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 158th issue of the AGB Newsletter. Not as thick as you are used to, but this is made up for by high quality content.

We congratulate the organisers of the very interesting and very-well attended AGB star meeting in Vienna two weeks ago, and are already looking forward to number three in the series!

If you need an excuse to visit Vienna before then — or one of the other partners in the European Interferometry Initiative — please consider the visitor exchange programme announcement at the end of the newsletter.

Last month's food for thought generated a few responses, mainly agreeing that astro (or astero) seismology is in principle a valuable tool to look inside AGB stars as well. There is for instance a nice analysis being carried out on the pulsation of α Herculis (Moravveji et al. 2010, Ap&SS, 328, 113), famous for the early discoveries of a wind (Deutsch 1956) and circumstellar dust (Gehrz & Woolf 1971), with the potential of settling on its mass: supergiant or AGB star?

The next issue is planned to be distributed on the 1st of October 2010.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

What can we learn about the nearby α Herculis system from interferometric observations?

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)

High resolution optical spectroscopy of the F supergiant proto-planetary nebula V887 Her = IRAS 18095+2704

Timur Sahin[1], David L. Lambert[1], Valentina G. Klochkova[2] and N.S. Tavolganskaya[2]

[1]Department of Astronomy and The W.J. McDonald Observatory, University of Texas, Austin, TX 78712, USA

[2]Special Astrophysical Observatory, Nizhnij Arkhyz Stavropol Territory, Karachai-Cherkessia, 369167 Russia

An abundance analysis is presented for IRAS 18095+2704 (V887 Her), a post-AGB star and proto-planetary nebula. The analysis is based on high-resolution optical spectra from the McDonald Observatory and the Special Astrophysical Observatory. Standard analysis using a classical Kurucz model atmosphere and the line analysis program MOOG provides the atmospheric parameters: $T_{\rm eff} = 6500$ K, $\log g = +0.5$, and a microturbulent velocity $V_{\rm t} = 4.7$ km s^{-1} and [Fe/H] $= -0.9$. Extraction of these parameters is based on excitation of Fe I lines, ionization equilibrium between neutral and ions of Mg, Ca, Ti, Cr, and Fe, and the wings of hydrogen Paschen lines. Elemental abundances are obtained for 22 elements and upper limits for an additional four elements. These results show that the star's atmosphere has not experienced a significant number of C- and s-process enriching thermal pulses. Abundance anomalies as judged relative to the compositions of unevolved and less-evolved normal stars of a similar metallicity include Al, Y, and Zr deficiencies with respect to Fe of about 0.5 dex. Judged by composition, the star resembles an RV Tauri variable that has been mildly affected by dust-gas separation reducing the abundances of the elements of highest condensation temperature. This separation may occur in the stellar wind. There are indications that the standard 1D LTE analysis is not entirely appropriate for IRAS 18095+2704. These include a supersonic macroturbulent velocity of 23 km s^{-1}, emission in Hα and the failure of predicted profiles to fit observed profiles of Hβ and Hγ.

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Comparative spectra of oxygen-rich vs. carbon-rich circumstellar shells: VY Canis Majoris and IRC +10 216 at 215–285 GHz

E.D. Tenenbaum[1,2], J.L. Dodd[1], S.N. Milam[3], N.J. Woolf[1] and L.M. Ziurys[1,4]

