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Abstract of recently accepted papers

Near-IR spectroscopy of planetary nebulae precursors

D.A. García-Hernández[1], *A. Manchado*[1,2], *P. García-Lario*[3], *C. Domínguez-Tagle*[1], *G.M. Conway*[4] *and F. Prada*[5]

[1] Instituto de Astrofísica de Canarias, E-38205 La Laguna, Tenerife, Spain

[2] Consejo Superior de Investigaciones Científicas, CSIC

[3] ISO Data Centre, Science Operations and Data Systems Division, Research and Scientific Support Department of ESA, VILSPA, E-28080 Madrid, Spain

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

[5] Centro Astronómico Hispano−Alemán. Apartado de Correos 511, E-04080, Almería, Spain

We present near-IR spectroscopy of a sample of 30 IRAS sources recently identified as late AGB stars, post-AGB stars or early PNe. The spectra obtained are centered at various wavelengths covering the molecular hydrogen v=3D1→0 S(1) 2.122 μm and v=3D2→1

S(1) 2.248 μm emission lines, the recombination lines of hydrogen Brγ 2.166 μm, Pfγ 3.741 μm and Brα 4.052 μm, and the CO[v=3D2→0] first overtone bandhead at 2.294 μm. As a result of these observations we have detected molecular hydrogen emission for the first time in 9 of these sources and confirmed a previous detection by Weintraub et al. (1998). This increases from 4 to 13 the total number of proto-PNe detected in molecular hydrogen. In most cases, the positive detections also show emission in the recombination lines of hydrogen (with the exception of IRAS 17150−3224) indicating that the onset of molecular hydrogen emission takes place in the post-AGB phase, very shortly before the nebula becomes ionized. When the molecular hydrogen is fluorescence-excited the detection rate is found to be directly correlated with the evolutionary stage of the central star, rather than with the nebular morphology. When the temperature of the central star is hot enough, fluorescence excitation can be induced by the absorption of UV photons escaping from the rapidly evolving central post-AGB star. In contrast, shocked-excited molecular hydrogen is detected only in strongly bipolar proto-PNe, sometimes even at an early stage in the post-AGB phase. Shock-excitation is the consequence of the interaction of the fast post-AGB wind with the slow wind material ejected during the AGB. The strong correlation of shocked-excited molecular hydrogen emission with bipolarity found confirms the result previously reported by Kastner et al. (1996) in evolved PNe. However, our results show that this correlation does not exist in the case of fluorescence-excited molecular hydrogen.

Accepted by A&A

Preprints can be obtained by contacting agarcia@ll.iac.es
or via WWW on http://xxx.unizar.es/abs/astro-ph/0203367

The extended atmosphere and evolution of the RV Tau star R Scuti

M. Matsuura[1] *I. Yamamura* [2] *A. A. Zijlstra*[1] *and T. R. Bedding*[3]

[1] Department of Physics, UMIST, P.O. Box 88, Manchester M60 1QD, UK

[2] Institute of Space and Astronautical Science (ISAS), Yoshino-dai 3-1-1, Sagamihara, Kanagawa, 229-8510, Japan

[3] School of Physics, University of Sydney 2006, Australia

We analyze ISO/SWS spectra of the RV Tau star R Scuti. The infrared spectra are dominated by H_2O emission bands. The near- and mid-infrared excess is attributed to H_2O; the dust contribution is less important. We also identify CO, SiO and CO_2 bands. The various molecular emission bands originate from an extended atmosphere, an atmosphere above the photosphere. The extended atmosphere of R Sct is formed from matter which gradually have lifted up from the photosphere through the pulsations of the star. In contrast to the abundant molecules around the star, the silicate dust feature is weak and the dust mass-loss rate is only $\dot{M}_{\rm d} = 10^{-11}$ $M_\odot\,{\rm yr}^{-1}$. This implies that there might be a process to inhibit dust formation from molecules. RV Tau stars are commonly considered as post-AGB stars. While a detached dust envelope around R Sct is consistent with such an interpretation, we show that its period evolution is slower than expected. We argue that R Sct may be a thermal-pulsing AGB star, observed in a helium-burning phase.

