THE AGB NEWSLETTER

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

No. 27 — 01 June 1996

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

Abstracts of recently accepted papers

Formation of PAHs, polyynes, and other macro-molecules in the photosphere of carbon stars

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Polycyclic Aromatic Hydrocarbons (PAH) have been suggested as a link in one of the possible routes from molecules to grains in carbon-rich stellar atmospheres. Carbon grains, except SiC, may form by conversion of C_2H_2 into PAHs. The most obvious site of this PAH production is the outer atmosphere of carbon stars. We present the first calculations of equilibrium partial pressures of PAHs and other complex carbon-bearing molecules in stellar photosphere models for carbon stars. We have included 38 atomic species and 338 molecules in chemical equilibrium. Our computed models have the following parameters: T_{eff}=(2800K, 2600K, 2400K), $Z=Z_\odot$, log(g) ϵ [−1,0.5], C/O ϵ [1.1,7.0]. The results of the hydrostatic model calculations show that for atmospheric regions with T>1000K the partial pressures of PAHs and other large molecules are negligible small. This result is independent of the choice of fundamental stellar parameters.

For shallower depths than our hydrostatic photosphere models, however, a systematic chemical equilibrium exploration of the T-P_{gas} plane, Tϵ[750K,1000K], logP_{gas} ϵ[-5,3] (P_{gas} in dyn/cm^2), discloses PAHs as the species containing the largest fraction of carbon atoms not bound in CO for a range of temperatures around 850K. More carbon is contained in PAHs than in CO at these temperatures for $C/O \geq 5.0$.

Chemical equilibrium considered in a dynamical atmospheric structure confirms these results. The higher column density of PAHs is sufficient for the dynamic model to have an effect on the structure of the model (levitation) and on the emergent spectrum. However, some studies (Frenklach & Feigelson 1989) on kinetic PAH formation require a residence time at favourable T and P_{gas} which is longer than the time scales of realistic wind models. In the framework of our hydrostatic models we confirm that the conditions for PAH formation (T, P_{gas} or residence time) are not met, and we can point at the lower boundary condition needed for the wind models. Therefore either the observed dust grains form via other routes, or more complex stellar environments are required.

Accepted by A&A

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OH 57.5+1.8: Two OH masers corresponding to two IRAS sources 19295+2228 and 19296+2227

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The two OH maser emitters with the designation OH 57.5+1.8 and velocities −75 and +40 km s^{-1}, discovered within one pointing by OH maser surveys, are shown to belong to the IRAS sources 19295+2228 and 19296+2227. The first is a well known OH/IR star, while the second is suggested to be a proto-planetary nebula. The latter classification is inferred from the peculiar properties of the OH maser and those of a newly discovered H_2O maser. If correct, the search for peculiar maser properties among IRAS sources with colors typical for late AGB stars may allow the discovery of proto-planetary nebulae in a very early stage of their departure from the AGB.

OH maser spectra with high velocity resolution of the OH/IR stars OH 66.8-1.2 and AFGL 4259 are displayed in addition to those of OH 57.5+1.8, showing that their two maser components are blends. The spectra support models of the circumstellar outflow, which predict clumpiness in the OH maser shell.

Accepted by Astronomy & Astrophysics

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IRC +10 216 revisited I: the circumstellar dust shell

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A spherically symmetric dust radiative transfer code is used to model the circumstellar dust shell around IRC +10 216. Compared to numerous previous models a much larger body of observational data is used as constraints; the spectral energy distribution between 0.5 and 60000 μm, 2-4 μm and 8-23 μm spectra, optical, far-infrared and centimeter sizes and interferometric visibility curves between 1.6 and 11.2 μm are used to constrain the model.

The most important result is that in order to fit the visibility curve at 2.2 μm and the size of the shell in the optical, scattering has to be invoked. The strong dependence of the scattering coefficient on grain size allows one to derive a mean grain size of 0.16 $\pm$ 0.01 μm.

For a model with a r^{-2} density distribution a dust mass loss rate of 8.1 $\pm$ 0.7 $\times$ 10^{-7} D (kpc) $M_\odot$ yr^{-1} (adopting v_∞ = 17.5 km s^{-1} and a dust opacity $\kappa_{60\mu m}$ = 68 $cm^2 g^{-1}$), a luminosity at maximum light of 823 $\pm$ 40 $\times$ 10^3 (D (kpc))^2 $L_\odot$, an inner dust radius of r_c = 4.5 $\pm$ 0.5 $R_\star$, an inner dust temperature of T_c = 1075 $\pm$ 50 K and an effective temperature of T_{eff} = 2000 $\pm$ 100 K are derived (all 1σ error bars).

It is found that a r^{-2} dust density law in the inner part of the shell gives a slightly better fit than the physically more realistic case of a steeper law where the effect of the increasing dust velocity with radius is taken into account. It is suggested that the dust-to-gas ratio *also* increases with radius and that therefore the net effect on the dust density distribution may be small.

Previous suggestions that the mass loss rate was higher in the past are confirmed. The principle argument is that with an r^{-2} model the calculated far-infrared sizes are smaller than observed. A good fit is obtained with a dust mass loss rate of 8.1 $\times$ 10^{-7} D (kpc) $M_\odot$ yr^{-1} for r < 123 arcsec and 7.3 $\times$ 10^{-6} D (kpc) $M_\odot$ yr^{-1} for r > 123 arcsec (assuming that v_∞ and the dust opacity do not change with time). An alternative model with an exponentially decreasing mass loss rate can be excluded.

The presently available constraints are not sensitive to the dust density beyond $\sim$ 10 arcmin. The total dust mass in the shell out to 10 arcmin is 1.0 (D (kpc))^2 $M_\odot$ in the model with the non constant mass loss rate, and 0.13 (D (kpc))^2 $M_\odot$ in the model with the constant mass loss rate.

