stellar remnants. In this note we give an abridged history of evidence for dusty stellar merger remnants in the Milky Way Galaxy.

Published in RNAAS, 4, 238 (2020)
Available from https://iopscience.iop.org/article/10.3847/2515-5172/abd32a

Evolved massive stars at low-metallicity – III. A source catalog for the Large Magellanic Cloud

Ming Yang[1], *Alceste Z. Bonanos*[1], *Biwei Jiang*[2], *Jian Gao*[2], *Panagiotis Gavras* [3], *Grigoris Maravelias*[1,4], *Shu Wang*[5], *Xiao-Dian Chen*[5], *Man I Lam*[6], *Yi Ren*[2], *Frank Tramper*[1] *and Zoi T. Spetsieri*[1]

[1]IAASARS, National Observatory of Athens, Vas. Pavlou and I. Metaxa, Penteli 15236, Greece

[2]Department of Astronomy, Beijing Normal University, Beijing 100875, People's Republic of China

[3]Rhea Group for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain

[4]Institute of Astrophysics, Foundation for Research and Technology-Hellas, Heraklion 71110, Greece

[5]Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Datun Road 20A, Beijing 100101, People's Republic of China

[6]Key Laboratory of Space Astronomy and Technology, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, People's Republic of China

We present a clean, magnitude-limited (IRAC1 or WISE1 ≤ 15.0 mag) multiwavelength source catalog for the Large Magellanic Cloud (LMC). The catalog was built by crossmatching ($1''$) and deblending ($3''$) between the source list of *Spitzer* Enhanced Imaging Products (SEIP) and Gaia Data Release 2 (DR2), with strict constraints on the Gaia astrometric solution in order to remove the foreground contamination. It is estimated that about 99.5% of the targets in our catalog are most likely genuine members of the LMC. The catalog contains 197,004 targets in 52 different bands, including two ultraviolet, 21 optical, and 29 infrared bands. Additional information about radial velocities and spectral and photometric classifications were collected from the literature. We compare our sample with the sample from Gaia Collaboration et al. (2018b), indicating that the bright end of our sample is mostly comprised of blue helium-burning stars (BHeBs) and red HeBs with inevitable contamination of main sequence stars at the blue end. After applying modified magnitude and color cuts based on previous studies, we identified and ranked 2,974 red supergiant, 508 yellow supergiant, and 4,786 blue supergiant candidates in the LMC in six color–magnitude diagrams (CMDs). The comparison between the CMDs from the two catalogs of the LMC and Small Magellanic Cloud (SMC) indicates that the most distinct difference appears at the bright red end of the optical and near-infrared CMDs, where the cool evolved stars (e.g., red supergiant stars (RSGs), asymptotic giant branch stars, and red giant stars) are located, which is likely due to the effect of metallicity and star formation history. A further quantitative comparison of colors of massive star candidates in equal absolute magnitude bins suggests that there is essentially no difference for the BSG candidates, but a large discrepancy for the RSG candidates since LMC targets are redder than the SMC ones, which may be due to the combined effect of metallicity on both spectral type and mass-loss rate as well as the age effect. The effective temperatures ($T_{\rm eff}$) of massive star populations are also derived from reddening-free color of $(J - K_{\rm S})_0$. The $T_{\rm eff}$ ranges are $3500 < T_{\rm eff} < 5000$ K for an RSG population, $5000 < T_{\rm eff} < 8000$ K for a YSG population, and $T_{\rm eff} > 8000$ K for a BSG population, with larger uncertainties toward the hotter stars.

Accepted for publication in A&A
Available from https://arxiv.org/abs/2012.08623

Effective temperatures of red supergiants estimated from line-depth ratios of iron lines in the YJ bands, 0.97–1.32 μm

Daisuke Taniguchi[1], *Noriyuki Matsunaga*[1,2], *Mingjie Jian*[1], *Naoto Kobayashi*[3,4,2], *Kei Fukue*[2], *Satoshi Hamano*[2,5], *Yuji Ikeda*[2,6], *Hideyo Kawakita*[2,7], *Sohei Kondo*[2,4], *Shogo Otsubo*[2], *Hiroaki Sameshima*[3], *Keiichi Takenaka*[8] *and Chikako Yasui*[5]

