THE AGB NEWSLETTER

An electronic publication dedicated to stellar evolution on the asymptotic giant branch and beyond

No. 100 — May 2003

Editors: Thierry Forveille and Claudine Kahane (agbnews@obs.ujf-grenoble.fr)
ISSN 1290-3930

Abstract of recently accepted papers

An Abundance Analysis of the New Carbon-Rich Proto-Planetary Nebula IRAS 06530−0213

Bruce J. Hrivnak[1] *and Bacham E. Reddy*[2]

[1] Department of Physics and Astronomy, Valparaiso University, Valparaiso, IN 46383, USA

[2] Department of Astronomy, University of Texas, Austin, TX 78712, USA

In this paper, we present a study of the proto-planetary nebula (PPN) IRAS 06530−0213 based on low- and high-resolution spectra. The low-resolution spectrum shows that star is an F5 supergiant with molecular C_2 and C_3 and enhanced s-process lines. From the high-resolution spectra, the following atmospheric parameters were determined: $T_{\rm eff}$ = 6900 K, log g = 1.0 and $\xi_{\rm t}$ = 4.5. Abundance analysis shows that IRAS 06530−0213 is metal-poor ([Fe/H]=−0.9) and overabundant in carbon ([C/Fe]=1.3), nitrogen ([N/Fe]=1.0), and s-process elements ([s-process/Fe]=1.9), indicating AGB nucleosynthesis and deep convective mixing. From the analysis of circumstellar C_2 and CN molecular bands in the spectrum of IRAS 06530−0213, an envelope expansion velocity of $V_{\rm exp}$= 14±1 km s^{-1} was determined, a typical value for post-AGB stars. Also typical of PPNs is the double-peaked spectral energy distribution. The properties of both the photosphere and circumstellar envelope suggest that IRAS 06530−0213 is unambiguously a low-mass, carbon-rich PPN. For comparison purposes, new, high-resolution spectra of the well-known PPN HD 56126 (IRAS 07134+1005) was also analyzed and compared with previous results.

To appear in the ApJ (June 20, 2003)

Preprints can be obtained by contacting bruce.hrivnak@valpo.edu
WWW *or via WWW on* http://arXiv.org/abs/astro-ph/0303234 *or via anonymous ftp on*
ftp://nebulae.valpo.edu/pub/preprints/i06530.pdf

Three-component modeling of C-rich AGB star winds. II. The effects of drift in long-period variables

C. Sandin and S. Höfner

Department of Astronomy and Space Physics, Box 515, S-75120 Uppsala, Sweden

We present three-component wind models for carbon rich pulsating AGB stars. In particular we study the effects of drift in models of long-period variables, meaning that the dust is allowed to move relative to the gas (drift models). In addition we investigate the importance of the degree of variability of the wind structures. The wind model contains separate conservation laws for each of the three components of gas, dust and the radiation field. We use two different representations for the gas opacity, resulting in models with different gas densities in the wind. The effects which we investigate here are important for the understanding of the wind mechanism and mass loss of AGB stars. This study is hereby a necessary step towards more reliable interpretations of observations. We find that the effects of drift generally are significant. They cannot be predicted from models calculated without drift. Moreover, the non-drift models showing the lowest mass loss rates, outflow velocities, and the smallest variability in the degree of condensation do not form drift model winds. The wind formation in drift models is, except for a few cases, generally less efficient and the mass loss consequently lower than in the corresponding non-drift models. The effects of drift are generally larger in the more realistic models using that representation of the gas opacity which results in lower densities. The outflow properties of these models are also – for all cases we have studied – sensitive to the period of the stellar pulsations. A check of the mass loss rates against a (recent) fit formula shows systematically lower values, in particular in the more realistic models with a low density. The fit is in its current form inapplicable to the new models presented here.

Accepted by Astronomy & Astrophysics

Preprints can be obtained by contacting Christer.Sandin@astro.uu.se
or via WWW on http://arxiv.org/abs/astro-ph/0304278

The radially expanding molecular outflow of VX Sagittarii

K. Murakawa[1], *J.A. Yates*[1,3], *A.M.S. Richards*[2], *R.J. Cohen*[2]

[1] Division of Physics and Astronomy, University of Hertfordshire, College Lane, Hatfield, AL10 9AB, UK.

[2] Jodrell Bank Observatory, University of Manchester, Jodrell Bank Observatory, Nr Macclesfield, SK11 9DJ, UK.

[3] Department of Physics and Astronomy, University College London, Gower Street, London. WC1E 6BT, U.K.

We used MERLIN to observe 22-GHz H_2O maser emission from the red supergiant VX Sgr in 1994 and 1999. The masers lie in a region 300 – 400 milli-arcsec in diameter. The angular size and the velocity distribution of the masers are similar at both epochs, although the total flux density in 1999 is only half of that seen in 1994.

The maser emission is resolved into clouds of average diameter (11.5 ± 4.0) mas which we infer are ~ 300 times denser than the surrounding wind. The cloud radius is comparable to the stellar radius (Danchi 1994). We have previously found an order of magnitude variation in the size of H_2O clouds around other evolved stars of masses 1 – 20 $M_\odot$ but the average size is consistently proportional to stellar size.

