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Abstracts of recently accepted papers

The SiC problem: astronomical and meteoritic evidence

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Pre-solar grains of silicon carbide found in meteorites and interpreted as having had an origin around carbon stars from their isotopic composition, have all been found to be of the β-SiC polytype. Yet to date fits to the 11.3-μm SiC emission band of carbon stars had been obtained only for α-SiC grains. We present thin film infrared (IR) absorption spectra measured in a diamond anvil cell for both the α- and β- polymorphs of synthetic SiC and compare the results with previously published spectra taken using the KBr matrix method. We find that our thin film spectra have positions nearly identical to those obtained previously from finely ground samples in KBr. Hence, we show that this discrepancy has arisen from inappropriate 'KBr corrections' having been made to laboratory spectra of SiC particles dispersed in KBr matrices. We re-fit a sample of carbon star mid-IR spectra, using laboratory data with no KBr correction applied, and show that β-SiC grains fit the observations, while α-SiC grains do not. The discrepancy between meteoritic and astronomical identifications of the SiC-type is therefore removed. This work shows that the diamond anvil cell thin film method can be used to produce mineral spectra applicable to cosmic environments without further manipulation.

Accepted by Astrophys. J. Letters

Preprints can be obtained by contacting aks@star.ucl.ac.uk *or via WWW on* http://www.star.ucl.ac.uk/~aks/publications.html

The AGB-star Phenomenon: Setting the Stage

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The asymptotic giant branch (AGB) evolution of stars is interesting from many points of view. It is the final evolutionary phase for the large majority of all stars in the Universe that have left the main sequence. During this stage they contribute to the chemical evolution of galaxies, contribute to the integrated starlight of many galaxies, may provide the only interstellar matter there is in some galaxies, and can, due to their high luminosities and ages, be used as important probes of galactic structure and dynamics. It is also the final evolutionary stage of our own star, the Sun, and hence touches on aspects beyond the immediate astronomical interest. Furthermore, these stars provide us with fascinating systems, where intricate interplays between physical and chemical processes take place, that we simply would like to understand. In this introductory outline our present knowledge of the AGB-star phenomenon is reviewed.

Proceedings of the IAU Symp. 191 AGB-stars

Preprints can be obtained by contacting hans@astro.su.se *or via anonymous ftp on* ftp://hp5.astro.su.se/pub/preprints/montpellie

Water Ice, Silicate and PAH Emission Features in the ISO Spectrum of the Carbon-rich Planetary Nebula CPD–56°8032

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Combined ISO SWS and LWS spectroscopy is presented of the late WC-type planetary nebula nucleus CPD-56°8032 and its carbon-rich nebula. The extremely broad coverage (2.4–197 μm) enables us to recognize the clear and simultaneous presence of emission features from both oxygen- and carbon-rich circumstellar materials. Removing a smooth continuum highlights bright emission bands characteristic of polycyclic aromatic hydrocarbons (hereafter PAHs) in the 3–14-μm region, bands from crystalline silicates longwards of 18 μm, and the 43- and 62-μm bands of crystalline water ice. We discuss the probable evolutionary state and history of this unusual object in terms of (a) a recent transition from an O-rich to a C-rich outflow following a helium shell flash; or (b) a carbon-rich nebular outflow encountering an O-rich comet cloud.

Accepted by ApJ Letters

A compressed version of the letter is available for downloading from ftp://ftp.star.ucl.ac.uk/pub/mjb/cpdiso.ps.gz

ISO Results on Circumstellar Envelopes

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This review covers spectroscopic results obtained with ISO on molecular and atomic line emission from the circumstellar envelopes of oxygen-rich AGB stars and post-AGB objects and from cool supergiant stars. As well as the SWS detection of the 4.27-μm CO_2 band in absorption and emission from cool star envelopes, several new emission bands which have been detected in SWS spectra between 13.9 and 16.2 μm have been identified with CO_2 bands. Strong H_2O line emission has been observed in the LWS and SWS spectra of high mass loss rate O-rich AGB and M supergiant stars, confirming the predicted importance of this molecule as a coolant in their outflows. The proposed infrared radiative pump mechanism for circumstellar OH masers has been directly confirmed for the first time via measurements for several stars of the OH infrared pumping lines between 34.6 μm and 163 μm. Water vapour emission lines are not present in the spectra of O-rich post-AGB objects, having been replaced by broad emission features at 43 and 62 μm due to crystalline water ice that has condensed in the very cool outflows.

