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NEARBY MAIN SEQUENCE STARS WITH COOL CIRCUMSTELLAR MATERIAL:

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The discovery of the so-called "Vega phenomenon" was one of the most important and unexpected results of the IRAS mission. Several nearby main sequence stars were found to possess clouds of solid grains emitting strongly in the far-IR. Three of these objects (alpha Lyr = Vega, alpha Piscis Austrinis = Formalhaut, and beta Pic) were marginally resolved by IRAS. Beta Pic has since been resolved by ground-based infrared photometry and visual and near-infrared coronagraph imaging. Formalhaut has been resolved at sub-millimeter wavelengths.

The grains have typical temperatures of 50-150K and fractional bolometric luminosities (L_{grains}/L_{star}) in the range 10^{-5} to 10^{-3}. The comparable figures for the zodiacal dust in our solar system are 225 K and 10^{-7}. The spatial information available indicates that: (1) the grains are larger than interstellar grains, (2) the material may lie in disks in the stellar equatorial planes, (3) the material extends to distances of order 100-1000 AU from the stars, and (4) a zone with radius smaller than 50 AU around the central stars is relatively depleted of material. The total mass included in the small grains detected by IRAS is of order 10^{-2} to 10^{-1} earth masses, although much more mass could reside in larger, undetectable bodies.

Subsequent detailed surveys of IRAS data reveal more than 100 additional cases of main sequence stars of classes A-K having far-IR excesses with similar temperature and fractional luminosity to the three prototypes. To the extent that a determination can be made with the present small-number statistics, the amount of circumstellar material does not appear to be a function of stellar type. The 3 prototypes are all younger than $5x10^8$ years, but some of the F, G, and K stars discovered in later surveys have ages estimated by various means to be $1\text{-}5x10^9$ years. Thus, this phenomenon appears to be widespread and not limited to proto-planetary epochs.

Possible connection of this phenomenon to the existence of planets is tantalizing. The sizes of these clouds/disks correspond most closely to the hypothetical "Kuiper disk" component of our solar system, which is supposed to lie in the ecliptic plane outside the planetary region but well within the larger Oort cloud, providing a source for short period comets.

PIXE Measurements on the Iron Meteorite Mundrabilla

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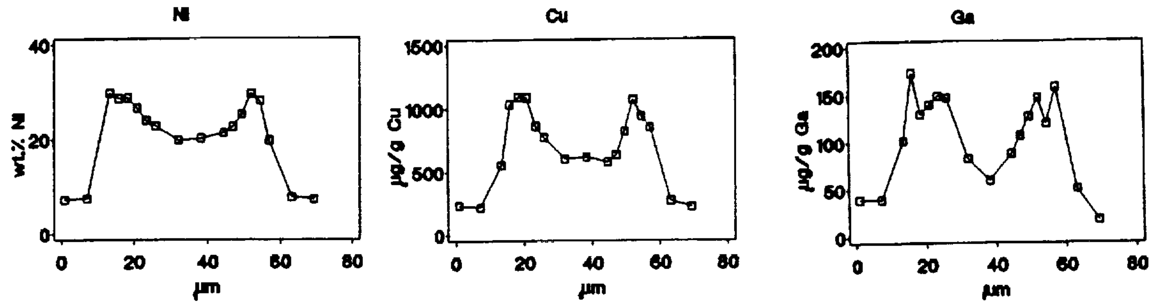
With the Heidelberg proton microprobe (PIXE) we have measured concentration profiles of Fe, Co, Ni, Cu, Ga, and Ge on the ungrouped iron meteorite Mundrabilla (Bajt et al. 1990). Absolute calibration of the Ni PIXE measurements were performed by analytical electron microscopy on known Fe-Ni standards.



Classical cooling rate calculations of the Ni-profile were conducted (Rasmussen, 1989). Local bulk Ni and P values were not measured, but were assumed to be equal to the bulk meteorite values, 7.7 wt% Ni and 0.26 wt% P (Buchwald, 1975). A cooling rate of 400 K/My were found for Mundrabilla based on measurements of 2 taenite lamellae. This cooling rate is uncertain ca. by a factor of 2. In order to evaluate the future potential of the trace elements Co, Cu, Ga, and Ge as cooling rate indicators we calculated from our measurements two parameters for each element. The first parameter, DF, which we term the "driving force" was:

$$DF = [E_{max}(\gamma)-E(\alpha)]/E(\alpha)$$

where $E_{max}(\gamma)$ is the maximum elemental abundance in the taenite, i.e. the concentration at the rim, and $E(\alpha)$ is the average concentration in the kamacite. A higher driving force indicates a higher potential for this element to yield information about the cooling history of the meteorite. The second parameter, DS, reflects the "diffusion speed" of the each particular element:

$$DS = E_{MPC}(\gamma)/E(\alpha)$$

where $E_{MPC}(\gamma)$ is the Mid Profile Concentration, i.e. the elemental abundance in the middle of the taenite lamella. This parameter allows us to empirically compare the diffusion speed of the elements without knowing the actual diffusion coefficients. A DS value close to unity signifies relatively slow diffusion speed allowing the system to reach equilibrium, whereas a DS-value greater than one signifies faster diffusion speed and disequilibrium.

	Co	Ni	Cu	Ga	Ge
$E_{MPC}(\gamma)$	1054 µg/g	19.89 wt%	602 µg/g	83 µg/g	141 µg/g
$E(\alpha)$	2479 µg/g	7.50 wt%	236 µg/g	37 µg/g	188 µg/g
$E_{max}(\gamma)$	544 µg/g	29.79 wt%	1085 µg/g	166 µg/g	265 µg/g
DF	0.78	2.97	3,61	3,44	0,41
DS	2,35	2,65	2,56	2,23	0,75

Our measurements and calculations on Mundrabilla show that the "driving force" is highest for Cu and progressively less for Ga, Ni, Co and Ge. Our results also show that the relative diffusion speed is largest for Ni and progressively slower for Cu, Co, Ga and Ge.

References: Bajt, S., Pernicka, E. and Traxel, K. (1990) *Beih. z. Eur. J. Mineral.* **2**, 9. Buchwald, V.F. (1975) *Handbook of Iron Meteorites*. Rasmussen, K.L. (1989) *Icarus* **80**, 315-325.