THE AGB NEWSLETTER

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

No. 71 — 01 June 2000

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

Abstract of recently accepted papers

The dust ring around AC Her

M. Jura[1], *C. Chen*[1] *& M. W. Werner*[2]

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

[2] Jet Propulsion Laboratory, 264-767, 4800 Oak Grove Dr., Pasadena CA 91109 USA

We have used the Keck I telescope to obtain images at 11.7 μm and 18.7 μm of AC Her, a post-AGB spectroscopic binary. The source is resolved into two spots separated by about 0.6" which can be explained as emission from particles associated with an edge-on dust ring with a radius of approximately 300 AU that is oriented approximately North-South. We propose that the ring is mainly composed of particles that are larger than 200 μm in radius which are orbiting the binary, while the infrared emission that we observe is emitted by small grains with sizes less than than 1 μm which are not gravitationally bound and, instead, are flowing out in a wind from the ring. We propose that collisions among the larger ring-particles produce the smaller wind-particles. Whether most of the 10^{30} g of dust orbiting AC Her ultimately is expelled in a wind or coalesces into macroscopic objects is unknown.

Accepted by ApJ

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

Isotopic compositions of different presolar SiC size fractions from the Murchison meteorite

Sachiko Amari[1], *Ernst Zinner*[1], *and Roy S. Lewis*[2]

[1] Laboratory for Space Sciences and the Physics Department, Washington University, St. Louis, MO 63130, USA

[2] Enrico Fermi Institute, University of Chicago, Chicago IL 60637, USA

We report measurements of isotopic ratios of C, N, Mg, Si, Ca, Ti, Cr and Fe in bulk samples (aggregates of many grains) of up to seven different fractions of SiC, ranging from 0.38 to 3.0 μm in diameter, from the Murchison CM2 carbonaceous chondrite. $^{12}C/^{13}C$ ratios range from 37 to 42 and $^{14}N/^{15}N$ ratios from 370 to 520, within the range of single grain measurements on coarser samples and in agreement with an asymptotic giant branch (AGB) star origin of most of the grains. Variations among size fractions do not show any simple trend and can be explained by varying contamination with isotopically normal material. Silicon isotopic ratios vary only little and, with one exception, lie to the right of the single-grain mainstream correlation line. This

might indicate a higher percentage of the minor populations Y and Z among finer grain size fractions. All bulk samples have large ^{26}Mg excesses attributed to the presence of short-lived ^{26}Al at the time of grain formation. Inferred ^{26}Al/^{27}Al ratios are much larger than those measured in single larger mainstream grains. This is probably because of the presence of SiC grains of type X; we obtain an estimate of 0.4 for their ^{26}Al/^{27}Al ratio. Our Ca isotopic measurements, the first made on presolar SiC grains, show excesses in ^{42}Ca and ^{43}Ca, in general agreement with theoretical expectations for AGB stars. ^{44}Ca excesses are much larger than expected and are probably due to X grains, which have high ^{44}Ca excesses due to the decay of short-lived ^{44}Ti produced in supernova explosions. We arrive at an estimate of 0.014 for the initial ^{44}Ti/^{48}Ti ratio of the X grains, within the range obtained from previous single X grain measurements. The Ti isotopic ratios of the bulk samples show a V-shaped pattern with excesses of all isotopes relative to ^{48}Ti. ^{46}Ti, ^{47}Ti and ^{50}Ti show excesses relative to the correlation between Ti and Si ratios for single grains and are in general agreement with theoretical models of s-process nucleosynthesis in AGB stars. In contrast, ^{49}Ti does not show any excess relative to the single grain data; it also fails to agree with theory, which predicts much larger excesses than observed. Measured ^{53}Cr/^{52}Cr and ^{57}Fe/^{56}Fe ratios are normal within errors. The first result is expected even for Cr in AGB star envelopes, but the second result suggests that most of the Fe analyzed originates from contamination. We have found no simple trends in isotopic composition with respect to grain size that can be interpreted in terms of nucleosynthetic origin, unlike the results for Kr, Xe, Ba, and Sr.