Invited review presented at IAU Symp. 191 : 'AGB Stars' eds.: T. Le Bertre, C. Waelkens and A. Lèbre.

A postscript copy of the review is available for downloading from ftp://ftp.star.ucl.ac.uk/pub/mjb/isoreview191.ps

On the third dredge-up phenomenon in asymptotic giant branch stars

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The third dredge-up phenomenon in asymptotic giant branch (AGB) stars is analyzed through evolutionary model calculations of a $3\,M_\odot$, solar metallicity star. The Schwarzschild criterion is used to test the stability of a given layer against convection, and the calculations are performed either with or without extra-mixing below the convective envelope. Based on these calculations, several questions are addressed regarding the occurrence of the third dredge-up in AGB star models, the laws governing that phenomenon, and some of its implications on the structural and chemical evolution of those stars.

The use of the Schwarzschild criterion *without* extra-mixing of any sort is shown to lead to unphysical afterpulse models which prevent the occurrence of third dredge-up. Model calculations of a $3\,M_\odot$ star using no extra-mixing confirm the failure to obtain dredge-up in those conditions. That conclusion is found to be independent of the mixing length parameter, stellar mass, or numerical accuracy of the models.

Model calculations performed on selected afterpulses of the $3\,M_\odot$ star, but with extra-mixing (using a decreasing bubble velocity field in the radiative layers and a diffusion algorithm for the mixing of the chemical elements), lead to efficient dredge-ups at a rate of $10^{-5} - 10^{-4}\,M_\odot$/yr. Test calculations using different extra-mixing extents and efficiencies reveal that the dredge-up predictions are rather insensitive to those extra-mixing parameters. This important conclusion is understood by analyzing the physics involved in the dredge-up process. It is shown that the dredge-up rate is determined by the thermal relaxation time-scale of the envelope as C-rich matter is added from the core into the envelope. The dredge-up predictions are, however, expected to depend on the convection prescription *in* the envelope.

Linear relations both between the dredge-up rate and the core mass M_c and between the dredge-up efficiency λ and M_c are predicted by the model calculations. Those linear relations are expected to still hold when the feedback of the dredge-ups on the AGB evolution is taken into account. They predict the dredge-up efficiency to level off at unity during the AGB evolution, at which point the core mass remains constant from one pulse to the next. The core mass is concomitantly predicted to evolve towards an asymptotic value. The existence of such an asymptotic core mass naturally provides an upper limit to the mass of the white dwarf remnant, and helps to constrain the initial-final mass of white dwarfs.

Synthetic calculations taking into account the dredge-up laws obtained from the full AGB model calculations predict a continuous increase of the stellar luminosity L with time, contrary to the predicted behavior of M_c and λ. This results from an adopted dependence of L on both M_c and the radius R_c of the H-depleted core of the form $L \propto M_c^2/R_c$. As a result of this increase of L with time, the initial-final mass relation can further be constrained if mass loss is taken into account. If, for example, a superwind is assumed to eject all the remaining envelope of the $3\,M_\odot$ star at $L = 15000\,L_\odot$, then the mass of the white dwarf remnant is predicted to be $0.66\,M_\odot$, instead of $0.73\,M_\odot$ predicted by models without dredge-up.

Finally, the synthetic calculations predict the formation of a $3\,M_\odot$ carbon star after about 20 pulses experiencing dredge-up. Taking into account the fact that the luminosity decreases by a factor of two during about 20% of the interpulse phases, such a $3\,M_\odot$ carbon star could be observed at luminosities as low as $7500\,L_\odot$.

