THE AGB NEWSLETTER

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

No. 97 — February 2003

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

Abstract of recently accepted papers

SiO Maser Survey of Cold IRAS Sources

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We present the results of observations of cold IRAS sources in the Galactic disk area, $-10° < l < 100°$ and $|b| < 5°$, in the SiO $J = 1$–0, $v = 1$ and 2 maser lines. SiO masers were detected in 51 out of 143 observed sources; 45 were new detections in SiO masers. The selected IRAS sources were objects with dust temperatures of between 160 and 280 K. According to a confirmation using 2MASS near-infrared images, a majority of the sample are AGB or post-AGB stars, although dense cores in the star-forming regions (or dusty HII regions) are involved in part of the sample. Among new detections, two were candidates for post-AGB stars: IRAS 18450−0148 (W 43A), and 19312+1950. We found that the intensity ratios of the SiO $J = 1$–0, $v = 2$ to the $v = 1$ line of the objects clearly correlate with those IRAS colors. The detection rates of SiO masers tend to increase toward the Galactic center as well as the cases of previous SiO maser surveys of typical AGB stars. No strong associations of the objects to the spiral arms were found. The radial-velocity dispersion of the present sample is comparable with the dispersion of the SiO maser sample of typical AGB stars. These facts suggest that the present sample of cold IRAS sources with SiO masers has a kinematic property very similar with that of typical AGB stars.

Accepted by PASJ
Preprints can be obtained by contacting junichi@astro.uiuc.edu
or via WWW on http://arXiv.org/abs/astro-ph/0301372

The origin of sdB stars (II)

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We have carried out a detailed binary populations synthesis (BPS) study of the formation of subdwarf B (sdB) stars and related objects (sdO, sdOB stars) using the latest version of the BPS code developed by Han et al.

(1994, 1995a, 1995b, 1998, 2001). We systematically investigate the importance of the five main evolutionary channels in which the sdB stars form after one or two common-envelope (CE) phases, one or two phases of stable Roche-lobe overflow (RLOF) or as the result of the merger of two helium white dwarfs (WD) (see Han et al. 2002, Paper I). Our best BPS model can satisfactorily explain the main observational characteristics of sdB stars, in particular their distributions in the orbital period – minimum companion mass ($\log P$ - $M_{\rm comp}$) diagram and in the effective temperature – surface gravity ($T_{\rm eff}$ - $\log g$) diagram, their distributions of orbital period, $\log(g\theta^4)$ ($\theta = 5040\,{\rm K}/T_{\rm eff}$) and mass function, their binary fraction and the fraction of sdB binaries with WD companions, their birthrates and their space density. We obtain a Galactic formation rate for sdB stars of $0.014-0.063\,{\rm yr}^{-1}$ with a best estimate of $\sim 0.05\,{\rm yr}^{-1}$ and a total number in the Galaxy of $2.4-9.5\times10^6$ with a best estimate of $\sim 6\times10^6$; half of these may be missing in observational surveys due to selection effects. The intrinsic binary fraction is 76 to 89 percent, although the observed frequency may be substantially lower due to the selection effects. The first CE ejection channel, the first stable RLOF channel and the merger channel are intrinsically the most important channels, although observational selection effects tend to increase the relative importance of the second CE ejection and merger channels. We also predict a distribution of masses for sdB stars that is wider than is commonly assumed and that some sdB stars have companions of spectral type as early as B. The percentage of A type stars with sdB companions can in principle be used to constrain some of the important parameters in the binary evolution model. We conclude that (a) the first RLOF phase needs to be more stable than is commonly assumed, either because the critical mass ratio $q_{\rm crit}$ for dynamical mass transfer is higher or because of tidally enhanced stellar wind mass loss; (b) mass transfer in the first stable RLOF phase is non-conservative, and the mass lost from the system takes away a specific angular momentum similar to that of the system; (c) common-envelope ejection is very efficient.