The slope of the dust opacity beyond $\sim$1000 μm (where no laboratory measurements are available) and the influence of free-free emission are investigated by comparing cm-observations to a newly developed radiative

transfer code to calculate the emission from a central star surrounded by a shell where free-free emission is assumed to occur. It is found that in small apertures dust emission is negligible for wavelengths $\gtrsim$ 2 cm. Free-free emission is negligible for wavelengths $\lesssim$0.5 cm. To account for the observed flux at 3300 μm the slope of the opacity is changed to $Q_\lambda \sim \lambda^{-0.85}$ for $\lambda > 1000$ μm. The free-free emission is found to be optically thin even at 6 cm. An ionization fraction of 7.8×10^{-5} is derived which, according to the Saha equation, corresponds to an electron temperature of about 2400 K. Although there are uncertainties in the free-free emission model this suggests that the free-free emission does not come from a chromosphere.

Accepted by A&A

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Variable central stars of young Planetary Nebulae. I. Photometric multisite observations of IC 418

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We report the results of a photometric multisite campaign devoted to HD 35914, the variable central star of the Planetary Nebula IC 418. From the analysis of 120 hours of data acquired with a variety of techniques, we find that HD 35914 exhibits two distinct kinds of variability: irregular light modulation with a time scale of days, as well as cyclic variations with a time scale of 6.5 hours. The short-term variations are not strictly periodic, and cannot be reasonably explained by multiperiodicity; they appear to be semiregular. The star is generally redder when it is brighter; this behavior appears to be connected with the long-term variability.

A re-analysis of most of the older data obtained for HD 35914 by various researchers suggests that the basic behavior of the star did not change during the last 15 years.

We carefully discuss all the possible causes for the light variations of the star. Rotational modulation of surface features cannot explain the observations, and binarity is unlikely. Pulsations may be excited, but wind variability (or a combination of both) can also not be ruled out.

Accepted by Astronomy & Astrophysics

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^{14}C in AGB stars: the case of IRC+10216

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Observations and stellar evolution computations have been dedicated to the search for ^{14}C in the archetype of AGB stars, IRC+10216/CW Leo. Contrary to Wright's (1994) tentative detection, we see no trace of ^{14}CO in

this star down to a 3σ limit $R = {}^{13}CO/{}^{14}CO \geq 1400$. The new limit is consistent with our stellar evolution computations, which indicate that R should be > 4000. Comparison of the C, N, O, Mg, Si, and S isotopic ratios observed in this source with the calculated ones reinforces our earlier conclusion that CW Leo had a main sequence mass $3\ M_\odot < M_{ZAMS} < 5\ M_\odot$

While searching for the ^{14}CO 2–1 line, we detected the $(1\nu_3)\ 9_{36} - 8_{35}$ line of vibrationally excited SiC_2. The latter line pertains to the first vibrational level of the ν_3 bending state and its upper level has an energy of 290 K, lower than the temperature of the dust forming shell. The line has a pyramidal shape and shows acceleration steps, which we interpreted in terms of dust formation.

Accepted by Astronomy and Astrophysics

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IRAS 22272+5435 – a source with 30 an 21 μm features.

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Recent observations have shown that IRAS 22272+5435, a post–AGB object with a cool central star, is one of the few sources known which displays strong 21 and 30 μm features. We present a detailed analysis of the spectral energy distribution and discuss the possible nature of the dust grains in the circumstellar envelope around this source. We find that grains of pure magnesium sulfides could be responsible for the observed 30 μm feature provided they have a high enough temperature and an appropriate broad distribution of shapes inside the shell. The absorption properties of such grains at optical and ultraviolet wavelengths are unknown, so at the present time we are unable to estimate how high a temperature they would have in the circumstellar shell; laboratory measurements of the the optical properties are needed. The 30 μm feature cannot be produced by mantles of magnesium sulfide covering an amorphous carbon core as such grains are shown to have two maxima in their absorption cross sections around a minimum at about 30 μm. Since the material(s) responsible for 21 and 30 μm features is (are) still unknown we constructed an empirical opacity function which provides a reasonable fit to the energy distribution at far–infrared wavelengths. We also show that small particles (with radii smaller than 10 Å) having properties very similar to those of PAH molecules are an indispensable part of dust around this source. For these small grains the quantum treatment of heating and cooling processes is important. Assuming that the central star of IRAS 22272+5435 is burning H quiescently in a shell, the parameters of the best fit to the energy distribution of this source indicate a stellar core mass 0.60 $M_\odot$ which is presently evolving with no (or with very little) mass loss.

Accepted by Astronomy and Astrophysics

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Detection of a new molecule in IRC+10216

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A series of ten unidentified lines was detected in the molecular envelope of IRC+10216 in the frequency range of 27-83GHz. The rotational and centrifugal distortion constants are determined to be B=1376.8641(43) MHz and D=0.000 0365(38) MHz, assuming a linear molecule is responsible for the unidentified lines. Candidate molecules are discussed from the spectroscopic characteristics and chemical points of view

Accepted by Ap. J., Part II.

Preprints can be obtained by contacting contact-kasai@postman.riken.go.jp

Meetings

IAU Symposium 180 on Planetary Nebulae

Groningen - August 1996

In the last week of August, IAU Symposium 180 will be organised in Groningen, with as topic Planetary Nebulae. This is a large conference in a long series of conferences on Planetary Nebulae, which is held once every five years. The total number of participants will be between 200 and 250. At the moment we have about 170 registered participants, so there is place for a few more.

Information about the conference can be found at http://www.astro.rug.nl:18096/

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