THE AGB NEWSLETTER

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

No. 44 — 01 December 1997

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

Abstracts of recently accepted papers

Multiple Molecular Winds in Evolved Stars I. A Survey of CO(2-1) and CO(3-2) Emission from 45 Nearby AGB Stars

G.R. Knapp[1], *K. Young*[2], *E. Lee*[1], *and A. Jorissen*[3]

[1] Princeton University Observatory, Princeton, NJ 08544, USA

[2] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA

[3] Institut d'Astronomie et d'Astrophysique, Universit Libre de Bruxelles, B-1050 Bruxelles, Belgium

This paper describes observations of a new phenomenon in evolved mass-losing AGB stars: the presence of two winds with different expansion velocities. CO(2-1) and CO(3-2) line emission was observed for 45 AGB stars at high velocity resolution and double winds found in 20other stars. The data tentatively suggest that double winds occur when the star undergoes a change (pulsational mode, chemical composition) and that the very narrow components represent the onset of a new phase of mass loss.

Accepted by Astrophysical Journal Supplements *For preprints, contact* gk@astro.princeton.edu *or http://astro.princeton.edu/~library/prep.html*

The circumstellar shell of the post-AGB star HD 56126: the $^{12}CN/^{13}CN$ isotope ratio and fractionation

Eric J. Bakker and David L. Lambert

Department of Astronomy and W. J. McDonald Observatory, University of Texas, Austin, TX 78712-1083, USA, ebakker@astro.as.utexas.edu, dll@astro.as.utexas.edu

We have detected circumstellar absorption lines of the ^{12}CN and ^{13}CN Violet and Red System in the spectrum of the post-AGB star HD 56126. From a synthetic spectrum analysis, we derive a Doppler broadening parameter of $b = 0.51 \pm 0.04$ km s^{-1}, $^{12}CN/^{13}CN = 38 \pm 2$, and a lower limit of 2000 on $^{12}CN/^{14}CN$ and $^{12}C^{14}N/^{12}C^{15}N$. A simple chemical model has been computed of the circumstellar shell surrounding HD 56126 that takes into account the gas-phase ion-molecule reaction between CN and C^+. From this we infer that this reaction leads to isotopic fractionation of CN. Taking into account the isotopic exchange reaction and the observed $^{12}CN/^{13}CN$ we find $^{12}C/^{13}C \sim 67$ (for $T_{\rm kin} = 25$ K). Our analysis suggests that ^{12}CN has a somewhat higher rotational temperature than ^{13}CN: $T_{\rm rot} = 11.5 \pm 0.6$ and 8.0 ± 0.6 K respectively. We identify possible causes for this difference in excitation temperature, among which the N'' dependence of the isotopic exchange reaction.

Accepted by ApJ *Preprints can be obtained by contacting* ebakker@astro.as.utexas.edu or from http://viking.as.utexas.edu:8080/articles.html

The Lutz-Kelker bias in trigonometric parallaxes

René D. Oudmaijer[1], Martin A.T. Groenewegen[2] & Hans Schrijver[3]

[1]Blackett Laboratory, Imperial College of Science, Technology and Medicine, Prince Consort Road, London SW7 2BZ, U.K.
[2]Max-Planck-Institut für Astrophysik, Karl-Schwarzschild-Straße 1, D-85740 Garching, Germany
[3]SRON, Sorbonnelaan 2, NL-3584 CA Utrecht, The Netherlands

The theoretical prediction that trigonometric parallaxes suffer from a statistical effect, has become topical again now that the results of the Hipparcos satellite have become available. This statistical effect, the so-called Lutz-Kelker bias, causes measured parallaxes to be too large. This has the implication that inferred distances, and hence inferred luminosities are too small. Published analytic calculations of the Lutz-Kelker bias indicate that the inferred lumonosity of an object is, on average, 30% to small when the error in the parallax is only 17.5%. Yet, this bias has never been determined empirically. In this paper we investigate whether there is such a bias by comparing the best Hipparcos parallaxes which ground-based measurements. We find that there is indeed a large bias affecting parallaxes, with an average and scatter comparable to predictions. We present a simple method to correct for the LK bias, and apply it successfully to a sub-sample of our stars. We then analyze the sample of 26 'best' Cepheids used by Feast & Catchpole (1997) to derive the zero point of the Period-Luminosity relation. The final result is based on the 20 fundamental mode pulsators and leads to a distance modulus to the Large Magellanic Cloud - based on Cepheid parallaxes - of 18.56 ± 0.08, consistent with previous estimates.

