# THE AGB NEWSLETTER

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

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Editors: Thierry Forveille and Claudine Kahane (agbnews@gag.observ-gr.fr)


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# One year already !

## ***Abstracts of recently accepted papers***

### Infrared Emission from Globular Clusters: Limits on Stellar Mass Loss and Interstellar Dust


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**The IRAS Faint Source Catalogue was searched for infrared emission from 84 Galactic globular clusters above $|b| = 10^o$. Emission was detected from nineteen clusters which can plausibly be attributed to photospheric radiation from the ensemble of cool evolved stars. The 12$\mu m$ flux**

densities show no measurable excess over the black body values, setting limits on the amount of circumstellar dust and hence on the stellar mass loss rates of typically $< a\ few\ \times 10^{-8}\ M_\odot\ yr^{-1}$ per star.

The IRAS data also set very low limits on interstellar dust in globular clusters. Together, these observations suggest that the rate of mass injection by globular cluster stars is $\leq 10^{-7}\ M_\odot\ yr^{-1}$ for the whole cluster. The only cluster for which emission is detected at long wavelengths (60$\mu m$ or 100$\mu m$) is M15. The 60$\mu m$ emission is positionally coincident with a small dark obscuring cloud and not with the planetary nebula K648.

Accepted by Ap.J. *For preprints, contact gk@astro.princeton.edu*

# Hot Bottom Burning in Asymptotic Giant Branch Stars and its Effect on Oxygen Isotopic Abundances

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A self-consistent calculation of AGB evolution was carried out, including nucleosynthesis at the base of the convective envelope (hot bottom burning). Hot bottom burning was found to occur for stars between $\sim 4.5$ and $\sim 7¿M_\odot$, producing envelopes with $^{18}O/^{16}O \lesssim 10^{-6}$ and $10^{-3} \lesssim {}^{17}O/^{16}O \lesssim 10^{-1}$. The $^{17}$O abundance depends sensitively on the nuclear $^{17}$O-destruction rate; this rate is only loosely constrained by the requirement that $1^{st}$ and $2^{nd}$ dredge-up models match O-isotope observations of RGB stars (Boothroyd, Sackmann, & Wasserburg 1994). In some cases, high mass loss rates can terminate hot bottom burning before further $^{17}$O enrichment takes place, or even before all $^{18}$O is destroyed. These predictions are in accord with the very limited available stellar observations of J-type carbon stars on the AGB, and with some of the circumstellar $Al_2O_3$ grains from meteorites. In contrast, data from a number of grains and from most low mass S and C AGB stars ($\lesssim 1.7¿M_\odot$) lie in a region of the $^{18}$O/$^{16}$O vs. $^{17}$O/$^{16}$O diagram that is not accessible by $1^{st}$ and $2^{nd}$ dredge-up or by hot bottom burning. We conclude that for AGB stars, the standard models of stellar evolution are not in accord with these observations. We surmise that an additional mixing mechanism must exist that transports material from the cool bottom of the stellar convective envelope to a depth at which $^{18}$O is destroyed. This "*cool bottom processing*" mechanism on the AGB is similar to extra mixing mechanisms proposed to explain the excess $^{13}$C (and depleted $^{12}$C) observed in the earlier RGB stage of evolution, and the large $^{7}$Li depletion observed in low mass main sequence stars. Hot bottom burning may lead to significant $^{17}$O enrichment of the interstellar medium; this could be from about 5% to twice the total amount of $^{17}$O produced by supernovae and low mass stars.

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# Infrared properties of circumstellar dust envelopes of oxygen-rich asymptotic giant branch stars

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Models of oxygen-rich circumstellar dust envelopes around red giant stars are calculated for a range of mass-loss rate up to $7 \times 10^{-4} M_\odot$ yr$^{-1}$. A new generalized two-stream Eddington approx-

imation was employed in the radiative transfer calculation for spherical circumstellar envelopes with non-gray dust grains. Calculating infrared spectral energy distributions of the models with various sets of input parameters, observational infrared characteristics such as IRAS properties are presented as a fucnction of physical conditions of the circumstellar dust envelope. Through a direct comparison of infrared observational data with the computation results, we can determine the physical status of the circumstellar dust envelope of each individual oxygen-rich AGB star. Observational data at wavelengths shorter than about 20 $\mu$m can well determine two physical parameters, the stellar mass-loss rate and the grain temperature at the inner boundary of the circumstellar dust envelope. Observational data at wavelengths longer than 60 $\mu$m can give an indication of the mass-loss history in a timescale longer than several handred years. It is possible to investigate AGB evolution with mass loss through model analyses of the infrared data of a number of AGB stars in various evolutionary stages.

