Properties of Grains Derived from IRAS Observations of Dust

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We have used the results of IRAS observations of diffuse medium dust to develop a theoretical model of the infrared properties of grains. Recent models based entirely on traditional observations of extinction and polarization include only particles whose equilibrium temperatures do not exceed 20 K in the diffuse interstellar medium. These "classical" grains, for which we have adopted the multipopulation model developed by Hong and Greenberg (1980), can explain only the emission in the IRAS 100 μm band. The measurements at shorter wavelengths (12, 25 and 60 μm) require two new particle populations. Vibrational fluorescence from aromatic molecules provides the most likely explanation for the emission observed at 12 μm, with PAH's containing about 10% of cosmic carbon. A simplified model of the emission process shows that PAH molecules can also explain most of the emission measured by IRAS at 25 μm.

We have identified the "warm" particles responsible for the excess 60 μm emission with small ($a \approx 0.01$ μm) iron grains. A compilation of the available data on the optical properties of iron indicates that the diffuse medium temperature of small iron particles should be close to 50 K and implies that a large, possibly dominant, fraction of cosmic iron must be locked up in metallic particles in order to match the observed 60 μm intensities. The model matches the infrared fluxes typically observed by IRAS in the diffuse medium and can also reproduce the infrared surface brightness distribution in individual clouds. In particular, the combination of iron and "classical" cool grains can explain the surprising observations of the 60/100 μm flux ratio in clouds, which is either constant or increases slightly towards higher opacities.

The presence of metallic grains has significant implications for the physics of the interstellar medium, including: 1) catalytic H_2 formation, for which iron grains could be the main site; 2) differences in depletion patterns between iron and other refractory elements (Mg, Si); 3) superparamagnetic behaviour of large grains with embedded iron clusters giving rise to the observed high degree of alignment by the galactic magnetic field.