Accepted by MNRAS, pink pages *For preprints, contact* r.oudmaijer@ic.ac.uk*, or look at* http://www.mpa-garching.mpg.de/~groen/groen.html

Obscured Asymptotic Giant Branch stars in the Magellanic Clouds IV. Carbon stars and OH/IR stars

Jacco Th. van Loon[1,2], Albert A. Zijlstra[1], Patricia A. Whitelock[3], Peter te Lintel Hekkert[4], Jessica M. Chapman[5,6], Cecile Loup[7,8], M.A.T. Groenewegen[9], L.B.F.M. Waters[2,10] and Norman R. Trams[11]

[1] European Southern Observatory, Karl-Schwarzschild Straße 2, D-85748 Garching bei München, Germany

[2] Astronomical Institute, University of Amsterdam, Kruislaan 403, NL-1098 SJ Amsterdam, The Netherlands

[3] South African Astronomical Observatory, P.O.Box 9, 7935 Observatory, Republic of South Africa

[4] Australia Telescope National Facility, Parkes Observatory, P.O.Box 276, Parkes, NSW 2870, Australia

[5] Anglo-Australian Observatory, P.O.Box 296, Epping, NSW 2121, Australia

[6] Australia Telescope National Facility, P.O.Box 76, Epping, NSW 2121, Australia

[7] European Southern Observatory, Casilla 19001, Santiago 19, Chile

[8] Institut d'Astrophysique de Paris, 98bis Boulevard Arago, F-75014 Paris, France

[9] Max-Planck Institut für Astrophysik, Karl-Schwarzschild Straße 1, D-85740 Garching bei München, Germany

[10] Space Research Organization Netherlands, Landleven 12, NL-9700 AV Groningen, The Netherlands

[11] ISO Science Operations Centre, Astrophysics Division of ESA, Villafranca del Castillo, P.O.Box 50727, E-28080 Madrid, Spain

We present N-band photometry for a sample of 21 dust-enshrouded AGB stars in the Large Magellanic Cloud, and three additional sources in the Small Magellanic Cloud. Together with near-infrared photometry, this is used to give a tentative classification into carbon and oxygen-rich atmospheres. Bolometric luminosities are also estimated for these stars. In addition, we present the results of a survey for OH masers in the LMC, which resulted in the discovery of OH maser emission from IRAS04407–7000. Spectra between 600 and 1000 nm have been obtained for two heavily obscured AGB stars in the LMC, confirming them to be highly reddened very late M-type giants. Because the dust-enshrouded stars are clearly undergoing heavy mass loss they are assumed to be very near the termination of their respective Asymptotic Giant Branch phases. The fraction of mass-losing carbon stars decreases with increasing luminosity, as expected from Hot Bottom Burning. The best candidate carbon star, with $M_{\rm bol} \sim -6.8$ mag, is the most luminous mass-losing carbon star in the Magellanic Clouds,

and amongst the most luminous AGB stars. At lower luminosities ($M_{\rm bol} \sim -5$ mag) both oxygen and carbon stars are found. This may be explained by a range in metallicity of the individual mass-losing AGB stars.

Accepted by Astronomy and Astrophysics, Main Journal *Preprints can be obtained by contacting* jvanloon@astro.uva.nl

Temperature fluctuations and chemical homogeneity in the planetary nebula NGC 4361

X.-W. Liu

Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, UK

We have obtained deep long-slit spectra of NGC 4361 between $\lambda\lambda$4000-4975 at a spectral resolution of 1.5 Å. The spectra were used to map the C II, C III and C IV recombination lines and the resulting C^{2+}/H^+, C^{3+}/H^+ and C^{4+}/H^+ ionic abundances across the nebular surface. Our results confirm the high recombination line C abundance derived by Torres-Peimbert, Peimbert & Peña (1990, TPPP hereafter) – the C^{2+}/H^+ and C^{3+}/H^+ ionic abundances derived from recombination lines are respectively a factor of $\sim$ 15 and $\sim$ 5 higher than the corresponding values derived from the UV collisionally excited C III] λ1908 and C IV λ1549 lines. The recombination line C abundance is found to be constant across the nebula within the measurement uncertainties ($\leq$ 0.2 dex), as opposed to the model proposed by TPPP which predicts a C-rich inner zone with a C/H abundance ratio two orders of magnitude higher than in the outer regions.