[1]Steward Observatory, Dept. of Astronomy, University of Arizona, USA

[2]Leiden Observatory, University of Leiden, The Netherlands

[3]NASA Goddard Space Flight Center, USA

[4]Arizona Radio Observatory, USA

A sensitive (1σ rms at 1 MHz resolution $\sim$ 3 mK) 1 mm spectral line survey (214.5–285.5 GHz) of VY Canis Majoris (VY CMa) and IRC +10 216 has been conducted to compare the chemistries of oxygen and carbon-rich circumstellar envelopes. This study was carried out using the Submillimeter Telescope (SMT) of the Arizona Radio Observatory (ARO) with a new ALMA-type receiver. This survey is the first to chemically characterize an O-rich circumstellar shell at millimeter wavelengths. In VY CMa, 128 emission features were detected arising from 18 different molecules, and in IRC +10 216, 720 lines were observed, assigned to 32 different species. The 1 mm spectrum of VY CMa is dominated by SO_2 and SiS; in IRC +10 216, C_4H and SiC_2 are the most recurrent species. Ten molecules were common to both sources: CO, SiS, SiO, CS, CN, HCN, HNC, NaCl, PN, and HCO^+. Sulfur plays an important role in VY CMa, but saturated/unsaturated carbon dominates the molecular content of IRC +10 216, producing CH_2NH, for example. Although the molecular complexity of IRC +10 216 is greater, VY CMa supports a unique "inorganic" chemistry leading to the oxides PO, AlO, and AlOH. Only diatomic and triatomic compounds were observed in VY CMa, while species with 4 or more atoms are common in IRC +10 216, reflecting carbon's ability to form multiple strong bonds, unlike oxygen. In VY CMa, a new water maser ($v_2 = 2$) has been found, as well as vibrationally-excited NaCl. Toward IRC +10 216, vibrationally-excited CCH was detected for the first time.

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Probing the mass-loss history of AGB and red supergiant stars from CO rotational line profiles — II. CO line survey of evolved stars: derivation of mass-loss rate formulae

E. De Beck[1], *L. Decin*[1,2], *A. de Koter*[2,3], *K. Justtanont*[4], *T. Verhoelst*[1], *F. Kemper*[5] *and K.M. Menten*[6]

[1]Department of Physics and Astronomy, Institute for Astronomy, K.U. Leuven, Celestijnenlaan 200D, B-3001 Leuven, Belgium
[2]Astronomical Institute "Anton Pannekoek", University of Amsterdam, Science Park XH, Amsterdam, The Netherlands
[3]Astronomical Institute Utrecht, University of Utrecht, P.O. Box 8000, NL-3508 TA Utrecht, The Netherlands
[4]Chalmers University of Technology, Onsala Space Observatory, SE-439 92 Onsala, Sweden
[5]Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, Manchester, M13 9PL, UK
[6]Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany

We aim to (1) set up simple and general analytical expressions to estimate mass-loss rates of evolved stars, and (2) from those calculate estimates for the mass-loss rates of asymptotic giant branch (AGB), red supergiant (RSG), and yellow hypergiant stars in our galactic sample. Rotationally excited lines of CO are a very robust diagnostic in the study of circumstellar envelopes (CSEs). When sampling different layers of the CSE, observations of these molecular lines lead to detailed profiles of kinetic temperature, expansion velocity, and density. A state-of-the-art, nonlocal thermal equilibrium, and co-moving frame radiative transfer code that predicts CO line intensities in the CSEs of late-type stars is used in deriving relations between stellar and molecular-line parameters, on the one hand, and mass-loss rate, on the other. We present analytical expressions for estimating the mass-loss rates of evolved stellar objects for 8 rotational transitions of the CO molecule, apply them to our extensive CO data set covering 47 stars, and compare our results to those of previous studies. Our expressions account for line saturation and resolving of the envelope, thereby allowing accurate determination of very high mass-loss rates. We argue that, for estimates based on a single rotational line, the CO(2–1) transition provides the most reliable mass-loss rate. The mass-loss rates calculated for the AGB stars range from 4×10^{-8} $M_\odot$ yr^{-1} up to 8×10^{-5} $M_\odot$ yr^{-1}. For RSGs they reach values between 2×10^{-7} $M_\odot$ yr^{-1} and 3×10^{-4} $M_\odot$ yr^{-1}. The estimates for the set of CO transitions allow time variability to be identified in the mass-loss rate. Possible mass-loss-rate variability is traced for 7 of the sample stars. We find a clear relation between the pulsation periods of the AGB stars and their derived mass-loss rates, with a levelling off at $\approx 3 \times 10^{-5}$ $M_\odot$ yr^{-1} for periods exceeding 850 days.