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Preprints can be obtained by contacting M.Matsuura (m.matsuura@umist.ac.uk)
or via WWW on http://arXiv.org/abs/astro-ph/0203234

Detections of SiO Masers from the Large-Amplitude Variables in the Galactic Nuclear Disk

Hiroshi Imai[1,2], *Shuji Deguchi*[3], *Takahiro Fujii*[2,4], *Ian S. Glass*[5],
Yoshifusa Ita[6], *Hideyuki Izumiura*[7], *Osamu Kameya*[1,2],
Atsushi Miyazaki[3], *Yoshikazu Nakada*[6]

[1] Mizusawa Astrogeodynamics Observatory, National Astronomical Observatory, Mizusawa, Iwate 023-0861, Japan

[2] VERA Project Office, National Astronomical Observatory, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

[3] Nobeyama Observatory, National Astronomical Observatory, Minamimaki, Minamisaku, Nagano 384-1305, Japan

[4] Faculty of Science, Kagoshima University, 1-21-35 Korimoto, Kagoshima 890-0065, Japan

[5] South African Astronomical Observatory, PO Box 9, Observatory 7935, South Africa

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

[7] Okayama Astrophysical Observatory, National Astronomical Observatory, Kamogata, Asakuchi, Okayama 719-023, Japan

[8] Department of Astronomical Science, The Graduate University for Advanced Studies, Minamimaki, Minamisaku, Nagano 384-1305, Japan

We have surveyed known large-amplitude variables within 15′ of the Galactic center in the SiO $J = 1$–0 $v = 1$ and 2 maser lines at 43 GHz, resulting in 79 detections and 58 non-detections. The detection rate of 58 percent is comparable to that obtained in Bulge IRAS source surveys. SiO lines were also detected from four other sources near the program objects. The SiO detection rate increases steeply with the period, particularly for stars with $P > 500$ d, where it exceeds 80%. We found at a given period that the SiO detection rate is approximately double that for OH. These facts suggest that the large-amplitude variables in the Nuclear Disk region are AGB stars similar in their overall properties to the inner and outer bulge IRAS/SiO sources.

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2MASS observations of spectroscopically identified extragalactic C stars

Serge Demers[1], *Mathieu Dallaire*[1] *and Paolo Battinelli*[2]

[1] Université de Montréal

[2] Osservatorio Astronomico di Roma

We matched spectroscopically identified C stars (from low resolution objective prism surveys) in the Magellanic Clouds with 2MASS sources. We confirm that C stars show a large spread in absolute magnitudes, even in the K_s band. We show that the I and K_s magnitude distributions of a population of C stars (in the LMC) have a similar narrow dispersion if the C stars are selected in a well defined color range. Using magnitude and color criteria, we employ the 2MASS data to identify 26 C stars in the the Fornax dwarf spheroidal galaxy.

The mean K_s magnitude and the mean bolometric magnitude of C stars are found to be slightly brighter in the LMC and SMC when compared to those of the Fornax dwarf spheroidal galaxy. The difference could be explained by ages or/and abundance differences.

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Preprints can be obtained by contacting demers@astro.umontreal.ca

The extended atmosphere and evolution of the RV Tau star R Scuti

M. Matsuura[1] *I. Yamamura* [2] *A. A. Zijlstra*[1] *and T. R. Bedding*[3]

[1] Department of Physics, UMIST, P.O. Box 88, Manchester M60 1QD, UK

[2] Institute of Space and Astronautical Science (ISAS), Yoshino-dai 3-1-1, Sagamihara, Kanagawa, 229-8510, Japan