Accepted by A&A

Preprints can be obtained by contacting Nami.Mowlavi@obs.unige.ch
or via WWW on http://obswww.unige.ch/ mowlavi/publications
or via anonnymous ftp on obsftp.unige.ch, *file* pub/mowlavi/dredge.ps.gz

SiO rotation-vibration bands in cool giants. II. The behaviour of SiO bands in AGB stars

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The first overtone rotation-vibration transitions of SiO give rise to prominent bandheads in the wavelength range between 4.0 and 4.5 μm. In order to study the behaviour of these features in AGB stars we observed the 3.94 to 4.12 μm spectra for a sample of 23 oxygen-rich late-type variables. In contrast to the SRb objects, the Miras show a very large scatter of the equivalent widths of the SiO bands. Despite their cool temperatures some of them have only weak or no SiO absorption, which seems to be related to their strong pulsations producing a large variability of the features. When comparing the band intensities with photometric data, we found a general decrease with bluer IRAS (12−25) colors. However, this trend may only reflect the different behaviour of the Miras and SRb stars in our sample. We did not discover any correlation of the equivalent widths with the effective temperatures derived from (J−K), or with the (K−12) color and the IRAS-LRS class, both of which can be regarded as a rough measure for the thickness of the circumstellar shell.

In Paper I of this series (Aringer et al. 1997) we have shown that synthetic spectra calculated from hydrostatic MARCS atmospheres are successful in reproducing the observed band intensities of giants with spectral types earlier than about M5 III and M2 II. However, they generally predict too strong features for very cool and extended objects, as they are discussed in this work. And they fail completely when it comes to Miras with weak or no SiO absorption. These stars are dominated by dynamical phenomena and, not surprisingly, they can therefore not be described by hydrostatic structures. Thus, we have also computed synthetic spectra based on experimental dynamical models. Although they still have some shortcomings, we demonstrate that, in principle, they are able to explain the whole range of equivalent widths of the observed SiO bandheads and their variations.

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Preprints can be obtained by contacting aringer@astro.astro.univie.ac.at
or via WWW on http://rigel.astro.univie.ac.at/∼aringer/agb98/siopap02.ps

Morphology and Composition of the Helix Nebula

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[3] Guest Observer, International Ultraviolet Explorer Satellite, which was operated by NASA, ESA, and the SERC.

We present new narrow-band filter imagery in Hα and [N II] λ6584 along with UV and optical spectrophotometry measurements from 1200Å to 9600Å of NGC 7293, the Helix Nebula, a nearby, photogenic planetary nebula of large diameter and low surface brightness. Detailed models of the observable ionized nebula support the recent claim that the Helix is actually a flattened disk whose thickness is roughly one-third its diameter with an inner region containing hot, highly ionized gas which is generally invisible in narrow-band images. The outer visible ring structure is of lower ionization and temperature and is brighter because of a thickening in the disk. We also confirm a central star effective temperature and luminosity of 120,000K and 100$L_\odot$, and we estimate a lower limit to the nebular mass to be 0.30$M_\odot$. Abundance measurements indicate the following values: He/H=0.12 (±0.017), O/H=4.60×10^{-4} (±0.18), C/O=0.87 (±0.12), N/O=0.54 (±0.14), Ne/O=0.33 (±0.04),

S/O=3.22×10^{-3} (±0.26), and Ar/O=6.74×10^{-3} (±0.76). Our carbon abundance measurements represent the first of their kind for the Helix Nebula. The S/O ratio which we derive is anomalously low; such values are found in only a few other planetary nebulae. The central star properties, the super-solar values of He/H and N/O, and a solar level of C/O are consistent with a $6.5M_{\odot}$ progenitor which underwent three phases of dredge-up and hot bottom burning before forming the planetary nebula.

Accepted by the Astrophysical Journal.