[1]Department of Astronomy, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

[2]Laboratory of Infrared High-resolution spectroscopy (LiH), Koyama Astronomical Observatory, Kyoto Sangyo University, Motoyama, Kamigamo, Kita-ku, Kyoto 603-8555, Japan

[3]Institute of Astronomy, The University of Tokyo, 2-21-1 Osawa, Mitaka, Tokyo 181-0015, Japan

[4]Kiso Observatory, The University of Tokyo, 10762-30 Mitake, Kiso-machi, Kiso-gun,Nagano 397-0101, Japan

[5]National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

[6]Photocoding, 460-102 Iwakura-Nakamachi, Sakyo-ku, Kyoto 606-0025, Japan

[7]Department of Astrophysics and Atmospheric Sciences, Faculty of Sciences, Kyoto Sangyo University, Motoyama, Kamigamo, Kita-ku, Kyoto 603-8555, Japan

[8]Division of Science, Graduate School, Kyoto Sangyo University, Motoyama, Kamigamo, Kita-ku, Kyoto 603-8555, Japan

Determining the effective temperatures (T_{eff}) of red supergiants (RSGs) observationally is important in many fields of stellar physics and galactic astronomy, yet some significant difficulties remain due to model uncertainty originating majorly in the extended atmosphere of RSGs. Here we propose the line-depth ratio (LDR) method in which we use only Fe I lines. As opposed to the conventional LDR method with lines of multiple species involved, the LDR of this kind is insensitive to the surface gravity effects and expected to circumvent the uncertainty originating in the upper atmosphere of RSGs. Therefore, the LDR–T_{eff} relations that we calibrated empirically with red giants may be directly applied to RSGs, though various differences, e.g., caused by the three-dimensional non-LTE effects, between the two groups of objects need to be kept in mind. Using the near-infrared YJ-band spectra of nine well-known solar-metal red giants observed with the WINERED high-resolution spectrograph, we selected 12 pairs of Fe I lines least contaminated with other lines. Applying their LDR–T_{eff} relations to ten nearby RSGs, the resultant T_{eff} with the internal precision of 30–70 K shows good agreement with previous observational results assuming one-dimensional LTE and with Geneva's stellar evolution model. We found no evidence of significant systematic bias caused by various differences, including those in the size of the non-LTE effects, between red giants and RSGs except for one line pair which we rejected because the non-LTE effects may be as large as ~ 250 K. Nevertheless, it is difficult to evaluate the systematic bias, and further study is required, e.g., with including the three-dimensional non-LTE calculations of all the lines involved.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2012.07856

Green Bank Telescope observations of ^{3}He$^+$: planetary nebulæ

T.M. Bania [1] *and Dana S. Balser*[2]

[1]Institute for Astrophysical Research, Astronomy Department, Boston University, Boston MA, USA

[2]National Radio Astronomy Observatory, Charlottesville, VA, USA

We use the Green Bank Telescope to search for ^{3}He$^+$ emission from a sample of four Galactic planetary nebulæ: NGC 3242, NGC 6543, NGC 6826, and NGC 7009. During the era of primordial nucleosynthesis the light elements ^{2}H, ^{3}He, ^{4}He, and ^{7}Li were produced in significant amounts and these abundances have since been modified primarily by stars. Observations of ^{3}He$^+$ in H II regions located throughout the Milky Way disk reveal very little variation in the ^{3}He/H abundance ratio – the "^{3}He Plateau" – indicating that the net effect of ^{3}He production in stars is negligible. This is in contrast to much higher ^{3}He/H abundance ratios reported for some planetary nebulæ. This discrepancy is known as the "^{3}He Problem". We use radio recombination lines observed simultaneously with the ^{3}He$^+$ transition to make a robust assessment of the spectral sensitivity that these observations achieve. We detect spectral lines at $\sim$ 1–2 mK intensities, but at these levels instrumental effects compromise our ability to measure accurate spectral line parameters. We do not confirm reports of previous detections of ^{3}He$^+$ in NGC 3242 nor do we detect ^{3}He$^+$

emission from any of our sources. This result calls into question all reported detections of $^3He^+$ emission from any planetary nebula. The $^3He/H$ abundance upper limit we derive here for NGC 3242 is inconsistent with standard stellar production of ^3He and thus requires that some type of extra mixing process operates in low-mass stars.