Accepted by MNRAS

Preprints can be obtained by contacting Zhanwen Han at zhanwen@public.km.yn.cn
or via WWW on http://arXiv.org/abs/astro-ph/0301380

SiO Maser Survey toward the Inner Galactic Disk: $40^\circ \leq l \leq 70^\circ$ and $|b| \leq 10^\circ$

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We present the results of an SiO maser survey for color-selected IRAS sources in the area $40^\circ < l < 70^\circ$ and $|b| < 10^\circ$ in the SiO $J = 1$–0, $v = 1$ and 2 transitions ($\sim$ 43 GHz). We detected 134 out of 272 observed sources in SiO masers; 127 were new detections. A systematic difference in the detection rates between SiO and OH maser searches was found. Especially, in the color ranges with $\log(F_{25}/F_{12})$ smaller than -0.1, the detection rate of the SiO masers is significantly higher than that of OH masers. We found a possible kinematic influence of the galactic arm on the distribution of SiO maser sources. It was found that the velocity dispersion of SiO maser sources tends to decrease with the galactocentric distance. Using the present and previous data of SiO maser surveys, we found that the local velocity gradient of the rotational velocity of the Galaxy is consistent with the values obtained from other kinds of disk population stars within a statistical uncertainty. The Oort's constants, A and B, were computed from the gradient of the rotation curve for the present data, and were consistent with the IAU standard values. In addition, in order to check the reliability of IRAS positions, we observed toward the MSX positions for 5 MSX counterparts, which are located more than $20''$ away (but within $60''$) from IRAS positions. We detected all of these 5 sources in SiO masers.

Accepted by PASJ

Preprints can be obtained by contacting junichi@astro.uiuc.edu
or via WWW on http://arXiv.org/abs/astro-ph/0301401

Kinematics, turbulence and evolution of planetary nebulae

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This paper discusses the location of a sample of planetary nebulae on the HR diagram. We determine the internal velocity fields of 14 planetary nebulae from high-resolution echelle spectroscopy, with the help of photoionization models. The mass averaged velocity is shown to be a robust, simple parameter describing the outflow. The expansion velocity and radius are used to define the dynamical age; together with the stellar temperature, this gives a measurement of the luminosity and core mass of the central star. The same technique is applied to other planetary nebulae with previously measured expansion velocities, giving a total sample of 73 objects. The objects cluster closely around the Schoenberner track of 0.61 $M_\odot$, with a very narrow distribution of core masses. The masses are higher than found for local white dwarfs. The luminosities determined in this way tend to be higher by a factor of a few than those derived from the nebular luminosities. The discrepancy is highest for the hottest (most evolved) stars. We suggest photon leakage as the likely cause. The innermost regions of the non-[WC] nebulae tend to show strong acceleration. Together with the acceleration at the ionization front, the velocity field becomes 'U'-shaped. The presence of strong turbulent motions in [WC] nebulae is confirmed. Except for this, we find that the [WC] stars evolve on the same tracks as non-[WC] stars.

Accepted by Astronomy and Astrophysics

Preprints can be obtained via WWW on http://arXiv.org/abs/astro-ph/0301393

HST/NICMOS Near-IR Imaging of the Proto-Planetary Nebula OH 231.8+4.2

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We present observations of the bipolar nebula OH231.8+4.2, made with the HST NICMOS camera, in 3 wide filter bands (F205W, F160W, and F110W). The images have excellent dynamic range after removal of low-level instrumental artifacts. In the F205W filter ($\lambda \approx 2.04$ μm), we achieve a (peak/rms) of > 8000 with an angular resolution of 0.20" (FWHM). The combination of high dynamic range and angular resolution confirm previous observations but also reveal new features in the near-IR morphology of the nebula, which at these wavelengths is dominated by scattered light. The N (approaching) lobe shows well-defined limb brightened edges. The central jet splits into two filaments and exhibits some curvature between the center of the nebula and the end of the N lobe. The S (receding) lobe has a diffuse, flocculent appearance without a sharply-defined central jet, in contrast to the N lobe. A sharpened version of the F205W image shows indications of turbulent structures in both the N lobe and jet, and in the S lobe. A faint cylindrical halo of scattered light shows a sharp increase in surface brightness inside a radius of ~ 4" from the center, possibly resulting from a transition from a spherical wind to a disk- or torus-like mass ejection, on the same timescale as the formation of the collimated fast wind seen in CO and HCO^+ images.