We have also detected the N III λ4379 and O IV λ4632 recombination lines from NGC 4361. The N^{3+}/H^+ abundance ratio derived from the λ4379 line is at least a factor of ten higher than the upper limit from the UV collisionally excited N IV] λ1487 line.

There is clear evidence of temperature variations across the nebular surface, with an amplitude of $\pm$1 000 K around a mean value of 18 000 K, probably produced by shock heating. The observed temperature fluctuations are however too small to have a significant effects on the ionic abundances derived from collisionally excited lines. Observations with higher spatial and spectral resolution might quantify better the amplitude of temperature fluctuations and their effects on abundance determinations.

We have obtained the first reliable measurement of the abundance of fluorine for a planetary nebula. From the [F IV] λ4060 line, a F/H abundance ratio of 4.5×10^{-8} is found. The [F/O] and C/O abundance ratios derived for NGC 4361 are roughly in agreement with the correlation found between these two quantities among red giant and AGB stars.

Accepted by MNRAS. *For preprints, contact* xwl@star.ucl.ac.uk

A thin molecular shell around the carbon star TT Cyg

H. Olofsson[1], *P. Bergman*[2], *R. Lucas*[3], *K. Eriksson*[4], *B. Gustafsson*[4], *and J.H. Bieging*[5]

[1] Stockholm Observatory, SE-133 36 Saltsjöbaden, Sweden

[2] Onsala Space Observatory, SE-439 92 Onsala, Sweden

[3] IRAM, 300, rue de la Piscine, F-38406 Grenoble-Cedex, France

[4] Uppsala Astronomical Observatory, Box 515, SE-75120 Uppsala, Sweded,

[5] Steward Observatory, Univ. of Arizona, Tucson, AZ 85721, USA

Interferometric CO(J=1–0 and 2–1) observations reveal a remarkably thin shell of molecular gas around the carbon star TT Cyg, width/radius $\leq 1.3''/34'' \approx 0.04$. It expands at $\approx$13 km s^{-1}, and contains $\sim$0.02 $M_\odot$ of gas provided the CO abundance with respect to H_2 is 10^{-3} and the distance is 1 kpc. Only about a quarter of the shell has been mapped, but we infer an overall spherical shell with only small, but clear, deviations at the

per cent level. The radial structure of the shell is barely resolved at the arc second level, but there exists weak emission extending a few arc seconds inwards from the peak. A drastic change in mass loss properties, possibly combined with the effects of interacting winds, provides the most likely explanation to the origin of the shell.

Accepted by Astronomy and Astrophysics. *Preprints can be obtained via anonymous ftp on* ftp://hp5.astro.su.se/pub/preprints/ttcyg_aaa.ps.gz

The Evolution of the Final Helium Shell Flash Star V605 Aquilae, from 1917 to 1997

G.C. Clayton[1] *and O. De Marco*[2]

[1] Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803

[2] ETHZ, Institut für Astronomie, HAA C13, Hädldeliweg 15, CH-8092 Zürich

Only three stars have been observed going through a final helium shell flash since the advent of modern instrumentation, FG Sagittae (in 1894), V605 Aquilae (in 1919) and Sakurai's Object (in 1996). In this paper, we present for the first time a spectrum taken of V605 Aql while it was in its cool giant phase in 1921. This spectrum is identical to that typically seen in R Coronae Borealis stars with $T_{eff} \sim 5000$ K. It shows strong Swan bands of C_2 and the violet CN bands as well as weak or absent hydrogen features and little or no evidence of ^{13}C. The star reached $M_B \sim -4.7$ at its outburst peak in 1919 assuming a distance of 3.5 kpc.

In addition, we discuss ground– and space–based observations of the present state of V605 Aql. The star is very faint ($m_V \lesssim 23$) but a broad C IV λ5800 emission line is seen, indicating V605 Aql now has a Wolf–Rayet–type spectrum with $T_{eff} \geq 50\,000$ K. We argue that the present faintness of the star is likely to be due to a thick cloud of dust, rather than of 1919. The dust is contained in a hydrogen–deficient nebular knot ejected during the final flash and now resolved as a small asymmetrical nebula. The star and knot are at the center of A58, an old Planetary Nebula. Surrounding A58 is a much larger shell–like structure seen in the IRAS 100 μm map. An apparent shell of diameter 40 arc minutes centered on V605 Aql can be seen.