Accepted by Meteoritic & Planetary Science

Preprints can be obtained by contacting sa@howdy.wustl.edu
or via WWW on http://presolar.wustl.edu/news.html

Infrared Properties of SiO Maser Sources in Late-Type Stars

M. Matsuura[1,2], I. Yamamura[3,1], H. Murakami[1], T. Onaka[2], T. Ootsubo[2], T. Tohya[1,2], Y. Okamura[1,4], M.M. Freund[1,5] and M. Tanaka[1]

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

[2] Department of Astronomy, School of Science, University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-0033, Japan

[3] Astronomical Institute 'Anton Pannekoek', University of Amsterdam, Kruislaan 403, 1098 SJ, Amsterdam, The Netherlands

[4] Department of Physics, University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-0033, Japan [5] Infrared Astrophysics Branch, Code 685, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

Results of an SiO maser survey for the late-type stars selected by the IRTS (Infrared Telescope in Space) are presented. We have detected SiO $J = 1 - 0$, $v = 1$ and/or $v = 2$ lines in 27 stars out of 59 stars. The maser intensity increases with the depth of the H_2O absorption in the infrared spectra and redness of the 2.2 and 12 μm color. The column densities of the water vapor in the target stars are estimated from the depth of the water absorption in the IRTS spectra. We found that the SiO maser was detected mostly in the stars with the column density of water vapor higher than 3×10^{19}–3×10^{20} cm^{-2}. We further estimate the density of hydrogen molecules in the outer atmosphere corresponding to these column densities, obtaining 10^9–10^{10} cm^{-3} as a lower limit. These values are roughly in agreement with the critical hydrogen density predicted by models for the excitation of the SiO masers. It is possible that the SiO masers are excited in clumps with even higher than this density. The present results provide useful information on the understanding of the physical conditions of the outer atmospheres in late-type stars.

Accepted by PASJ

Preprints can be obtained by contacting mikako@astro.isas.ac.jp
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Infrared Colours for Mira-like Long Period Variables found in the Hipparcos Catalogue

Patricia Whitelock[1] *Freddy Marang*[1] *and Michael Feast*[2]

[1] South African Astronomical Observatory, PO Box 9, Observatory, 7935, South Africa.
email: paw@saao.ac.za

[2] Astronomy Department, University of Cape Town, Rondebosch, 7701, South Africa.
email: mwf@artemisia.uct.ac.za

Near-infrared, $JHKL$, photometry is presented for 193 Mira and SR variables which were observed by Hipparcos; periods, bolometric magnitudes and amplitudes are derived for 92 of them. Because of the way the Hipparcos targets were selected, this group of stars provides a useful database of Miras with low mass-loss rates ($\dot{M} \leq 10^{-7}\ M_{\odot} yr^{-1}$). Various period-colour relationships are discussed in detail. The colour, particularly $K-L$, at a given period is found to depend on the pulsation amplitude of the star. A comparison with models suggested this is a consequence of atmospheric extension, in the sense that large amplitude pulsators have very extended atmospheres and redder $K-L$ and $H-K$ but bluer $J-H$ than their lower amplitude counterparts. The stars with very extended atmospheres also have higher values of $K-[12]$ and hence higher mass-loss rates. This finding provides further evidence for the causal connection between pulsation and mass loss. Two sequences are identified in the $Hp-K$ vs. $\log P$ diagram (where Hp is the Hipparcos broad-band magnitude) at short periods ($\log P < 2.35$). At a given period these two groups have, on average, the same pulsation amplitude, but different $JHKL$ colours and spectral types. The short period stars in the bluer sequence have similar near-IR colours to the Miras found in Globular Clusters.

Long-term trends in the IR light-curves are discussed for stars which have sufficient data.

Accepted by MNRAS

Preprints can be obtained by contacting paw@saao.ac.za

Hipparcos Parallaxes for Mira-like Long Period Variables

Patricia Whitelock[1] *and Michael Feast*[2]

[1] South African Astronomical Observatory, PO Box 9, Observatory, 7935, South Africa.
email: paw@saao.ac.za

[2] Astronomy Department, University of Cape Town, Rondebosch, 7701, South Africa.
email: mwf@artemisia.uct.ac.za

This paper concerns the calibration of the K period-luminosity relation for Mira variables using Hipparcos parallaxes. K magnitudes are available for 255 Mira-like variables which were observed by Hipparcos. Period-luminosity zero-points are evaluated for various subgroups of data. The best solution for oxygen-rich Miras, which uses 180 stars, omitting the short period red group (which had different kinematics from the short period blue stars) and the low amplitude variables, provides a zero-point of 0.84 ± 0.14 mag, which implies a distance modulus for the LMC of 18.64 ± 0.14 mag, or perhaps slightly greater if a metallicity correction is required, in good agreement with the value derived from Cepheids. The zero-point of the period-luminosity relation for carbon stars is briefly discussed.