We calculate the extinction through the nebula from the measured near-IR colors and a silicate grain model. For a simple geometric model of a dense central disk, we estimate a disk mass (gas and dust) in the range 0.03 to 0.06 $M_\odot$, relatively insensitive to grain size. The circumstance of an AGB star with a massive, highly-collimated, high-velocity bipolar flow, may be understood in terms of the model of Soker & Rappaport (2000) if the central star underwent a change in mass loss properties from a (roughly) spherical AGB wind to equatorially-enhanced mass loss beginning $\sim 1 - 3 \times 10^3$ yr ago. Supposing the presence of a dwarf companion in a suitable orbit, the

bipolar nebula then is a consequence of a strong increase in mass loss as the central star evolves close to the tip of the AGB, and will soon evolve to higher T_{eff} and appear as a more typical proto-planetary nebula.

Accepted by The Astrophysical Journal.

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The superwind mass-loss rate of the metal-poor carbon star LI-LMC 1813 in the LMC cluster KMHK 1603

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LI-LMC 1813 is a dust-enshrouded Asymptotic Giant Branch (AGB) star, located in the small open cluster KMHK 1603 near the rim of the Large Magellanic Cloud (LMC). Optical and infrared photometry between 0.5 and 60 μm is obtained to constrain the spectral energy distribution of LI-LMC 1813. Near-infrared spectra unambiguously show it to be a carbon star. Modelling with the radiation transfer code Dusty yields accurate values for the bolometric luminosity, $L = 1.5 \times 10^4$ L$_\odot$, and mass-loss rate, $\dot{M} = 3.7(\pm1.2) \times 10^{-5}$ M$_\odot$ yr^{-1}. On the basis of colour-magnitude diagrams, the age of the cluster KMHK 1603 is estimated to be $t = 0.9$–1.0 Gyr, which implies a Zero-Age Main Sequence mass for LI-LMC 1813 of $M_{\rm ZAMS} = 2.2 \pm 0.1$ M$_\odot$. This makes LI-LMC 1813 arguably the object with the most accurately and reliably determined (circum)stellar parameters amongst all carbon stars in the superwind phase.

Accepted by Monthly Notices of the Royal Astronomical Society

Preprints can be obtained by contacting jacco@astro.keele.ac.uk

2-DUST: A Dust Radiative Transfer Code for an Axisymmetric System

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We have developed a general purpose dust radiative transfer code for an axisymmetric system, **2-D**UST, motivated by the recent increasing availability of high-resolution images of circumstellar dust shells at various wavelengths. This code solves the equation of radiative transfer following the principle of long characteristic in a 2-D polar grid while considering a 3-D radiation field at each grid point. A solution is sought through an iterative scheme in which self-consistency of the solution is achieved by requiring a global luminosity constancy throughout the shell. The dust opacities are calculated through Mie theory from the given size distribution and optical properties of the dust grains. The main focus of the code is to obtain insights on (1) the *global* energetics of dust grains in the shell (2) the 2-D projected morphologies that are strongly dependent on the mixed effects of the axisymmetric dust distribution and inclination angle of the shell. Here, test models are presented with discussion of the results. The code can be supplied with a user-defined density distribution function, and thus, is applicable to a variety of dusty astronomical objects possessing the axisymmetric geometry.

Accepted by the Astrophysical Journal

Preprints and the code can be obtained by contacting ueta@oma.be or meixner@stsci.edu
or via WWW on http://homepage.oma.be/ueta/research/2dust/

The structure of H_2O shells in Mira atmospheres: correlation with disk brightness distributions and a spectrophotometric signature

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Dynamic models of M-type Mira variables predict the occurrence of water "shells", i.e. of zones of high H_2O density and high H_2O absorption inside the stellar atmosphere. The density, position and width of these shells is closely correlated with different types of two-component shapes of the intensity distribution on the disk in the H, K and L near-continuum bandpasses. We investigate these correlations and highlight the role of a spectrophotometric H_2O index that warns against serious complications in diameter measurements in the case of substantial water contamination of the bandpass of observation. Simultaneous spectrophotometric and interferometric measurements may allow observers to estimate real continuum diameters more precisely.