V605 Aql provides a unique opportunity to investigate the evolution of a final flash star over a period of 80 years. In the observed evolution of V605 Aql, we may be seeing the future of Sakurai's object and also a possible link to the formation of R Coronae Borealis stars.

Accepted by Astronomical Journal (December 1997 issue) *Preprints can be obtained by contacting* gclayton@fenway.phys.lsu.edu *or via WWW on* http://www.phys.lsu.edu/faculty/gclayton

The Morphology of Planetary Nebulae: Simulations with Time-Evolving Winds

Vikram V. Dwarkadas[1] *and Bruce Balick*[1]

[1] Department of Astronomy, Univ of WA, Box 351580, Seattle, WA 98195

We have carried out simulations of PNe within the general framework of the Interacting Stellar Winds Models, wherein the fast wind from a central star sweeps up the slow wind emitted in a previous epoch. Our two-dimensional simulations take into account the evolution of the velocity and mass loss rate of the fast wind. This leads to considerably more structure on smaller scales than was seen in those nebulae where the fast wind velocity is held constant. The nebula evolves through an initial momentum-conserving phase before entering the more commonly encountered energy-conserving stage. Both stages are prone to instabilities, which may be the precursor of knots, filaments, and other micro-structures that are now commonly seen in HST images of PNe. In particular we note the occurrence of the Non-Linear Thin Shell Instability in the early stages, and the formation of Rayleigh-Taylor filaments in the energy-conserving stage. The growth of small-scale structure in the momentum-conserving stage is sensitive to the ratio of the initial wind momenta; the lifetime of the

nebula in this stage depends also on the evolution of the wind properties. The overall size scale of the system is determined mainly by the evolution of the fast wind properties. If the evolution is not taken into account when computing kinematic ages then the ages may be underestimated.

Accepted by The Astrophysical Journal *Preprints can be obtained by contacting* vikram@astro.washington.edu

Nonspherical Structures and Temporal Variations in the Dust Shell of o Ceti Observed with a Long Baseline Interferometer at 11 Microns

Lopez[2,1], *B.; Danchi*[2], *W. C.; Bester*[2], *M.; Hale*[3,2], *D. D. S.; Lipman*[2], *E. A.; Monnier*[2], *J. D.; Tuthill*[2], *P. G.; Townes*[2], *C. H.; Degiacomi*[4], *C. G.; Geballe, T. R.; Greenhill*[6], *L. J.; Cruzalebes*[1], *P.; Lefevre*[1], *J.; Mekarnia*[1], *D.; Mattei*[7], *J. A.; Nishimoto*[8], *D.; Kervin*[9], *P. W.*

[1] instituteObservatoire de la Côte d'Azur, Département Fresnel UMR 6528, BP 4229, F-06034 Nice Cedex 4, France

[2] Space Sciences Laboratory, University of California, Berkeley, Berkeley, CA 94720-7450

[3] Allegheny Observatory, University of Pittsburgh

[4] KOSMA, I. Physikalisches Institut, Universität zu Köln, Zülpilcher Strasse, 77 D-50937 Köln, Germany

[5] United Kingdom Infrared Telescope, 660 North A'ohoku Place, University Park, Hilo, HI 96720

[6] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138

[7] American Association of Variable Star Observers, 25 Birch Street, Cambridge, MA 02138

[8] Rockwell Power Systems, 535 Lipoa Parkway, Suite 200, Kihei, HI 96753

[9] USAF Phillips Laboratory, Kihei, HI 96753

Visibility observations at 11 mu m of o Ceti have been made with the University of California (Berkeley) Infrared Spatial Interferometer during the time period 1988–1995. The observed visibilities change dramatically from one epoch to another and are not consistent with simple heating or cooling of the dust with change in luminosity as a function of stellar phase. Instead, large temporal variations in the density of dust within a few stellar radii of the photosphere of o Ceti have occurred. Spherically symmetric models of the dust distribution with two dust shells, one within three stellar radii of the photosphere of the star, the other approximately 10 stellar radii from the star, can account reasonably well for the observed changes. Four types of axially symmetric radiative transfer models were also compared with the data—a spherical shell with an ellipsoidal inner cavity, a disk, a spherical shell with one or two inhomogeneities or clumps, and a set of thin partial shells with a fixed distance between them. Of the four models, only the one with the ellipsoidal inner cavity is excluded. The data were best-fitted with the last two models, which emphasize inhomogeneities or clumps. To fit the observed temporal changes in the visibility data, all models must include a change in the density—increasing and decreasing—of dust close to the photosphere of the star. The axially symmetric models had clumps placed at distances from the star in agreement with distances of the spherical models. Good fits to the observed broadband spectrum of the star were also obtained with these models.