Accepted by The Astrophysical Journal *For preprints, contact hasimoto@aps.seikei.ac.jp*

# Injection of freshly synthesized $^{41}$Ca in the early solar nebula by an AGB star

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We show that one asymptotic giant branch star of M $\sim$ 3 $M_\odot$ may account for many of the short lived nuclei in the early solar system, and also for the recent evidence of the presence of $^{41}$Ca ($\tau_{41}$ = 1.50 $\times 10^5$ yr) in early solar nebula condensates. This would require that the injection into the proto-solar molecular cloud took place within a narrow time interval of (5-7) $\times$ $10^5$ yr before the formation of the solar system. If true, this places extremely tight constraints on the whole process of injection, mixing and collapse. The time scales for both $^{41}$Ca and $^{26}$Al require that the placental medium be a dense molecular cloud ($2 \times 10^3 - 8 \times 10^3$ H/cm$^3$). If the observed residual $^{41}$Ca is instead produced by a proton bombardment mechanism within the early solar system, similar to what appears necessary to explain $^{53}$Mn, then the time interval is relaxed but would still be (1-3) $\times$ $10^6$ yr, from consideration of $^{26}$Al.

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# Theoretical interferometric visibilities accross absorption bands in circumstellar shells

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The interferometric fringe visibility presents a variation accross an absorption band. This is due to the variation of the relative contribution of the direct stellar flux. Theoretical visibility curves are presented for two carbon stars (Y Tau and AFGL 799) and one oxygen star ($\alpha$ Ori) showing the importance of measurements at several wavelengths accross the band. Results deduced from such measurements will provide an improvement of our knowledge of silicate and SiC optical properties. The aim of this work is to encourage interferometrists to developp the infrared interferometry with spectral resolution in 10$\mu$m band. A bandwidth of 0.01 $\mu$m seems enough to display the variation of the visibility for a fixed baseline.

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## The 30 $\mu$m Emission Band in Carbon-rich Pre-Planetary Nebulae

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The 16–48 $\mu m$ spectra of five carbon–rich post–AGB objects known to have an unidentified 21 $\mu m$ emission feature in their ***IRAS*** LRS spectra have been obtained using the Kuiper Airborne Observatory. A broad emission band extending from 24 to $\sim 45\,\mu m$ is present in the spectra of these objects. Peaking at $\sim 30\,\mu m$, the intensity of the band is variable from source to source, accounting in one case (IRAS 22272+5435) for about twenty percent of its bolometric luminosity. However, its strength is not correlated with that of the 21 $\mu m$ feature. The 30 $\mu m$ band is similar to the feature previously found in other carbon–rich AGB stars and planetary nebulae which was suggested to be carried by solid MgS particles. The observed 30 $\mu m$ emission is modeled combining distributions of carbon grains and MgS grains. The required MgS abundance is roughly estimated to be less than $\sim 7\ 10^{-6}$, i.e. representing about 50 and 25% of the total abundances of S and Mg, respectively. Despite the relatively good fit with MgS, the possibility of alternative models especially with carbon-related compounds should still be addressed.

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## Maps of the molecular emission around 18 evolved stars

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We present maps at $20''$ resolution of the molecular emission around 18 evolved stars (14 asymptotic giant branch stars, one supergiant, two proto-planetary nebulae and one planetary nebula), mostly in the $^{12}$CO(3-2) line. Almost all molecular envelopes appear to be at least marginally resolved at this resolution. A substantial fraction of the molecular envelopes show clear deviations from spherical symmetry in the form of elliptical or bipolar envelopes. This indicates that there is a need to implement non-spherical mass loss in current scenarios of the late stages of stellar evolution, in particular on the asymptotic giant branch.

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## *Request for help in the preparation of a review article*

**I would appreciate your help in the preparation of a review article on circumstellar chemistry for Annual Reviews of Astronomy and Astrophysics, with a deadline of October 15, 1995. The emphasis will be on gas-phase chemistry and related physics of the winds of evolved stars, especially on and just after the AGB. Please send me hardcopies of recent reprints as well as preprints. Many thanks.**

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