Accepted by A & A.
Preprints can be obtained by contacting http://xxx.lpthe.jussieu.fr/abs/astro-ph/0301500

Near-Infrared Photometric Survey of Proto-Planetary Nebula Candidates

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We present JHK' photometric measurements of 78 objects mostly consisting of proto-planetary nebula candidates. Photometric magnitudes are determined by means of imaging and aperture photometry. Unlike the observations with a photometer with a fixed-sized beam, the method of imaging photometry permits accurate derivation of photometric values because the target sources can be correctly identified and confusion with neighboring sources can be easily avoided. Of the 78 sources observed, we report nearly 10 cases in which the source seems to have been misidentified or confused by nearby bright sources. We also present nearly two dozen cases in which the source seems to have indicated a variability which prompts a follow-up monitoring. There are also a few sources that show previously unreported extendedness. In addition, we present H band finding charts of the target sources.

Accepted by the Astronomical Journal
Preprints can be obtained by contacting ueta@oma.be
or via WWW on http://xxx.lanl.gov/abs/astro-ph/0301286

An icy, bipolar proto-planetary nebula with knotty jets : IRAS22036+5306

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Using the Hubble Space Telescope's Wide-Field Planetary Camera 2, we have discovered that the proto-planetary nebula (PPN) IRAS 22036+5306 (I 22036) is an extended ($5\farcs7 \times 1\farcs3$) bipolar nebula. A dark, (partial)

ring-like band defines the nebular waist region, probably due to a tilted, geometrically-thick disk which obscures the central star. Knotty, linear structures are seen in each lobe. VLA A-array observations of OH maser emission in I 22036 show the 1667 MHz emission features aligned in a roughly 1.″8-long linear structure along the nebular axis. The source's far-infrared fluxes imply the presence of a massive [$\sim$5(D/2kpc)^2 $M_\odot$], dusty, cool (T_{dust} $\sim$35-67 K), circumstellar envelope. Strong 3.08 and 11μm absorption features in the ISO spectra show the presence of icy silicate grains, which probably reside in the disk's shielded outer regions. A low-resolution optical spectrum indicates an F5 (or earlier) spectral type for the post-AGB central star, and shows Hα and Hβ emission lines. The elongated and highly structured lobes of I 22036 are likely to have been produced as a result of the interaction of a collimated, fast wind (CFW) with the AGB progenitor's dense, slow wind. Highly-collimated jet-like components in the CFW have probably operated at some time during the formation of this PPN.

Accepted by Astrophysical Journal (Letters)
Preprints can be obtained by contacting sahai@jpl.nasa.gov