Linear diameters are derived for red variables with measured angular diameters and parallaxes, and are used to examine the long standing question of the pulsation mode(s) of these stars. Evidence is presented to suggest that most of them are pulsating in the same mode and, if published model atmospheres are correct, this is probably the first overtone. Some discussion is given of sequences in the period-luminosity and period-colour diagrams and their bearing on the pulsation mode problem.

Accepted by MNRAS

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Mira Kinematics from Hipparcos Data: A Galactic Bar to Beyond the Solar Circle

Michael Feast[1] *and Patricia Whitelock*[2]

[1] Astronomy Department, University of Cape Town, Rondebosch, 7701, South Africa.
email: mwf@artemisia.uct.ac.za

[2] South African Astronomical Observatory, PO Box 9, Observatory, 7935, South Africa.
email: paw@saao.ac.za

The space motions of Mira variables are derived from radial velocities, Hipparcos proper motions and a period-luminosity relation. The previously known dependence of Mira kinematics on the period of pulsation is confirmed and refined. In addition it is found that Miras with periods in the range 145 to 200 days in the general solar neighbourhood have a net radial outward motion from the Galactic Centre of $75 \pm 18\,\mathrm{km\,s^{-1}}$. This together with a lag behind the circular velocity of galactic rotation of $98 \pm 19\,\mathrm{km\,s^{-1}}$ is interpreted as evidence for an elongation of their orbits with their major axes aligned at an angle of $\sim 17°$ with the Sun - Galactic Centre line, towards positive galactic longitudes. This concentration seems to be a continuation to the solar circle and beyond of the bar-like structure of the Galactic Bulge, with the orbits of some local Miras probably penetrating into the Bulge. These conclusions are not sensitive to the distance scale adopted.
A further analysis is given of the SP-red group of Miras discussed in previous papers in this series.
In an appendix the mean radial velocities and other data for 842 oxygen-rich Mira-like variables are tabulated. These velocities were derived from published optical and radio observations.

Accepted by MNRAS

Preprints can be obtained by contacting paw@saao.ac.za

Discovery of a symmetrical highly-collimated bipolar jet in HE2-90

Raghvendra Sahai[1] *& L-Å. Nyman*[2,3]

[1] Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109

[2] ESO/ La Silla, Casilla 19001, Santiago 19, Chile

[3] Onsala Space Observatory, S–439 92 Onsala, Sweden

Using the Hubble Space Telescope, we have obtained Hα imaging of the object He2-90, which has long been classified as a planetary nebula (PN). We find that the morphology of He2-90 does not look like that of any known PN, but resembles that of a classical young stellar object (YSO) – a bipolar nebula bisected by a flaring disk-like structure, and a highly collimated bipolar jet perpendicular to the disk. The linear jet shows at least six pairs of emission knots located symmetrically on either side of the nebular center. Taking a kinematic distance of 2.5 kpc, we find that the gas density in the knots decreases steadily from about 10^4 cm^{-3} in the knots closest to the center, to 1.1×10^3 cm^{-3} in the more distant knots, and their masses lie in the range of $(0.7\text{-}3.6)\times10^{-6}\,M_\odot$. The jet opening angle is about 4°, from which we estimate its speed to be $\sim$150 km s^{-1}. He2-90's near- and mid-infrared fluxes imply the presence of a massive dusty nebula containing "warm" (183 K) and "hot" (513 K) dust in components with mass 5×10^{-3} and $2.4\times10^{-5}M_\odot$, respectively (assuming a gas-to-dust ratio of 100); the source luminosity is 5280 $L_\odot$. Millimeter-wave line observations show no molecular gas directly associated with the source and the absence of star-forming activity, indicating that He2-90 is probably not a YSO. The most likely hypothesis for explaining He2-90 requires a binary with a cool giant and a compact companion with an accretion disk.

Accepted by The Astrophysical Journal (Letters)

Preprints can be obtained by contacting sahai@grandpa.jpl.nasa.gov

or via WWW on http://wfpc2.jpl.nasa.gov/~idt/sahai.html

The Nature of the Lithium Rich Giants. Mixing episodes on the RGB and early-AGB

C. Charbonnel[1] *and S.C. Balachandran*[2]

[1] Laboratoire d'Astrophysique de l'Observatoire Midi-Pyrénées, CNRS UMR 5572, 14, Av.E.Belin, 31400 Toulouse, France