Lopez et al. 1997 ApJ 488, 807 *Preprints can be obtained by contacting* lopez@obs-nice.fr *via WWW on* http://adsabs.harvard.edu/cgi-bin/nph-bib_query

DENIS Survey of AGB and Tip-RGB Stars in the LMC Bar West and Optical Center Fields

C. Loup and A. Omont[1], *P.A. Duc, P. Fouqué, and E. Bertin*[2], *and N. Epchtein*[3]

[1] Institut d'Astrophysique de Paris, CNRS

[2] European Southern Observatory (ESO)

[3] DESPA, Observatoire de Paris

We have observed with the DENIS instrument two regions of 22x23', located in the Bar of the LMC, and overlapping the Bar West and Optical Center fields studied by Blanco et al. (1980, BMB) in a prism-objective survey. Observations were performed simultaneously in the I, J, and K_S bands. There were 376 AGB stars identified in previous studies in these 2 fields. We typically find back 97% of them in the DENIS data. We show that the BMB's M and C stars follow two different sequences in the (I–J,J–K_S) colour-colour diagram. For M stars, the [I–J] colour is an indicator of the M subtype, increasing from 0.9 to 1.8 as one goes from M0 to M7 spectral types, while the [J–K_S] colour remains almost constant (from 1.0 to 1.35). Conversely, C stars are located on a "redening" branch, with [J–K_S] ranging from 1.0 to about 2.2. M and C stars discovered by BMB have no or faint mass-loss. The (I–J,J–K_S) diagram allows to define a simple criterium to select stars of spectral types M and C. With this criterium, we find a total of 1177 new AGB and tip-RGB stars candidates, and have calculated the bolometric luminosities of all of them as well as previously known stars, assuming a distance modulus of 18.55. 90% of the new candidates are blue sources, not searched for in a complete way by BMB. Their luminosity distribution shows a very clear peak at $M_{bol} \simeq -3.5$, that we interpret as the tip of the Red Giant Branch. A second group is formed by stars for which the BMB survey should have been complete (i.e. relatively red C stars and M stars with spectral type later than M5.5). We find, howver, 23% and 38% more such stars than they do in the Bar West and Optical Center, respectively.

Finally, we also discover in this study 42 red sources, with $2.2 <$ [J–K_S] < 4.2. These stars experience mass-loss at significant rates. Note that there might be redder obscured AGB stars in the fields, but that the DENIS limiting magnitudes do not allow to detect sources with [J–K_S] larger than about 4. Only 4 of them have an IRAS counterpart. It is interesting to note that we discover 42 mass-loosing AGB stars in 0.14 square degrees, while only about 50 have been discovered in the whole LMC using the IRAS data. The luminosity distribution of these red sources is very similar to the one of the BMB's C stars, ranging from $M_{bol} \simeq -3.5$ to -6.

Proceedings of the third Euroconference on near IR surveys, helded in June 1997 at Meudon Observatory, France, in press. *Preprints can be obtained by contacting* loup@iap.fr

The WC10 central stars CPD–56° 8032 and He 2–113: II. Model analysis and comparison with nebular properties

Orsola De Marco & Paul A. Crowther

Department of Physics and Astronomy, University College London, Gower Street, London, WC1E 6BT, UK

We present detailed atmospheric analyses of two [WC10] central stars of planetary nebulae, CPD–56°8032 and He 2–113, the results of which are compared with parameters inferred from their nebular properties. Our quantitative study is based on modelling diagnostic He I-II, C II-IV and O II-III lines identified in high resolution AAT–UCLES spectroscopy spanning 3500–9200 Å, using the non-LTE iterative scheme of Hillier (1990). We find that spectroscopic similarities are reflected in the derived stellar properties: for both stars we obtain $T_{\rm eff}\sim$30kK and $\log L/L_{\odot}$=3.7; $\log (\dot{M}/M_{\odot}{\rm yr}^{-1})$=−5.4 for CPD–56° 8032 and $\log (\dot{M}/M_{\odot}{\rm yr}^{-1})$=−6.1 for He 2–113, while v_{∞}=225 and 160 km s^{-1} for CPD–56° 8032 and He 2–113, respectively.