Preprints can be obtained by contacting henry@mail.nhn.ou.edu *or via WWW on* http://xxx.lanl.gov/abs/astro-ph/9901060

Dynamical Modelling of AGB Star Atmospheres

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Time-dependent dynamics is an important ingredient for understanding the atmospheres of pulsating AGB stars. The shock waves created by stellar pulsation modify the atmospheric structure and, consequently, influence the mass loss and the observable properties. So far, hydrostatic model atmospheres have been used in most cases to analyse photospheric spectra, neglecting the effects of dynamics. The recent progress in observational techniques, however, has demonstrated the importance of consistent time-dependent models. The main topics of this contribution are to discuss fundamental physical processes and technical problems in constructing dynamical model atmospheres, to review the present status of modelling and to indicate possible future developments.

Invited review presented at IAU Symp. 191, 'Asymptotic Giant Branch Stars', eds. T. Le Bertre, A. Lebre, C. Waelkens, A.S.P. Conf. Ser., in press

Preprints can be obtained by contacting hoefner@astro.univie.ac.at

SiO Masers in Stars in the Inner and Outer Galactic Disk

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Observations in the J = 1–0, v =1 and v =2 ^{28}SiO and v =0 ^{29}SiO maser lines were made towards 97 outer- and 19 inner-disk IRAS sources with typical IRAS colors of AGB stars. 21 new ^{28}SiO and 1 new ^{29}SiO maser sources were detected above the 5 σ level of $\sim$ 1 Jy with the Nobeyama 45m telescope. Collecting all of the observational data in SiO J = 1–0 maser lines taken with a 45m telescope, a comparison is made between the outer-disk, inner-disk, and bulge samples. The samples, themselves, align a sequence of mid-infrared color, flux at 12μm and IRAS variability index. The detection rates are 66%, 51%, and 31%, respectively, in the bulge, inner disk, and outer disk. This fact is consistent with the tendency of increasing proportion of C-rich stars in the IRAS sample and metallicity gradient with the galactocentric distance.

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Preprints can be obtained by contacting deguchi@nro.nao.ac.jp
WWW *or via WWW on* http://www.nro.nao.ac.jp/~eiko/nroreport
or via anonymous ftp on ftp://ftp.nro.nao.ac.jp/nroreport/no481.ps.gz

Thesis Abstracts

Modelling of Planetary Nebulae: photoionization and kinematics

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Thesis work conducted at: Université Denis Diderot - Paris 7, France and European Southern Observatory, Germany

Ph.D dissertation directed by: Daniel Péquignot & Jeremy R. Walsh

Ph.D degree awarded: December 1998

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The thesis presents photoionization and kinematic models of planetary nebulae in order to derive in a consistent manner their physical properties and velocity structure. Low-resolution long slit spectra were acquired at the NTT and 1.5m ESO telescopes. High resolution kinematic data have been obtained using the TAURUS-2 scanning Fabry-Pérot installed on the WHT at La Palma.

Photoionization models of the two PNe recently discovered in the Sagittarius dwarf galaxy are presented. Empirical abundances are confirmed and for some elements improved. These PNe appear C-rich. The luminosities are revised and are now consistent with the central stars being H-burners. This study compared the results of two different photoionization codes, thus allowing a better understanding of the stability of the solutions and errors induced by the models.

A photoionization model of the Galactic PN NGC 3242 is presented, for which more observational constraints are available: 1) narrow band images constrain the density law; and 2) UV spectra, obtained from the IUE archive, constrain the abundances of important elements like C. The modelled emissivity in different emission lines is used as input for a 3D kinematic model study of NGC 3242. The other main parameters required are the 3D structure and orientation and the radial expansion velocity. Synthetic line profiles through apertures and slits are compared to the observations in several emission lines. A velocity gradient in the shell is required. The microstructures called FLIERs do not in consequence appear very supersonic. Kinematic studies of NGC 6826 and IC 4593 are also presented.

Finally, the morphologies and ionization structures of four elliptical PN with microstructures imaged by HST are discussed. It is concluded that the determination of the 3D spatial and kinematic structure of PN is essential in order to better understand their shaping and evolution at large and small scales.

Availability: Paperback copies are available from J. R. Walsh (jwalsh@eso.org) or by downloading from http://ecf.hq.eso.org/ jwalsh/materials/thesis as postscript.