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Shocks and a giant planet in the disk orbiting BP Piscium?

C. Melis[1,2], *C. Gielen*[3], *C. H. Chen*[4], *J.H. Rhee*[5], *I. Song*[5] *and B. Zuckerman*[1]

[1]UCLA, USA
[2]UCSD, USA
[3]Instituut voor Sterrenkunde, Belgium
[4]STScI, USA
[5]University of Georgia, USA

Spitzer IRS spectroscopy supports the interpretation that BP Piscium, a gas and dust enshrouded star residing at high Galactic latitude, is a first-ascent giant rather than a classical T Tauri star. Our analysis suggests that BP Piscium's spectral energy distribution can be modeled as a disk with a gap that is opened by a giant planet. Modeling the rich mid-infrared emission line spectrum indicates that the solid-state emitting grains orbiting BP Piscium are primarily composed of ∼75 K crystalline, magnesium-rich olivine; ∼75 K crystalline, magnesium-rich pyroxene; ∼200 K amorphous, magnesium-rich pyroxene; and ∼200 K annealed silica ('cristobalite'). These dust grains are all sub-micron sized. The giant planet and gap model also naturally explains the location and mineralogy of the small dust grains in the disk. Disk shocks that result from disk-planet interaction generate the highly crystalline dust which is subsequently blown out of the disk mid-plane and into the disk atmosphere.

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Post-main sequence evolution of main sequence A star debris discs

A. Bonsor[1] and M.C. Wyatt[1]

[1]IoA Cambridge, UK

While the population of main-sequence debris discs is well constrained, little is known about debris discs around evolved stars. This paper provides a theoretical framework considering the effects of stellar evolution on debris discs, particularly the production and loss of dust within them. Here, we repeat a steady-state model fit to disc evolution statistics for main-sequence A stars, this time using realistic grain optical properties, then evolve that population to consider its detectability at later epochs. Our model predicts that debris discs around giant stars are harder to detect than on the main sequence because radiation pressure is more effective at removing small dust around higher luminosity stars. Just 12% of the first ascent giants within 100 pc are predicted to have discs detectable with Herschel at 160 μm. However, this is subject to the uncertain effect of sublimation on the disc, which we propose can thus be constrained with such observations. Our model also finds that the rapid decline in stellar luminosity results in only very young white dwarfs having luminous discs. As such systems are on average at larger distances they are hard to detect, but we predict that the stellar parameters most likely to yield a disc detection are a white dwarf at 200 pc with cooling age of 0.1 Myr, in line with observations of the helix nebula. Our model does not predict close-in (< 0.01 au) dust, as observed for some white dwarfs; however we find that stellar wind drag leaves significant mass ($\sim 10^{-2}$ $M_\oplus$), in bodies up to $\sim$ 10 m in diameter, inside the disc at the end of the asymptotic giant branch (AGB) phase which may replenish these discs.

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Mapping and spectroscopy of the Planetary Nebula NGC 7009 in the visual and infrared

J.P. Phillips[1], L. Cuesta[2] and G. Ramos-Larios[1]

[1]Instituto de Astronomía y Meteorología, Av. Vallarta No. 2602, Col. Arcos Vallarta, C.P. 44130 Guadalajara, Jalisco, México
[2]Centro de Astrobiología, Instituto Nacional de Técnica Aeroespacial, Carretera de Ajalvir, km 4, 28850 Torrejón de Ardoz, Madrid, Spain