Accepted for publication in The Astrophysical Journal
Available from https://arxiv.org/abs/2012.11707

Supersoft X-ray phases of recurrent novæ as an indicator of their white dwarf masses

Mariko Kato[1] *and Izumi Hachisu*[2]

[1]Keio Univerisity, Japan
[2]The University of Tokyo, Japan

We have examined the optical/X-ray light curves of seven well-observed recurrent novæ,V745 Sco, M31N 2008-12a, LMC N 1968, U Sco, RS Oph, LMC N 2009a, T Pyx, and one recurrent nova candidate LMC N 2012a. Six novæ out of the eight show a simple relation that the duration of supersoft X-ray source (SSS) phase is 0.70 times the total duration of the outburst (= X-ray turnoff time), i.e. $t_{\rm SSS} = 0.70\ t_{\rm off}$, the total duration of which ranges from 10 to 260 d. These six recurrent novæ show a broad rectangular X-ray light curve shape, the first half-period of which is highly variable in the X-ray count rate. The SSS phase also corresponds to an optical plateau phase that indicates a large accretion disk irradiated by a hydrogen-burning white dwarf (WD). The two other recurrent novæ, T Pyx and V745 Sco, show a narrow triangular-shaped X-ray light curve without an optical plateau phase. Their relations between $t_{\rm SSS}$ and $t_{\rm off}$ are rather different from the above six recurrent novæ. We also present theoretical SSS durations for recurrent novæ with various WD masses and stellar metallicities (Z = 0.004, 0.01, 0.02, and 0.05) and compare them with the observed durations of these recurrent novæ. We show that SSS duration is a good indicator of WD mass in recurrent novæ with a broad rectangular X-ray light curve shape.

Published in PASJ, 72, 82 (2020)
Available from https://arxiv.org/abs/2007.03387

Gas and dust from metal-rich AGB stars

Paolo Ventura[1], *Flavia Dell'Agli*[1], *Maria Lugaro*[2], *Donatella Romano*[3], *Marco Tailo*[4] *and Andres Yague*[2]

[1]INAF–Observatory of Rome, Monte Porzio Catone, Italy
[2]Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Budapest, Hungary
[3]INAF, Astrophysics and Space Science Observatory, Bologna, Italy
[4]Dipartimento di Fisica e Astronomia "Galileo Galilei", Padova University, Padova, Italy

Context: Stars evolving through the asymptotic giant branch (AGB) phase provide significant feedback to their host system, in the form of both gas enriched in nuclear-burning products and dust formed in their winds, which they eject into the interstellar medium. Therefore AGB stars are an essential ingredient for the chemical evolution of the Milky Way and other galaxies.
Aims: We study AGB models with super-solar metallicity, to complete our large database, so far extending from metal-poor to solar chemical compositions. We provide chemical yields for masses in the range 1–8 $M_\odot$ and metallicities $Z = 0.03$ and $Z = 0.04$. We also study dust production in this metallicity domain.
Methods: We calculated the evolutionary sequences from the pre-main sequence through the whole AGB phase. We follow the variation of the surface chemical composition to calculate the chemical yields of the various species and model dust formation in the winds to determine the dust production rate and the total dust mass produced by each star during the AGB phase.
Results: The physical and chemical evolution of the star is sensitive to the initial mass: $M > 3$-$M_\odot$ stars experience

hot bottom burning, whereas the surface chemistry of the lower mass counterparts is altered only by third dredge-up. The carbon-star phase is reached by 2.5–3.5 $M_\odot$ stars of metallicity $Z = 0.03$, whereas all the $Z = 0.04$ stars (except the 2.5 $M_\odot$) remain O-rich for the whole AGB phase. Most of the dust produced by metal-rich AGBs is in the form of silicates particles. The total mass of dust produced increases with the mass of the star, reaching ~ 0.012 $M_\odot$ for 8-$M_\odot$ stars.