[2] Department of Astronomy, University of Maryland, College Park, MD 20742, USA

We present a critical analysis of the nature of the so-called Li-rich RGB stars. For a majority of the stars, we have used Hipparcos parallaxes to determine masses and evolutionary states by comparing their position on the Hertzsprung-Russell diagram with theoretical evolutionary tracks. Among the twenty Li-rich giants whose location on the HR diagram we were able to determine precisely, eight should be re-classified as Li-normal. For the remaining stars, the high Li abundance must be a result of fresh synthesis of this fragile element. We identify two distinct episodes of Li production which occur in advanced evolutionary phases depending upon the mass of the star. We suggest that the Li-rich stars are formed mainly as a precursor to the deeper mixing process which produces anomalously low carbon isotopic ratios. Low-mass RGB stars, which later undergo the helium flash, produce Li at the phase referred to as the bump in the luminosity function. In intermediate-mass stars, the Li-rich phase occurs on the early-AGB. The compiled data provide constraints on the time scales for extra mixing and some insight on processes suggested in the literature. However, our results do not suggest any specific trigger mechanism. Since the Li-rich phases are extremely short, enrichment of the Li content of the ISM as a result of these episodes is negligible.

Accepted by A&A

Preprints can be obtained by contacting corinne@obs-mip.fr
or via WWW on http://webast.ast.obs-mip.fr/people/corinne/publiccReferee.html

The evolution of AGB stars with convective overshoot

Falk Herwig[1,2]

[1] Universität Potsdam, Institut für Physik, Astrophysik, 14469 Potsdam, Germany

[2] Astrophysikalisches Institut Potsdam (AIP), 14482 Potsdam, Germany

The influence of extended convective mixing (overshoot) on asymptotic giant branch stellar evolution is investigated in detail. The extended mixing is treated time-dependently, and the efficiency declines exponentially with the geometric distance from the convective boundary. It has been considered at all convective boundaries, including the He-flash convection zone in the intershell region which forms during the thermal pulses.

Both the structural and the chemical evolution are affected by the inclusion of overshoot. The main results include a very efficient third dredge-up which leads to the formation of carbon stars of low mass and luminosity. A ^{13}C pocket which may serve as a neutron source for the *s*-process can form after the third dredge-up has reached into the ^{12}C rich intershell. Overshoot applied to the pulse-driven convective zone during the He-flash leads to a deeper penetration of the bottom of this convective zone into the C/O core below the He-burning shell. This in turn causes ^{4}He to be less abundant in the intershell while ^{12}C and ^{16}O are more abundant compared to calculations without overshoot. We show that overshoot at the He-flash convection zone as well as at the base of the envelope convection enhance the efficiency of the third dredge-up. Characteristic properties of the structural and chemical evolution of AGB stars are presented.

Accepted by A&A

Preprints can be obtained by contacting fherwig@astro.physik.uni-potsdam.de
or via WWW on http://www.astro.physik.uni-potsdam.de/~fherwig

Submm- and mm-wavelength observations of SiO and HCN in circumstellar envelopes of AGB stars

J.H. Bieging[1], *S. Shaked*[1], *and P.D. Gensheimer*[2]

[1] Steward Observatory, University of Arizona, Tucson AZ 85721 USA

[2] Submillimeter Telescope Observatory, University of Arizona, Tucson AZ 85721 USA

We report molecular line observations with the Heinrich Hertz Submillimeter Telescope of a sample of 30 AGB stars with spectral types M, S, and C. Measured lines include SiO J=5-4, 8-7, 10-9, and HCN J=3-2 and 4-3 transitions, which arise from energy levels ranging from 26 to 115 K above ground. The observed transitions were detected in almost all stars observed, regardless of spectral type. The HCN J=3-2 and 4-3 lines in the M stars are bright compared with previous observations of the J=1-0 line.

We calculated emergent spectra for model circumstellar envelopes and compare these with the observed line intensity ratios. We conclude that: (1) the HCN line intensity ratios for the M stars are inconsistent with chemical models in which HCN is produced via photochemistry in the outer circumstellar envelope. HCN must be formed by a non-equilibrium chemical process in the inner envelope or extended stellar atmosphere. (2) The HCN/SiO intensity ratios of lines with similar excitation energies clearly separate the carbon stars from the M and S stars. The M and S stars show a trend of increasing HCN/SiO intensity ratios with increasing mass loss rate. (3) These data support the idea that pulsation-driven shocks result in the formation of organic molecules like HCN in the envelopes of M stars. Observations of these molecules could give useful constraints on hydrodynamic models for stellar mass loss driven by pulsational shocks in the stellar atmosphere.