[3] School of Physics, University of Sydney 2006, Australia

We analyze ISO/SWS spectra of the RV Tau star R Scuti. The infrared spectra are dominated by H_2O emission bands. The near- and mid-infrared excess is attributed to H_2O; the dust contribution is less important. We also identify CO, SiO and CO_2 bands. The various molecular emission bands originate from an extended atmosphere, an atmosphere above the photosphere. The extended atmosphere of R Sct is formed from matter which gradually have lifted up from the photosphere through the pulsations of the star. In contrast to the abundant molecules around the star, the silicate dust feature is weak and the dust mass-loss rate is only $\dot{M}_{\rm d} = 10^{-11}$ $M_\odot\,{\rm yr}^{-1}$. This implies that there might be a process to inhibit dust formation from molecules. RV Tau stars are commonly considered as post-AGB stars. While a detached dust envelope around R Sct is consistent with such an interpretation, we show that its period evolution is slower than expected. We argue that R Sct may be a thermal-pulsing AGB star, observed in a helium-burning phase.

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Preprints can be obtained by contacting M.Matsuura (m.matsuura@umist.ac.uk)
or via WWW on http://arXiv.org/abs/astro-ph/0203234

CK Vul: reborn perhaps, but not hibernating

A. Evans[1], *J. Th. van Loon*[1], *A. A. Zijlstra*[2], *D. Pollacco*[3], *B. Smalley*[1], *V. H. Tyne*[1], *S. P. S. Eyres*[4]

[1]Department of Physics, Keele University, Keele, Staffordshire, ST5 5BG

[2]Astrophysics Group, Department of Physics, UMIST, PO Box 88, Manchester, M60 1QD

[3]Department of Pure & Applied Physics, Queen's University of Belfast, Belfast, BT7 1NN

[4]Centre for Astrophysics, University of Central Lancashire, Preston, PR1 2HE

It has been claimed that CK Vul (the remnant of Nova Vul 1670) may be the oldest recovered 'old nova' and as such provides evidence in support of the hibernation scenario for classical nova systems. However this

interpretation has been challenged. We present 450 μm and 850 μm photometry of CK Vul which cast further doubt on its old nova status. It displays a large far infrared-sub-millimetre flux excess, inconsistent with the properties of an old nova. Furthermore, IRAS images show that CK Vul is located in a 'cavity' in the infrared emission, a feature often associated with planetary nebulae. It seems more likely that CK Vul – and hence Nova Vul 1670 — is (like V605 Aql and V4334 Sgr) an evolved star in the throes of a final thermal pulse.

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Possible detection of V4334 Sgr (Sakurai's Object) at 450 μm and 850 μm

A. Evans[1], *T. R. Geballe*[2], *V. H. Tyne*[1], *D. Pollacco*[3], *S. P. S. Eyres*[4], *B. Smalley*[1]

[1]Department of Physics, Keele University, Keele, Staffordshire, ST5 5BG

[2] Gemini Observatory, 670 N. A'ohoku Place, Hilo, HI 96720

[3]Department of Pure & Applied Physics, Queen's University of Belfast, Belfast, BT7 1NN

[4]Centre for Astrophysics, University of Central Lancashire, Preston, PR1 2HE

We report the possible detection of V4334 Sgr (Sakurai's Object) at 450 μm and 850 μm with SCUBA on the James Clerk Maxwell Telescope. The sub-millimetre photometry, combined with a $1-5\,\mu$m spectrum and 8–10 μm photometry obtained nearly contemporaneously, suggests that the sub-millimetre emission originates in material ejected during the 1995 event. The dust mass is a few $\times 10^{-7}$ M_{odot}, the average mass-loss in the form of dust is few $\times 10^{-8}$ M_{odot} yr^{-1}, and the integrated luminosity is $\log(L/\ L_{odot})$=3.66 for a distance of 2 kpc. The ejected shell had angular diameter $\sim$ 55 mas in 2001 August, and should by now be resolvable in the mid-infrared by 8–10 m class telescopes.