Published in Astronomy & Astrophysics, 614, A103 (2020)
Available from https://arxiv.org/abs/2007.02120

Hydrodynamic simulations of pre-supernova outbursts in red supergiants: asphericity and mass loss

Shing-Chi Leung[1] *and Jim Fuller*[1]

[1]TAPIR, Walter Burke Institute for Theoretical Physics, Mailcode 350-17, Caltech, Pasadena, CA 91125, USA

The activity of a massive star approaching core-collapse can strongly affect the appearance of the star and its subsequent supernova. Late-phase convective nuclear burning generates waves that propagate toward the stellar surface, heating the envelope and potentially triggering mass loss. In this work, we improve on previous one-dimensional models by performing two-dimensional simulations of the pre-supernova mass ejection phase due to deposition of wave energy. Beginning with stellar evolutionary models of a 15-$M_\odot$ red supergiant star during core O-burning, we treat the rate and duration of energy deposition as model parameters and examine the mass-loss dependence and the pre-explosion morphology accordingly. Unlike one-dimensional models, density inversions due to wave heating are smoothed by Rayleigh–Taylor instabilities, and the primary effect of wave heating is to radially expand the star's hydrogen envelope. For low heating rates with long durations, the expansion is nearly homologous, whereas high but short-lived heating can generate a shock that drives envelope expansion and results in a qualitatively different density profile at the time of core-collapse. Asymmetries are fairly small, and large amounts of mass loss are unlikely unless the wave heating exceeds expectations. We discuss implications for pre-supernova stellar variability and supernovæ light curves.

Published in The Astrophysical Journal
Available from https://arxiv.org/abs/2007.11712
and from https://doi.org/10.3847/1538-4357/abac5d

Job Advert

Centro de Astrobiologia (CAB, CSIC–INTA) and Observatorio Astronómico Nacional (OAN), Madrid, Spain

Postdoctoral contract

Title:
postdoctoral contract within the "Attraction of Talent program" of the regional government of Madrid (Spain). Reasearch Area: Circumstellar envelopes around low-to-intermediate mass evolved stars (AGB, post-AGB, PPNe and PNe).

Description:
The regional government of Madrid will soon (January 2021) be offering postdoctoral positions within the "Attraction of Talent program", aimed at hiring experienced international researchers. The program offers two types of contracts, with the following basic characteristics:

Modality 1:

- Independent researchers with several years of postdoctoral experience
- Duration: 5 years
- Annual gross salary of about 48 keuros (2020) + social benefits as per Spanish standards (health care, paid parental leave, etc.)
- Additional funding of 200 keuros for equipment, travels, and hiring of Ph.D. student or junior postdoc
- Start Autumn 2021

Modality 2:

- Recent/Junior Ph.D. graduates
- Duration: 4 years
- Annual gross salary of about 36 keuros (2020) + social benefits as per Spanish standards (health care, paid parental leave, etc.)
- Additional funding of 3 keuros per year for travel and equipment
- Start Autumn 2021

These contracts must be supported by a local research group and, therefore, we like to invite excellent candidates with interests in studies of the physics and chemistry of circumstellar envelopes around AGB and post-AGB stars and Planetary Nebulæ to contact us via email by January 11^{th}, sending a short research statement and a CV.

The successful applicant(s) will work in collaboration with researchers at the Astrophysics Department of the Center for Astrobiology (CAB) and the Observatorio Astronómico Nacional (OAN) in our main research activities, which are framed within the following projects:

a) Identification of the processes responsible for the morphological, dynamic and chemical changes induced in the circumstellar material during the short transition from the AGB to the PN phase.

b) Use of recombination lines in the mm-wavelength domain (ALMA) to penetrate into the enigmatic central regions of pPNs/PNs where jet launching mechanisms operate.

c) Use of high angular resolution observations of molecular lines (ALMA) to characterize the nebular structure and dynamics at different spatial scales, to recreate the history of mass loss, and to study the physical and chemical effects of post-AGB+AGB wind interaction.

d) Use of optical and near infrared imaging and spectroscopy to directly probe the elusive pristine post-AGB winds, ultimately responsible for PN-shaping, and the medium/high excitation gas component.

e) Use of spectroscopic data from the far-infrared to the sub/mm wavelength range to constrain the physical properties and the molecular content of the inner and warm molecular layers of the envelopes around AGB and post-AGB stars.

f) Comprehensive analysis of multi-wavelength observations, including radiative transfer modelling both for the molecular and for the ionized gas components, to reach a broad perspective of the complex phenomenology of these objects.

For inquiries about these positions, please contact:
Carmen Sánchez Contreras (csanchez@cab.inta-csic.es)
Javier Alcolea Jimenez (j.alcolea@oan.es)