We detected emission from vibrationally excited HCN in the v=(0,1^{1c},0), J=3-2 and 4-3 transitions toward 4 carbon stars. In one star, V Cyg, the lines are strong and narrow, and are most likely a result of maser amplification.

Accepted by The Astrophysical Journal

Preprints can be obtained by contacting jbieging@as.arizona.edu

Chemical composition of HD 179821 (IRAS 19114+0002)

F. Thévenin[1], *M. Parthasarathy*[2] *and G. Jasniewicz*[3]

[1] Observatoire de la Côte d'Azur, B.P. 4229, F-06304 Nice Cedex 4, France

[2] Indian Institute of Astrophysics, Bangalore - 560034, India

[3] GRAAL, UMR 5024, Université de Montpellier II, CC 72, F-34095 Montpellier Cedex 05, France

A LTE analysis of medium resolution spectra of HD 179821 has been made. Derived atmospheric parameters of HD 179821 are $T_{\rm eff}$ = 5660 K, $\log g = -1.0$ and [Fe/H]=-0.5. The position of the star in the H-R diagram, its high radial velocity (V_r=100 km s^{-1}), its far infrared excess similar to PNe and its chemical composition suggest that HD 179821 is a low mass post-AGB carbon-poor supergiant and not a population I massive red supergiant. The underabundance of carbon and of the s-process element zirconium shows that HD 179821 has not gone through the third dredge-up. We emphasize the similarity of the chemical pattern of the post-AGB star HD 179821 and the C-poor halo PN DDDM-1.

Accepted by A&A

Preprints can be obtained by contacting thevenin@obs-nice.fr
or via WWW on http://www.dstu.univ-montp2.fr/GRAAL/preprints.html

SiO Maser Survey of the Galactic Disk IRAS Sources. III. $-10° < l < 15°$ and $|b| \leq 3°$, a Central Part of the Galaxy

S. Deguchi,[1] *T. Fujii,*[2,3] *H. Izumiura,*[4] *O. Kameya,*[5]
Y. Nakada,[3] *and J. Nakashima,*[6,7]

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

[2] Department of Astronomy, University of Tokyo, Bunkyo, Tokyo 113-0032, Japan

[3] Kiso Observatory, Institute of Astronomy, University of Toky, Japano Mitaka, Tokyo 181-8588, Japan

[4] Okayama Astrophysical Observatory, National Astronomical Observatory, Kamogata, Asakuchi, Okayama 719-0200, Japan

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

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

[7] Astronomical Institude, Osaka Kyoiku University, Asahigaoka 4-698-1, Kashihara, Osaka 582-8582, Japan

A survey has been made in the SiO J =1–0, v =1 and 2 transitions ($\sim$ 43 GHz) for the color-selected IRAS sources in the central region of the Galaxy, $-10° < l < 15°$ (except $|l| \leq 3°$) and $|b| \leq 3°$, with the Nobeyama 45-m telescope. We have detected 124 out of 200 observed sources in SiO masers. Distances to the sources range approximately from 2 kpc to 11 kpc, if estimated from the IRAS 12 and 25 μ flux densities. Radial velocities of the detected sources spread between $\pm$260 km s^{-1}. The distribution of SiO sources in the longitude–velocity diagram is compared with the HI contours. A number of sources are out of the HI limiting velocities; a group of negative-velocity (~ -200—-80 km s^{-1}) sources is found at l = 3–12°, region. The subsamples of sources exhibit negative and positive shifts of the average radial velocity depending on distance, suggesting evidence of a streaming motion of stars in the bulge bar.

Accepted by APJ Suppl. Ser. (130 n2p (2000 Oct. issue) in press)
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Dissertation abstracts

Synthetic spectra of cool stars observed with the Short-Wavelength Spectrometer: improving the models and the calibration of the instrument

Leen Decin

Thesis work conducted at: Instituut voor Sterrenkunde, K.U.Leuven, Belgium

Ph.D dissertation directed by: Prof. dr. Christoffel Waelkens

Ph.D degree awarded: May, 30 2000

Current address: Instituut voor Sterrenkunde, Celestijnenlaan 200B, B-3001 Heverlee (Leuven), Belgium

Electronic mail: Leen.Decin@ster.kuleuven.ac.be

The purpose of this thesis was to investigate standard stellar sources observed with the Short Wavelength Spectrometer (SWS) on-board the Infrared Space Observatory (ISO), in order to improve the calibration of the SWS spectrometers and to elaborate on new theoretical developments for the computation of the stellar model atmospheres and/or corresponding synthetic spectra.