The Mineralogy of Dust Around Evolved Stars

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Thesis work conducted at: Department of Physics & Astronomy, University College London

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Infrared (IR) observations of evolved red giant stars (AGB stars) have shown that many are surrounded by dust envelopes, which are ejected into the interstellar medium and seed the next generation of stars and planets. By studying these one can understand the origins of interstellar and solar system materials. AGB stars fall into two main categories: oxygen-rich and carbon-rich. The prominent features of the IR spectra of AGB stars are: the 11.3μm feature of C-stars, attributed to silicon carbide (SiC); and the 9.7μm feature of O-rich stars, attributed to silicates. There are also various minor features with less secure identifications. Identifying dust around stars requires the use of laboratory spectra of dust species analogous to those one expects to observe. I have compiled a database of such spectra, and thereby constrained the identifications of circumstellar dust, which I have also tried to ensure are compatible with data from meteoritic presolar grains. Some laboratory spectra need to be modified before they are relevant to the problem in hand, i.e. stardust. The techniques used for such modifications are outlined in the thesis. In order to fully comprehend the problems that can arise from using laboratory spectra, the way in which light interacts with matter must be understood. To this end the optical properties of matter are discussed.

While the mineral constituents of the Earth have been reprocessed so extensively that they no longer contain any evidence of their stellar origins, the same is not true of primitive meteorites which contain "presolar" dust grains with isotopic fingerprints identifying their stellar sources. By comparing these presolar grains with nucleosynthesis models, grains expected to form around various stars and observational evidence of dust, we can gain a better picture of the formation mechanisms and sites of the various dust grains.

I have investigated the mineralogy of SiC of 32 C-stars and its relationship to meteoritic dust by using a χ^2-minimisation routine to fit the observed SiC features, using laboratory optical constants that have been published for a variety of SiC samples. In addition to the extreme carbon star AFGL 3068, the only C-star previously known to show the 11.3μm SiC feature in absorption, I have discovered three further examples of sources that show SiC in net absorption. Previous attempts to identify the type of SiC present around carbon stars have all identified it with α-SiC. However, I have found that the previous work is based on flawed laboratory data and that a better fit is achieved using β-SiC, which agrees with meteoritic data.

I have also used the same techniques to investigate the mineralogy of 80 O-rich stars. Dust mineralogy around O-rich stars is considerably more complicated. The 9.7μm feature attributed to silicates varies greatly in shape and intensity as well as exact peak position from star to star, and the number of possible laboratory analogues is much greater than for SiC. Most of these spectra have been fitted using some form of forsterite (Mg_2SiO_4) and/or enstatite ($MgSiO_3$), although constraining the mineralogy further was not possible. There is little evidence of Al_2O_3 around these stars, contrary to theoretical predictions and previous radiative transfer models. Relating the O-rich dust species to meteoritic data is also more complicated, as most of the silicate material was reprocessed in the early solar system, although data on a small number of O-rich presolar grains have been used for this purpose. I have also discovered a previously unrecognized feature in the spectra of O-rich stars at 9.25μm. This feature, and the 12.5-13.0μm feature previously attributed to Al_2O_3, have been attributed to SiO_2.

Implications of the new attributions for both C- and O-rich stars are discussed

Data availability

Preliminary Release of Point Source Data from the DENIS project

The DENIS consortium is providing access to a preliminary set of extracted point sources, corresponding to about 120 strips (2southern sky) resulting from observations performed in 1996, in the I, J and Ks bands, using a dedicated 1m-telescope in ESO, La Silla. Data are available through a Web server developed by the CDS (Strasbourg astronomical Data Center).

Data reduction.

The observation strips have been reduced in Paris and Leiden Data Analysis Centers, and were selected according to their astrometric and photometric quality, in order to form a representative sample of the current DENIS three-colour (I, J, K short) point source catalogue. It is to be noted, however, that this is NOT a subset of the final DENIS catalogue of point sources, because some improvements in the pipeline reduction software are still currently being implemented, and will imply a new reduction of already observed data. Planned improvements concern both astrometry (which is based, in the presently released data strips, on the GSC and USNO A1.0 catalogs, while data will eventually be reduced to ICRF by means of the USNO A2.0 and Tycho Reference Catalogs), and photometry (with a better processing of the PSF, not yet implemented in the released data). These improvements are not of such a nature that they will change the statistical interpretation of the currently released data sets.