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Two Subclasses of Proto-Planetary Nebulae: Model Calculations

Margaret Meixner[1], *Toshiya Ueta*[1], *Matthew Bobrowsky*[2], *and Angela K. Speck*[1]

[1] Department of Astronomy, University of Illinois at Urbana-Champaign, MC-221, Urbana, IL 61801, USA

[2] Challenger Center for Space Science Education, 1250 North Pitt Street, Alexandria, VA 22314, USA

We use detailed radiative transfer models to investigate the differences between the Star-Obvious Low-level-Elongated proto-planetary nebulae (SOLE PPNs) and DUst-Prominent Longitudinally-EXtended proto-planetary nebulae (DUPLEX PPNs) which are two subclasses of PPNs suggested by Ueta, Meixner, and Bobrowsky (2000). We select one SOLE PPN, HD 161796, and one DUPLEX PPN, IRAS 17150−3224, both of which are well studied and representative of their PPN classes. Using an axisymmetric dust shell radiative transfer code, we model these two sources in detail and constrain their mass-loss histories, inclination angles and dust composition. The physical parameters derived for HD 161796 and IRAS 17150−3224 demonstrate that they are physically quite different and that their observed differences can not be attributed to inclination angle effects. Both HD 161796 and IRAS 17150−3224 are viewed nearly edge-on. However, the more intensive axisymmetric superwind mass loss experienced by IRAS 17150−3224 (8.5×10^{-3} $M_\odot$ yr^{-1} and an $\dot{M}_{equator}/\dot{M}_{pole} = 160$) has created a high optical depth dust torus (A_V=37) which obscures its central star. In contrast, HD 161796, which underwent a lower rate superwind ($\dot{M} = 1.2 \times 10^{-4}$ $M_\odot$ yr^{-1} and an $\dot{M}_{equator}/\dot{M}_{pole} = 9$), has an optically thinner dust shell which allows the penetration of direct star light. Based on our analysis of the dust composition, which is constrained by dust optical constants derived from laboratory measurements, both objects contain oxygen rich dust, mainly amorphous silicates, but with some significant differences. IRAS 17150−3224 contains only

amorphous silicates with sizes ranging from 0.001 μm to larger than $\sim$200 μm. HD 161796 contains amorphous silicates, crystalline silicates (enstatite and forsterite), and crystalline water ice with sizes ranging from 0.2 μm to larger than $\sim$ 10 μm. If these calculations reflect a more general truth about SOLE vs. DUPLEX PPNs, then these two subclasses of PPNs are physically distinct with the SOLE PPNs derived from low mass progenitors and DUPLEX PPNs derived from high mass progenitors.

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The Massive Disk Around OH 231.8+4.2

M. Jura[1], *C. Chen*[1], *P. Plavchan*[1]

[1] Department of Physics and Astronomy, UCLA, Los Angeles CA 90095-1562, USA

We have obtained 11.7 micron and 17.9 micron images at the Keck I telescope of the circumstellar dust emission from OH 231.8+4.2, an evolved mass-losing red giant with a well studied bipolar outflow. We detect both a central unresolved point source and extended emission which is aligned with the bipolar outflow seen on larger scales. We find that the unresolved central source can be explained by an opaque, flared disk with an outer radius near 300 AU and an outer temperature of about 130 K. One possible model to explain this flaring is that the material in the disk is orbiting the central star and not simply undergoing a radial expansion.

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Preprints can be obtained by contacting jura@astro.ucla.edu