43 out of 92 distinct maser clouds observed in 1994 were matched with clouds seen in 1999. The mean change in position is 10.7 milli-arcsec. The radial component of proper motion is directed away from the centre of expansion and increases with increasing angular separation. There is no significant rotational proper motion. The expansion proper motions are consistent with the maser Doppler velocities if VX Sgr is at (1.8 ± 0.5) kpc.

The maser distribution and kinematics suggest a spheroidal thick shell in which the stellar wind is undergoing radial acceleration, from 10 km s^{-1} at the inner edge of the maser shell to 20 km s^{-1} at the outer edge. We suggest a model for the asymmetric appearance of the maser shell and compare this with the magnetic field direction deduced from OH 1612 MHz maser observations [**?**]. The maser expansion velocities have doubled

between 1983 [?] and 1994, suggesting the entire H_2O maser shell has become more effectively accelerated, on a timescale much longer than the light-crossing time for the maser shell and much shorter than the wind-crossing time.

Accepted by MNRAS

Preprints can be obtained by contacting amsr@jb.man.ac.uk

Mid-IR imaging of the dust shell around the post-AGB star HD 161796

T.M. Gledhill[1] *and J.A. Yates*[2]

[1] Department of Physical Sciences, University of Hertfordshire, College Lane, Hatfield, Hertfordshire AL10 9AB, England

[2] Department of Physics and Astronomy, University College London, Gower Street, London, WC1E 6BT, England

We present mid-IR images of HD 161796 (IRAS 17436+5003), taken with the OSCIR imager on Gemini North, that resolve for the first time the thermal emission structure of the dust shell around this post-AGB star. As well as a basic axisymmetric structure, the observations show deviations from axisymmetry in the dust density and a twist in the symmetry axis. Modelling of the images and of the SED from UV to sub-millimetre wavelengths reproduces all of the axisymmetric features with an equator-to pole density contrast of 6:1 and an inclination of the symmetry axis of 10° to the plane of the sky. We find that a model incorporating small (0.01 μm) grains and a steep ($\propto a^{-6}$) power law size distribution can successfully account for the thermal emission and for the observed degrees of near-IR polarization. Assuming a distance of 1.2 kpc to HD 161796, then the stellar luminosity is 3.4×10^3 $L_\odot$ and the mass of the shell is ~ 0.8 $M_\odot$. This is consistent with a star of initial mass between 1 and 2 $M_\odot$ that has undergone an intensive (2.5×10^{-4} $M_\odot$ yr^{-1}) phase of mass-loss lasting about 3000 yr at the end of the AGB. A current stellar mass of 0.56 $M_\odot$, as indicated by the luminosity, suggests that HD 161796 is a few hundred years into its post-AGB evolution and will take about 5000 yr to evolve from its present temperature of 7500 K to become the central star of an extended elliptical planetary nebula.

Accepted by Monthly Notices of the RAS

Preprints can be obtained by anonymous ftp on ftp://star.herts.ac.uk/pub/Gledhill/papers/hd161796.ps.gz

HIGH-RESOLUTION NEAR-INFRARED IMAGING AND POLARIMETRY OF FOUR PROTO-PLANETARY NEBULAE

Kate Y. L. Su[1,2,3]*, Bruce J. Hrivnak*[2]*, Sun Kwok*[1]*, and Raghvendra Sahai*[4]

[1] Department of Physics and Astronomy, University of Calgary, Calgary, Canada T2N 1N4

[2] Department of Physics and Astronomy, Valparaiso University, Valparaiso, IN 46383

[3] Present address: Steward Observatory, University of Arizona, Tucson, AZ 85721

[4] JPL/Caltech, 4800 Oak Grove Drive, Pasadena, CA 91109

High-resolution near-infrared *HST* NICMOS (F160W, F222M) images and polarization (2 μm) observations were made of four bipolar proto-planetary nebulae (PPNs): IRAS 17150−3224, IRAS 17441−2411, IRAS 17245−3951, and IRAS 16594−4656. The first three of these are viewed nearly edge-on, and for the first time the central stars in them are seen. Color maps reveal a reddened torus between the bipolar lobes in the edge-on cases, with bluer lobes. The polarization values are high, with maximum values ranging from 40 to 80%. The polarization patterns are basically centrosymmetric, with some deviations in the low polarization equatorial regions. For IRAS 17150−3224, circumstellar arcs are seen at 1.6 μm, along with a newly-discovered

loop in the equatorial region. Bright caps are seen at the end of the lobes, indicating that they are not open-ended. A distinct point-symmetric pattern is seen in the strengths of the polarization vectors, especially in IRAS 17150−3224. *HST* NICMOS observations provide a valuable complement to the WFPC2 visible images in deriving the basic structure of bipolar PPNs.

Accepted by Astrnomical Journal

Preprints can be obtained by contact ksu@as.arizona.edu
or via URL http : //katherine.as.arizona.edu/~ksu/cv/su_nicmos7840.ps.gz