s-Process Nucleosynthesis in AGB Stars : a Test for Stellar Evolution

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We study the *slow* neutron capture process (*s* process) in Asymptotic Giant Branch (AGB) stars using three different stellar evolutionary models computed for a 3 $M_\odot$ and solar metallicity star. First we investigate the formation and the efficiency of the main neutron source: the ^{13}C(α,n)^{16}O reaction that occurs in radiative conditions. A tiny region rich in ^{13}C (the ^{13}C *pocket*) is created by proton captures on the abundant ^{12}C in the top layers of the He intershell, the zone between the H shell and the He shell. We parametrically vary the number of protons mixed from the envelope. For high local protons over ^{12}C number ratio, p/^{12}C $>$ 0.3, most of the ^{13}C nuclei produced are further converted by proton capture to ^{14}N. Besides, ^{14}N nuclei represent a major neutron poison. We find that a linear relationship exists between the amount of ^{12}C in the He intershell and the maximum value of the time-integrated neutron flux. Then we generate detailed *s*-process calculations on the basis of stellar evolutionary models constructed with three different codes, all of them self-consistently finding the third dredge up, although with different efficiency. One of the codes includes a mechanism at each convective boundary that simulates time-dependent hydrodynamic overshoot. This mechanism depends on a free parameter f, and results in partial mixing beyond convective boundaries, the most efficient third dredge up and the formation of the ^{13}C pocket. For the other two codes an identical ^{13}C pocket is introduced in the post-processing nucleosynthesis calculations. The models typically produce enhancements of heavy elements of about two orders of magnitude in the He intershell and of up to one order of magnitude at the stellar surface, after dilution with the convective envelope, thus generally reproducing spectroscopic observations. The results of the cases without overshoot are remarkably similar, pointing out that the important uncertainty in *s*-process predictions is the ^{13}C pocket and not the intrinsic differences among different codes when no overshoot mechanism is included. The code including hydrodynamic overshoot at each convective boundary finds that the He intershell convective zone driven by the recurrent thermal instabilities of the He shell (thermal pulses) penetrates the CO core, producing a He intershell composition near to that observed in H-deficient central stars of planetary nebulae. As a result of this intershell dredge up the neutron fluxes have a higher efficiency, both during the interpulse periods and within thermal pulses. The *s*-element distribution is pushed toward the heavier *s*-process elements and large abundances of neutron-rich isotopes fed by branching points in the *s*-process path are produced. Several observational constraints are better matched by the models without overshoot. Our study need to be extended to different masses and metallicities and in the space of the free overshoot parameter f.

Accepted by Astrophysical Journal
Preprints can be obtained by contacting mal@ast.cam.ac.uk
or via WWW on http://www.journals.uchicago.edu/ApJ/journal/

More lead stars

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The standard model for the operation of the s-process in asymptotic giant branch (AGB) stars predicts that low-metallicity ([Fe/H] ≤ -1) AGB stars should exhibit large overabundances of Pb and Bi as compared to other s-elements. The discovery of the first three such 'lead stars' (defined as stars enriched in s-elements with [Pb/hs] ≥ 1, hs being any of Ba, La or Ce) among CH stars has been reported in a previous paper (Van Eck et al., Nature 2001, 412, 793). Five more CH stars (with [Fe/H] ranging from -1.5 to -2.5) are studied in the present paper, and two of them appear to be enriched in lead (with [Pb/Ce]$\simeq 0.7$). The Pb I line at λ4057.812 Å is detected and clearly resolved thanks to high-resolution spectra ($R = \lambda/\Delta\lambda = 135000$). The abundances for these two stars (HD 198269 and HD 201626) are consistent with the predictions for the s-process operating in low-metallicity AGB stars as a consequence of the 'partial mixing' of protons below the convective hydrogen envelope. Another two stars (HD 189711 and V Ari) add to a growing number of low-metallicity stars (also including LP 625-44 and LP 706-7, as reported by Aoki et al., 2001, ApJ 561, 346) which do not conform to these predictions, however. Variations on the canonical proton-mixing scenario for the operation of the s-process in low-metallicity stars, that could account for these discrepant stars, are briefly discussed.

Accepted by Astronomy and Astrophysics
Preprints can be obtained by contacting svaneck@astro.ulb.ac.be
or via WWW on http://www-astro.ulb.ac.be/~svaneck/publi.html

Spectroscopy of planetary nebulae in M 33

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Spectroscopic observations of 48 emission-line objects of M 33 have been obtained with the multi-object, wide field, fibre spectrograph AF2/WYFFOS at the 4.2m WHT telescope (La Palma, Spain). Line intensities and logarithmic extinction, c_β, are presented for 42 objects. Their location in the Sabbadin & D'Odorico diagnostic diagram (Hα/[S II] vs Hα/[N II]) suggests that >70% of the candidates are Planetary Nebulae (PNe). Chemical abundances and nebular physical parameters have been derived for the three of the six PNe where the 4363Å [O III] emission line was measurable. These are disc PNe, located within a galactocentric distance of 4.1 kpc, and, to date, they are the farthest PNe with a direct chemical abundance determination. No discrepancy in the Helium, Oxygen and Argon abundances has been found in comparison with corresponding abundances of PNe in our Galaxy. Only a lower limit to the sulphur abundance has been obtained since we could not detect any [S III] line. N/H appears to be lower than the Galactic value; some possible explanations for this under-abundance are discussed.