NGC 7009 is a fascinating example of a high excitation, elliptical planetary nebula (PN) containing circum-nebular rings, and FLIERs and jets along the major axis. We present visual spectroscopy along multiple position angles through the nucleus, taken with the Observatorio Astronómico Nacional (México); mid-infrared (MIR) spectroscopy and imaging acquired using the Infrared Space Observatory (ISO) and *Spitzer* Space Telescope (SST), and narrow band imaging obtained using the *Hubble* Space Telescope (HST). The data show that the mid-infrared (MIR) continuum is dominated by a broad $\sim$ 100 K continuum, and a strong excess attributable to crystalline silicate emission. The primary peaks in this excess are similar to those observed in Forsterite and clino- and ortho-enstatite. We use the ground-based spectroscopy, and ratioing of HST images to investigate the presence of shocks in the ansae and interior envelope. It is concluded that line ratios in the ansae may be partially consistent with shock excitation, although these features are primarily dominated by photo-ionisation. We also note evidence for shock excitation at the limits of the interior elliptical shell, and for multiple bow-shock structures centered upon the ansae.

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Annual parallax distance and kinematical property of H_2O masers in IRAS 19312+1950

Hiroshi Imai[1], Daniel Tafoya[1], Mareki Honma[2], Tomoya Hirota[2] and Takeshi Miyaji[2]

[1]Department of Physics and Astronomy, Graduate School of Science and Engineering, Kagoshima University, Japan
[2]Mizusawa VLBI Observatory, National Astronomical Observatory of Japan, Japan

We report on results of astrometric observations of H_2O masers in the pre-planetary nebula candidate source IRAS 19312

+1950 with the VLBI Exploration of Radio Astrometry (VERA), yielding an annual parallax, $\pi = 263 \pm 47$ μas, and a secular motion, $(\mu_\alpha, \mu_\delta) = (-2.61 \pm 0.47, -6.73 \pm 0.14)$ [mas yr^{-1}], for IRAS 19312+1950. Then we derived a heliocentric distance of $D = 3.80^{+0.83}_{-0.58}$ kpc, a location in the Galaxy (R, z) = (7.07 ± 0.12 kpc, 28 ± 3 pc), and a three-dimensional velocity vector $(V_R, V_\theta, V_z) = (33 \pm 28, 214 \pm 4, -14 \pm 8)$ [km s^{-1}] in galactic cylindrical coordinates. Based on these parameters, we discuss the intrinsic properties of IRAS 19312+1950. We estimated a mass of the central star to be ~ 8 M$_\odot$ and a deviation of the source motion from the circular Galactic rotation to be ~ 40 km s^{-1}. These are consistent with this source being an intermediate-mass late AGB or early post-AGB star.

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The origin and evolution of the Halo PN BoBn 1: From a viewpoint of chemical abundances based on multiwavelength spectra

Masaaki Otsuka[1], Akito Tajitsu[2], Siek Hyung[3] and Hideyuki Izumiura[4]

[1]Space Telescope Science Institute, USA

[2]Subaru Telescope, NAOJ, Japan

[3]School of Science Education (Astronomy), Chungbuk National University, South Korea