The derived stellar properties are fairly consistent with the recent study of Leuenhagen et al. (1996), when adjusted for the different distances adopted. We find excellent agreement between our C^{2+} wind temperature and the independent determination by De Marco et al. (1998), supporting our assumption of radiative equilibrium. We find that both stars are highly enriched in carbon and oxygen, but with an undetectable stellar hydrogen

content for He 2–113 (in contrast to Leuenhagen et al. 1996). Our final abundance determinations indicate H:He:C:O mass fractions of 0:34:52:14 for CPD–56° 8032 and 0:34:53:13 for He 2–113.

We confront our model flux distributions with observed nebular properties using Zanstra and photoionization techniques and identify a major discrepancy between the observed and predicted nebular properties for these PNe. The hydrogen ionizing fluxes predicted by our WR non–LTE models greatly exceed those implied by nebular observations. The lack of heavy element line blanketing in our wind models could be responsible. However, the geometry and high nebular densities of these PNe indicate that they represent poor probes of the Lyman continuum flux of their central stars.

to appear in *Monthly Notices of the RAS. Preprints can be obtained by contacting* `orsola@astro.phys.ethz.ch` *or via WWW on* `http://www.star.ucl.ac.uk/~pac/publications.html` *or via anonymous ftp on* `ftp://ftp.star.ucl.ac.uk/pub/pac/cspn.ps.gz`

Velocity fields of planetary nebulae

K. Gesicki[1]*, A. Zijlstra*[2]*, A. Acker*[3] *and R. Szczerba*[4]

[1] Centrum Astronomii UMK, ul.Gagarina 11, PL-87-100 Torun, Poland

[2] European Southern Observatory, Karl Schwarzschild Strasse 2, D–85748 Garching b. Muenchen, Germany

[3] Observatoire de Strasbourg, 11, rue de l'université, 67 000 - Strasbourg, France

[4] Nicolaus Copernicus Astronomical Center, ul.Rabianska 8, PL-87-100 Torun, Poland

Density distributions and velocity fields are derived for four spatially resolved planetary nebulae, based on high-resolution long-slit emission line spectra. We use a photo-ionization code to fit the spectra and to derive the nebular structure, assuming spherical symmetry. We present the results for individual nebulae and compare with three objects analyzed earlier. The expansion velocities are found to increase outward: this is shown to be likely related to the presence of an ionization front. Six PN in the sample are found to be ionization bounded. For one object, which has a WR-type central star, a large amount of turbulence or irregular structure in the velocity field is found. The results are in agreement with hydrodynamical calculations, in which the velocities also tend to increase with distance from the star. However, the common presence of an ionization front was not predicted.

Accepted by Astronomy and Astrophysics 8.8.97. *Preprints can be obtained by contacting* gesicki@astri.uni.torun.pl *or via anonymous ftp on* ftp://ftp.ncac.torun.pl/pub/hide/KGE/gzas97.ps.gz

Jobs

Columbia University
Columbia Astrophysics Laboratory
Mail Code 5240
550 W. 120th St.
New York, NY 10027

Attn: Assoc. Prof. Arlin Crotts
email: arlin@astro.columbia.edu

We seek a postdoctoral scientist to conduct research into the circumstellar and interstellar environment of Supernova 1987A. The work would include completed, ongoing and planned observations of SN1987A and its surroundings, including data from IUE, UIT, ISO, HST and ground-based observatories, plus preparation for observations with future ground, airborne and space-based instruments. Research topics include mapping the SN's circumstellar nebula and the interstellar medium of the 30 Doradus region using light echoes, detailing the composition, density and velocity structure of the circumstellar envelope, analyzing polarimetric and photometric properties of surrounding dust, measuring the reflected ultraviolet flux from SN shock breakout, and observing interaction between the SN ejecta and circumstellar envelope during the formation of Supernova Remnant 1987A.

We seek excellent candidates practiced in some of the above observational techniques and knowledgeable concerning circumstellar and interstellar processes. The person selected will study these problems as well as to develop her/his own related investigations, with support for observation, publication and professional travel. This funded position is available for one year with the possible extension to up to three years, starting in mid-to-late 1998. Applicants should provide a curriculum vitae, summary of research, and names of three colleagues willing to write letters of reference, by 2 February 1998 to the address above.

Further information can be found at the website
http://www.astro.columbia.edu/~arlin/sn1987a.html.
Columbia University is an Affirmative Action/Equal Opportunity Employer.