Overlaps between individual frames (12 arcmin x 12 arcmin) constituting a strip have been processed (with the exception of bad quality flagged sources, which are not matched, and will generally appear duplicated). Eventual overlaps between adjacent strips have NOT been matched in this preliminary release. These elements should be taken carefully into account when working on star counts derived from the released data.

Data access through the CDS Web server.

The released data are being made available on-line through the CDS Web server at the following address:

http://cdsweb.u-strasbg.fr/denis.html

Data are primarily organized by strips of observations (a strip is an elongated rectangular zone of 12 arc minutes width in right ascension, and 30 degrees in declination). A map provides a graphical access to individual strips, while an auxiliary database provides information about night and strip qualities.

In addition a query mechanism provides access to individual data records (including position, I, J, K magnitudes, and additional flags related to the source extraction) for about 22 million of extracted DENIS sources.

Queries can be made for DENIS sources around a given position (center and radius, where the center is to be specified in J2000 coordinates, or by the name of a central object to be resolved by Simbad). Selection of objects in the colour-colour diagrams of specified strips is also possible. Finally, the DENIS database is also available through VizieR and Aladin, where additional query modes and functionalities are available.

The DENIS Website at CDS also includes general information about the DENIS project, including scientific reports, lists of publications, etc.

2MASS Sampler

The Two Micron All Sky Survey (2MASS) announces the public availability of the 2MASS Sampler Data Release. The Sampler data products can be accessed from the IPAC/2MASS Web site at http://www.ipac.caltech.edu/2mass/ or directly from the NASA/Infrared Science Archive site at http://irsa.ipac.caltech.edu/.

The objective of the 2MASS Sampler is to introduce the astronomical community to the content and format of the 2MASS datasets, and to the web-based Access Tools, to provide an opportunity for the 2MASS project to receive community feedback in preparation for a large 1999 Spring data release, and to enable the community to carry out scientific investigations with the 2MASS dataset for the first time.

The 2MASS Sampler consists of a Point Source Catalog containing 227,197 objects, an Extended Source Catalog containing 2,133 resolved sources, and 5,658 compressed 512x1024 pixel (1"/pixel) images, covering about 63 square degrees of the northern sky.

The 2MASS webpage contains general information and documentation about this data release. Assistance with the Sampler is available via the 2MASS Help Desk at 2mass@ipac.caltech.edu.

A CD-ROM containing the Sampler data is also available.

The Two Micron All Sky Survey is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center, funded by the NASA and the NSF.

Job Opportunity

Post-Doctoral Position at the University of Illinois

A postdoctoral research position is available in the Dept. of Astronomy at the University of Illinois starting as early as April 1999. The successful applicant will work with Prof. Margaret Meixner and collaborators on a study of circumstellar dust shells found in evolved stars. This research will involve reduction and analysis of data already obtained with ISOPHOT and NICMOS. Independent research in related areas will be supported and encouraged. Research experience in the areas of evolved stars, circumstellar envelopes, radiative transfer or dust is desirable. The Dept. of Astronomy at the University of Illinois has strength in stellar evolution research. Research facilities include the BIMA millimeter array, the Mt. Laguna 1 m telescope, the UnISIS adaptive optics project at Mt. Wilson and the NCSA supercomputing center. (http://www.astro.uiuc.edu)

The position will be initially for one year, with likely renewal for a second year. Salary is commensurate with experience. A PhD in astronomy or astrophysics is required. Interested applicants should send a curriculum vitae, publication list and a statement of research interests by March 15, 1999 in order to ensure full consideration. Send applications to: Margaret Meixner Dept. of Astronomy, MC-221, University of Illinois, Urbana, IL 61820. For inquiries about the position send email to: meixner@astro.uiuc.edu. Three letters of reference in support of the candidate should be sent directly to Margaret Meixner at the above address. The University of Illinois is an affirmative action, equal opportunity employer.