Water vapor masers in stars departing from the AGB

D. Engels[1]

[1] Hamburger Sternwarte, Gojenbergsweg 112, D-21029 Hamburg, Germany

The 22 GHz water vapor masers of four "non-variable" OH/IR stars considered to be young Proto-Planetary Nebulae (PPNs) were monitored for more than 10 years. In two of them, OH 15.7+0.8 and OH 17.7–2.0 having Mira-like line profiles, the maser flux decreased and the maser finally disappeared. The decrease of the maser brightness is spectacular for OH 17.7–2.0 in particular. The maser had a flux density of several hundred Jansky in the eighties and is now absent since 1990. The masers of OH 15.7+0.8 and OH 17.7–2.0 probably emerged in the "dying AGB wind" during the mass loss reduction process accompanying the departure from the AGB. The other two, OH 12.8–0.9 and OH 37.1–0.8, have double-peaked profiles with a considerably larger velocity spread than the OH masers in these sources. The velocities are incompatible with the spherical symmetric mass loss process on the AGB and give evidence for the presence of probably bipolar outflows with a projected velocity of $v_e \approx 28$ km s-1 during the very early PPN phase. The gross structure of their profiles was rather stable during the monitor period while individual maser lines appeared and disappeared. An increase of the velocity range was found in both sources implying that the outflow is accelerating. Analysis of the profile variations of all four objects suggests a lifetime of individual maser components of 1–3 years. There is no evidence for ordered motion traced by the masers. The H_2O maser properties of all these objects are strongly different from those of ordinary OH/IR stars, allowing to find new young PPNs among optically still hidden objects by looking for irregular maser profiles. In contrast to current definitions in the literature "non-variable" OH/IR stars are proposed to be classified as (young) PPNs. It is argued that beyond the end of the AGB, maser properties cannot be used to infer the evolutionary stage of the objects in transition to Planetary Nebulae.

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A new look at the evolution of Wolf-Rayet central stars of PN

Orsola De Marco[1] *and Noam Soker2*[2]

[1] Department of Astrophysics, American Museum of Natural History
Central Park West at 79th Street, New York, NY 10024
[2] Department of Astronomy, University of Virginia
on sabbatical from Department of Physics, University of Haifa at Oranim
Oranim, Tivon 36006, ISRAEL

On the basis of recent observational evidence and new theoretical results, we construct a speculative scenario for the evolution of Wolf-Rayet central stars of planetary nebula. Although single star evolutionary calculations have recently succeeded in reproducing the composition of these objects, it is clear from the latest infra-red observations that a new perspective has to be adopted: the simultaneous presence of carbon- and oxygen-rich dust (double dust chemistry), while being a rare phenomenon for H-rich central stars, is found around the vast majority of cool Wolf-Rayet central stars. This correlation between Wolf-Rayet characteristics and double dust chemistry points to a common mechanism. Within the binary evolution framework established by Soker, two scenarios are proposed, responsible for the majority (80-85%) and minority (15-20%) of Wolf-Rayet central stars. In the first scenario, proposed here for the first time, a low mass main sequence star, brown dwarf or planet spirals into the Asymptotic Giant Branch star inducing extra mixing, hence a chemistry change, and terminating the Asymptotic Giant Branch evolution. In the second scenario, previously proposed, a close binary companion is responsible for the formation of a disk around either the binary or the companion. This long-lived disk harbors the O-rich dust. Both models are *speculative*, although supported by several observations and recent theoretical results.

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What are the Hot R Coronae Borealis Stars?

Orsola De Marco[1]*, Geoffrey C. Clayton*[2]*, F. Herwig*[3]*, D.L. Pollacco*[4] *J.S. Clark*[5] *& David Kilkenny*[6]

[1]Department of Astrophysics, American Museum of Natural History, New York, NY 10024-5192
[2]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803
[3]University of Victoria, Box 3055, Victoria B.C., V8W 3P6, Canada
[4]Department of Pure and Applied Physics, Queen's University Belfast, University Road, Belfast BT7 1NN, UK
[5]Department of Physics & Astronomy, University College London, Gower Street, London WC1E 6BT, UK
[6]South African Astronomical Observatory, P.O. Box 9, Observatory 7935, South Africa