[4]Okayama Astrophysical Observatory, NAOJ, Japan

We have performed a comprehensive chemical abundance analysis of the extremely metal-poor ([Ar/H] < -2) halo planetary nebula (PN) BoBn 1 based on *IUE* archive data, Subaru/HDS spectra, VLT/UVES archive data, and *Spitzer*/IRS spectra. We have detected over 600 lines in total and calculated ionic and elemental abundances of 13 elements using detected optical recombination lines (ORLs) and collisionally excited lines (CELs). The estimations of C, N, O, and Ne abundances from the ORLs and Kr, Xe, and Ba from the CELs are done the first for this nebula, empirically and theoretically. The C, N, O, and Ne abundances from ORLs are systematically larger than those from CELs. The abundance discrepancies apart from O could be explained by a temperature fluctuation model, and that of O might be by a hydrogen deficient cold component model. We have detected 5 fluorine and several slow neutron capture elements (the *s*-process). The amounts of [F/H], [Kr/H], and [Xe/H] suggest that BoBn 1 is the most F-rich among F detected PNe and is a heavy *s*-process element rich PN. We have confirmed dust in the nebula that is composed of amorphous carbon and PAHs with a total mass of 5.8×10^{-6} M$_\odot$. The photo-ionization models built with non-LTE theoretical stellar atmospheres indicate that the progenitor was a 1–1.5 M$_\odot$ star that would evolve into a white dwarf with an ~ 0.62 M$_\odot$ core mass and ~ 0.09 M$_\odot$ ionized nebula. We have measured a heliocentric radial velocity of $+191.6 \pm 1.3$ km s^{-1} and expansion velocity $2V_{\rm exp}$ of 40.5 ± 3.3 km s^{-1} from an average over 300 lines. The derived elemental abundances have been reviewed from the standpoint of theoretical nucleosynthesis models. It is likely that the elemental abundances except N could be explained either by a 1.5 M$_\odot$ single star model or by a binary model composed of 0.75 M$_\odot$ + 1.5 M$_\odot$ stars. Careful examination implies that BoBn 1 has evolved from a 0.75 M$_\odot$ + 1.5 M$_\odot$ binary and experienced coalescence during the evolution to become a visible PN, similar to the other extremely metal-poor halo PN, K 648 in M 15.

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Chemical abundances for 855 giants in the globular cluster ω Centauri (NGC 5139)

Christian I. Johnson[1,2,3] and Catherine A. Pilachowski[1,3]

[1]Department of Astronomy, Indiana University, Swain West 319, 727 East Third Street, Bloomington, IN 47405-7105, USA; cijohnson@astro.ucla.edu; catyp@astro.indiana.edu

[2]Department of Physics and Astronomy, University of California, Los Angeles, 430 Portola Plaza, Box 951547, Los Angeles, CA 90095-1547, USA

[3]Visiting astronomer, Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatory, which are operated by the Association of Universities for Research in Astronomy, under contract with the National Science Foundation

We present elemental abundances for 855 red giant branch (RGB) stars in the globular cluster ω Centauri (ω Cen)

from spectra obtained with the Blanco 4m telescope and Hydra multifiber spectrograph. The sample includes nearly all RGB stars brighter than $V = 13.5$, and spans ω Cen's full metallicity range. The heavy α elements (Si, Ca, and Ti) are generally enhanced by $\sim +0.3$ dex, and exhibit a metallicity dependent morphology that may be attributed to mass and metallicity dependent Type II supernova (SN) yields. The heavy $\alpha-$ and Fe-peak abundances suggest minimal contributions from Type Ia SNe. The light elements (O, Na, and Al) exhibit > 0.5 dex abundance dispersions at all metallicities, and a majority of stars with [Fe/H] > -1.6 have [O/Fe], [Na/Fe], and [Al/Fe] abundances similar to those in monometallic globular clusters, as well as O–Na, O–Al anticorrelations and the Na–Al correlation in all but the most metal-rich stars. A combination of pollution from intermediate mass asymptotic giant branch (AGB) stars and *in situ* mixing may explain the light element abundance patterns. A large fraction (27%) of ω Cen stars are O-poor ([O/Fe] < 0) and are preferentially located within 5–10$'$ of the cluster center. The O-poor giants are spatially similar, located in the same metallicity range, and are present in nearly equal proportions to blue main sequence stars. This suggests the O-poor giants and blue main sequence stars may share a common origin. [La/Fe] increases sharply at [Fe/H] > -1.6, and the [La/Eu] ratios indicate the increase is due to almost pure s-process production.

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Announcement

Fizeau exchange visitors program in optical interferometry — call for applications —

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

The deadline for applications is the 15$^{\text{th}}$ September for visits starting 1$^{\text{st}}$ of November.

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

The program is funded by OPTICON/FP7.

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

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

See also www.european-interferometry.eu