Accepted by A&A

Preprints can be obtained contalcting laura@arcetri.astro.it
or via WWW on http://xxx.sissa.it/abs/astro-ph/0301129

UV Observations of Neutron Capture Elements in Planetary Nebulae

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We present results from a search through existing *Far Ultraviolet Spectroscopic Explorer (FUSE)* and *HST* data for neutron capture species in planetary nebulae (PNe), which can be enriched by slow neutron capture (the *s*-process) in the progenitor stars. Measurements of such enrichments shed light on the *s*-process in AGB stars and the heavy element enrichment of the interstellar medium. We derive Ge (Z=32) abundances relative to S or Fe from observations of Ge III λ1088.46 for five PNe; four of these exhibit Ge abundances elevated by a factor of $>$ 3–10 above solar, depending on assumptions about depletion into dust. In contrast, we find an approximately solar abundance for Ge in IC 4776, and also in the ISM towards Abell 36 as derived from Ge II λ1237.06. Another neutron-capture element, Ga (Z = 31), is probably detected in SwSt 1 via Ga III λ1495.05, with a strength indicating a greatly enhanced Ga abundance. The strongest evidence for enrichment is seen for PNe with H-deficient, C-rich Wolf-Rayet central stars. While the evolutionary path producing a [WR] central star is not well understood at present, these objects are likely to have experienced extensive mixing and dredge-up of nuclear-processed material.

To appear in "Energetics of Cosmic Plasmas: The 8th Texas-Mexico Conference on Astrophysics," RevMexAA, Ser. de Conf.

Preprints can be obtained by contacting sterling@astro.as.utexas.edu

The chemistry of protoplanetary nebulae

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We describe the chemistry occurring in a dense slab of outwardly expanding gas in the post-AGB phase of stellar evolution. Despite the high flux of UV photons from the central star, the intrinsic dust extinction in the slab prevents rapid photodissociation and allows chemical reactions to make a variety of gas-phase species, some complex. We find that chemical evolution ends when the intrinsic extinction falls below about 10 magnitudes. At this point, rapid photodissociation occurs. As a particular example of our model, we discuss chemical synthesis in the protoplanetary nebula, CRL 618, and find that for many species we obtain good agreement between the model and observation, despite the complexity of the source.

Accepted by Astronomy & Astrophysics

Preprints can be obtained by contacting pwoods@eso.org

Job opportunity

Post-Doctoral Fellow - Space Telescope Science Institute

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Attention: Dr. Margaret Meixner

Applications are invited for a postdoctoral research position at the Space Telescope Science Institute starting as early as summer 2003. The successful applicant will work with Dr. Margaret Meixner and collaborators on studies of circumstellar dust shells found around main sequence stars, pre-main sequence stars and evolved stars. This research will involve observations with HST, SIRTF, and ground based facilities. Independent research in related areas will be supported and encouraged. Research experience in the areas of planet formation, star formation, evolved stars, dust or radiative transfer is desirable. A PhD in astronomy or astrophysics is required.

The position is for two years, with a possible renewal for a third year. STScI, located on Johns Hopkins University Campus in Baltimore, Maryland, offers an excellent benefit package, competitive salaries, and a stimulating work environment. The minimum salary is $41,900; however, STScI's pay is commensurate to the year of Ph.D.

Applicants should send a cover letter with position applying for, curriculum vitae, list of publications, and a brief statement of research interests, accomplishments, and relevant technical expertise to the address above or email to meixner@stsci.edu, please cc: mccarty@stsci.edu. They should also arrange for three letters of recommendation to be sent directly to the same address. Completed applications received by 15 March 2003 are assured of full consideration. EOE/AA/M/F/D/V