We investigate the evolutionary status of four stars: V348 Sgr, DY Cen and MV Sgr in the Galaxy and HV 2671 in the LMC. These stars have in common random deep declines in visual brightness which are characteristic for R Coronae Borealis (RCB) stars. RCB stars are typically cool, hydrogen deficient supergiants. The four stars studied in this paper are hotter (T_{eff} = 15-20 kK) than the majority of RCB stars (T_{eff} = 5000-7000 K). Although these are commonly grouped together as the *hot RCB stars* they do not necessarily share a common evolutionary history. We present new observational data and an extensive collection of archival and previously-published data which is reassessed to ensure internal consistency. We find temporal variations of various properties on different time scales which will eventually help us to uncover the evolutionary history of these objects. DY Cen and MV Sgr have typical RCB helium abundances which excludes any currently known post-AGB evolutionary models. Moreover, their carbon and nitrogen abundances present us with further problems for their interpretation. V348 Sgr and HV 2671 are in general agreement with a born-again post-AGB evolution and their abundances are similar to Wolf-Rayet central stars of PN. The three Galactic stars in the sample have circumstellar nebulae which produce forbidden line radiation (for HV 2671 we have no information). V348 Sgr and DY Cen have low density, low expansion velocity nebulae (resolved in the case of V348 Sgr), while MV Sgr has a higher density,

higher expansion velocity nebula. All three stars on the other hand have split emission lines which indicate the presence of an equatorial bulge but *not* of a Keplerian disk. In addition, the historical light-curves for the three Galactic hot RCB stars, show evidence for a significant fading in their maximum-light brightnesses of ∼1 mag over the last 70 yr. From this we deduce that their effective temperature increased by a few thousand degrees. If V348 Sgr is a born-again star, as we presume, this means that the star is returning from the born-again AGB phase to the central star of PN phase. Spectroscopically, no dramatic change is observed over the last 50 years for V348 Sgr and MV Sgr. However, there is some evidence that the winds of V348 Sgr and DY Cen have increased in strength in the last decade. HV 2671, located in the LMC has not been analyzed in detail, but at 5-Å resolution is almost identical to V348 Sgr. Through the bolometric correction derived for V348 Sgr and the known distance, we can estimate the absolute V magnitude of HV 2671 (M_V = –3.0 mag) and its bolometric luminosity (∼6000 $L_\odot$).

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Submillimetre photometry of post-AGB stars

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

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

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

Stars in the post-AGB phase of evolution are surrounded by detached circumstellar envelopes containing dust which emits thermally in the mid- and far-IR. Here we present 850 μm SCUBA photometry of nine candidate post-AGB stars. All targets are detected at 850 μm and we use these fluxes to estimate the envelope dust masses and, by comparison to the 100 μm *IRAS* fluxes, the dust emissivity index.

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VLA Observations of H I in the Helix Nebula (NGC 7293)

Luis F. Rodríguez[1], *W. M. Goss*[2], *and Robert Williams*[3]

[1] Instituto de Astronomía, Campus UNAM, Morelia, Michoacán 58190, México

[2] National Radio Astronomy Observatory, P.O. Box O, Socorro, NM 87801-0387

[3] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218

We report the detection of 21-cm line emission from H I in the planetary nebula NGC 7293 (the Helix). The observations, made with the Very Large Array, show the presence of a ring of atomic hydrogen that is associated with the outer portion of the ionized nebula. This ring is most probably gas ejected in the AGB phase that has been subsequently photodissociated by radiation from the central star. The H I emission spreads over ∼50 km s^{-1} in radial velocity. The mass in H I is ∼0.07 $M_\odot$, about three times larger than the mass in molecular hydrogen and comparable with the mass in ionized hydrogen.

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HST observations of the protoplanetary nebula OH 231.8+4.2: The structure of the jets and shocks

V. Bujarrabal[1], *J. Alcolea*[2], *C. Sánchez Contreras*[3], *and R. Sahai*[3]

[1] Observatorio Astronómico Nacional (IGN), Apdo. 1143, E-28800 Alcalá de Henares, Spain

[2] Observatorio Astronómico Nacional (IGN), C/ Alfonso XII, 3, E-28014 Madrid, Spain

[3] Jet Propulsion Laboratory, MS 183-900, California Institute of Technology, Pasadena, CA 91109

