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THE ORIGIN OF MICROGRAINS

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Using ultraviolet and infrared techniques, we have investigated the origins of the tiny (~ 10A) grains whose presence in the interstellar medium is inferred from near-infrared photometry (Sellgren, Werner, and Dinerstein 1983; Sellgren 1984). We consider two possibilities: (1) that the grains are formed by condensation in stellar atmospheres; or (2) that they are formed by fragmentation of larger grains in interstellar shocks.

We have searched for evidence of very small grains in circumstellar environments by analyzing ultraviolet extinction curves in binaries containing hot companions, and by searching for the 3.3-micron emission feature in similar systems. The ultraviolet extinction curve analysis could be applied only to oxygen-rich systems, where small carbonaceous grains would not be expected, so these results provide only indirect information. We find a deficiency of grains smaller than 800A in oxygen-rich systems, consistent with theoretical models of grain condensation which suggest that grains grow to large sizes before injection into the interstellar medium. More direct information on carbonaceous micrograins was obtained from the search for the 3.3-micron feature in carbon-rich binaries with hot companions, whose ultraviolet flux should excite the tiny grains to emit in the infrared. No 3.3-micron feature was found, suggesting that the micrograins are absent in these systems.

In addition to the negative search for micrograins in circumstellar environments, we have also studied the possible association of these grains with shocks in the diffuse interstellar medium. Using IRAS colors as indicators of the presence or absence of the small grains (e.g Ryter, Puget, and Pérault 1987 and references cited therein), we have systematically searched for them in regions (reflection nebulae) expected to have sufficient ultraviolet flux to make them glow in the infrared. We find that the distribution is not uniform.

We propose that production of micrograins by fragmentation of larger grains in shocks could explain this uneven distribution. We note that the presence of micrograins in carbon-rich planetary nebulae may also be attributed to shock fragmentation of larger grains, since the rapid winds from planetary nebulae central stars could fragment larger grains formed during earlier mass-losing phases.

If the overall size distribution of grains in the diffuse interstellar medium is controlled by shock processing, as recent theoretical work has suggested (Seab and Shull 1985; McKee et al. 1987), then we must ask why the micrograins are not ubiquitous. It is possible that the general carbon abundance is variable with location in the galaxy, so that carbonaceous micrograins are produced only in specific regions. Another possibility is that the formation of micrograins requires shocks that are unusual in some respect such as velocity, so that only some shock-processed regions have the grains. Yet another possibility is that the micrograins are selectively destroyed by ultraviolet radiation in regions of high flux intensity (Ryter, Puget, and Pérault 1987).

Calculations in progress (Tielens et al. 1988) show that micrograins are rather easily produced in shocks; in fact it is difficult to explain how the larger grains responsible for visible extinction and polarization can survive. One suggestion is that grain coagulation is responsible, so that in effect all grains larger than micrograins are the result of the sticking of small grains to each other (Seab 1987). If so, the variable distribution of micrograins could be a density effect, since coagulation would be most efficient in relatively dense regions. Possible further observational tests of this picture will be discussed.

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