To calibrate the ISO-SWS spectrometers accurately, standard stars are observed. In the SWS spectral region, the primary standard calibration candles are bright, mostly cool, stars. Since ISO-SWS offered the astronomical community the first opportunity to perform accurate intermediate resolution spectroscopic observations in the infrared spectral window (2.38 - 45.2 μm), our theoretical understanding of cool stellar sources - and more precisely cool stellar atmospheres - is not as refined as it is for hotter sources, which radiate more in the visible spectral window. A full interpretation of the ISO-SWS data will therefore result from an iterative process, in which both better theoretical modeling and more accurate instrumental calibration are involved.

At a first stage of this research, it was necessary to develop an adequate method of analysis to perform this study. Precisely because this research entailed an iterative process in which both theoretical developments on the model spectra and calibration improvements on the spectral reduction are involved, we had to be extremely careful not to confuse technical detector problems with astrophysical issues. Therefore, the analysis in its entirety enclosed several steps, including 1. a spectral cover of standard infrared sources from A0 to M8, 2. a homogeneous way of data reduction, 3. a detailed literature study, 4. a detailed knowledge of the impact of the various stellar parameters on the spectral signature, 5. a statistical method to test the goodness-of-fit and 6. high-resolution observations with two independent instruments. This method has proven to be very valuable and adequate.

In spite of the moderate resolution of ISO-SWS, the stellar parameters of the cool giants could be pinned down very accurately. The large wavelength range of ISO-SWS results in the presence of many molecules, which are each related in another way to the several heterogeneous stellar parameters. This way, the ISO-SWS data provided us with a very good diagnostic and consistent tool for the determination of the fundamental parameters of cool stars.

The discrepancies between the ISO-SWS and synthetic spectra were subjected to a careful scrutiny in order to elucidate their origin. Problems with the calibration as well as problems in constructing the theoretical models and computing the synthetic spectra were uncovered.

Problems with the relative spectral-response functions in band 1A and band 2 were indicated, and it was shown that fringes at the end of band 1D destroy the flux accuracy in this wavelength range. The responsibles for the SWS calibration will try to correct for these artifacts and implement improvements in the next calibration files. Problems with the first-overtone CO lines have demonstrated that one needs to know the instrumental profile and resolution accurately. Since the same molecules are absorbing in band 2 as in band 1, the synthetic spectra of the standard stars will be used as a tool to check the recently developed method for memory-effect correction.

Concerning the modeling part, the main problems were situated in the complex computation of the hydrogen lines and the incomprehensive knowledge of the atomic oscillator strengths in the infrared. The fact that the low-excitation first-overtone CO lines and fundamental OH lines are predicted as too weak, indicates a problematic temperature distribution in the outermost layers of the atmospheric models.

With this in mind, fourteen stars of our sample were studied individually. Specific calibration details were given, together with a comparison with other AOT01 observations, if available. The agreement between the observed and synthetic spectra was discussed, and the resultant fundamental parameters were evaluated with respect to published stellar parameters. This comparison underlined the adequacy of the used method for the stellar-parameter determination by exploiting the sensitivity of the molecular absorption in evolved stars on the various stellar parameters. The comparison with other AOT01 observations revealed that the relative flux accuracy seems now to be $\leq 2\%$ in band 1, while the absolute flux accuracy is $\sim 10\%$.

New Jobs

Opening for a PhD-student position

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ASTROPHYSICAL INSTITUTE POTSDAM

The Astrophysical Institute Potsdam has an opening in the stellar physics group to work in the DFG-project

"Hydrodynamical modelling of time variable AGB wind envelopes"

The position is available **immediately** for a two year's period (with the option of a 3rd year). Salary is according to the German civil service system, BAT-O IIa/2, approximately 30 000 DM per year before taxes and social insurances. Some travel money is also available.

The group is engaged in

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3) stellar evolution with mass loss and detailed nucleosynthesis,
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Further information about the group is available via the internet address `'http://www.aip.de/groups/sternphysik/'`

The successful candidate is expected to work within the stellar physics group, with the goal to apply and extent existing numerical codes according to the plan of the project. Knowledge of the numerical treatment of complex astrophysical processes would be of advantage.

Applicants are encouraged to contact us informally before submitting the usual documents:

Prof. D. Schönberner
Tel/Fax: 0331 7499 395/526
email : DeSchoenberner@aip.de

Dr. M. Steffen
Tel/Fax: 0331 7499 371/526
email : MSteffen@aip.de

Applications will be reviewed after **June 30, 2000**.