We present high-resolution images obtained with the WFPC2, on board the *HST*, of the protoplanetary nebula (PPN) OH 231.8+4.2. Hα and NII line emission and scattered light in the continuum at 6750 and 7910 Å were observed. We also discuss NIR NICMOS images from the *HST* archive. The images show with high accuracy the shape and excitation state of the shocks developed in the nebula. Our high-resolution images (and data from other works) allow a very detailed and quantitative description of the different nebular components and of the physical conditions in them. We interpret specific structures identified in our images using existing models of shock interaction. In the center of the nebula, there is a dense torus- or disk-like condensation continued by an hourglass-like structure, with relatively high densities ($\sim 10^5 - 10^6$ cm^{-3}) and temperatures ($\sim$ 30 K). Inside this torus we have identified the location of the central star, from SiO maser observations. Two shock regions are detected from the optical line emission images, respectively in the north and south lobes. In both regions, a forward and a backward shock are identified. The densities of this hot gas vary between 40 and 250 cm^{-3}, with the densest clumps being placed in the reverse shocks. The total mass of the shocked hot gas is $\sim$ 2 10^{-3} $M_\odot$, both lobes showing similar masses in spite of their different extents. The relatively collimated jet that impinges on an originally slow shell, so producing the shocks, is identified from the scattered light images and in CO maps. This flow is significantly denser and cooler than the shocked Hα regions. Its density decreases with the distance to the star, with typical values $\sim 10^5 - 10^4$ cm^{-3}, and its temperature ranges between about 25 and 8 K. We explain the high Hα emission of the backward shock assuming that it propagates in a diffuse gas component, entrained by the observed collimated flow and sharing its axial movement. The existence of shocks also in the collimated densest flow is suggested by the high abundance of some molecules like HCO^+ and its structure and kinematics in certain regions, but they are not seen in Hα emission, probably because of the absence of (well developed) hot components in this dense flow. We think that the exceptionally detailed and quantitative image derived for the wind interaction regions in OH 231.8+4.2 is a challenge to check and improve hydrodynamical models of wind interaction in PPNe.

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Unveiling the structure of the planetary nebula M 2-48: Kinematics and physical conditions.

LL. López-Martín[1,2], *J. A. López*[3], *C. Esteban*[1], *R. Vázquez*[3], *A. Raga*[4], *J. M. Torrelles*[5], *L. F. Miranda*[6], *J. Meaburn*[7], *and L. Olguín*[8]

[1] Instituto de Astrofísica de Canarias, c/Vía Láctea s/n, 38200 La Laguna, Tenerife, Spain

[2] Observatoire de Paris, DEMIRM, UMR 8540 du CNRS, 61 Avenue de l'Observatoire, 75014 Paris, France

[3] Instituto de Astronomía, UNAM, Km 103, Carretera Tijuana-Ensenada, 22860 Ensenada, B. C., Mexico

[4] Instituto de Ciencias Nucleares, Circuito de la Investigación Científica, 04510 Cd. Universitaria, D. F., Mexico

[5] Institut d'Estudis Espacials de Catalunya and Instituto de Ciencias del Espacio (CSIC), Edifici Nexus, c/ Gran Capitá 2-4, 08034, Barcelona, Spain

[6] Instituto de Astrofísica de Andalucía, CSIC, c/ Sancho Panza s/n, 18008 Granada, Spain

[7] Astronomy Department, University of Manchester, Jodrell Bank, Macclesfield, Cheshire SK11 9DL, UK

The kinematics and physical conditions of the bipolar planetary nebula M 2-48 are analysed from high and low dispersion long-slit spectra. Previous CCD narrow-band optical observations have suggested that this nebula

is mainly formed by a pair of symmetric bow-shocks, an off-center semi-circular shell, and an internal bipolar structure. The bipolar outflow has a complex

structure, characterised by a series of shocked regions located between the bright core and the polar tips. There is an apparent kinematic discontinuity between the bright bipolar core and the outer regions. The fragmented ring around the bright bipolar region presents a low expansion velocity and could be associated to ejection in the AGB-PN transition phase, although its nature remains unclear. The chemical abundances of the central region are derived, showing that M 2-48 is a Type I planetary nebula (PN).

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