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INFRARED EMISSION FROM INTERPLANETARY DUST

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I. INTRODUCTION

The infrared sky is dominated on large scales by emission from interplanetary dust, which produces the Zodiacal Emission (ZE), and interstellar dust (Hauser *et al.* 1984). These two components of the infrared background differ in angular and spectral distribution, allowing the two to be separated easily in some places. In this contribution, we describe our method of determining the emission from interplanetary dust near the Earth's orbit, and we compare our results to predictions for realistic materials with the interplanetary size distribution measured *in situ*.

II. OBSERVATION OF THE LOCAL VOLUME EMISSIVITY

The brightness of the ZE observed toward the north and south ecliptic poles varies sinusoidally with a period of one year, due to the inclination ($\simeq 1.8°$) of the Earth's orbit with respect to the surface of maximum interplanetary dust density. The polar brightness difference is equal to the integral of the local volume emissivity over the short path between the Earth and the symmetry plane, so we may determine the local emissivity from the amplitude of the annual brightness variation. We performed least-squares fits to the polar brightness data in the IRAS Zodiacal Observation History File, which contains the 0.5°-averaged sky brightnesses and pointing information as a function of time throughout the IRAS mission. The brightness differences are calculated from individual half-orbit scans, so that the calibration is identical. The derived local volume emissivities in the four IRAS bands are shown in Table 1. The uncertainties listed in this table are due only to the statistical uncertainty in the amplitude of the polar brightness variation.

The second method of determining the local emissivity uses the variation of the ZE brightness with the solar elongation angle, ϵ, defined as the angle between the line of sight and the sun. The gradient at $\epsilon = 90°$, *i.e.* tangent to the Earth's orbit, is equal to the local volume emissivity. We used least squares fits of the IRAS data, which cover $60° < \epsilon < 120°$, to determine the emissivities which are shown in the second row of Table 1. The least-squares fits were performed using a variety of terms in addition to those dependent on ϵ. A term proportional to the Galactic H I column density was crucial at 60 and 100μm, and significant in all four IRAS bands.

TABLE 1

Volume Emissivity of Interplanetary Dust[a]

	12μm	25μm	60μm	100μm
polar brightness variation	2.89 ± 0.03	4.85 ± 0.06	1.34 ± 0.04	0.65 ± 0.13
ecliptic plane gradient	3.19 ± 0.01	4.67 ± 0.03	1.74 ± 0.02	0.76 ± 0.04

[a] Units 10^{-29} erg cm^{-3} sec^{-1} Hz^{-1} Str^{-1}

The statistical uncertainties listed in Table 1 are underestimates of the true uncertainties, which include calibration and systematic errors. Note that since we use differential measurements, an isotropic background (instrumental or astronomical) would not affect our results directly.

III. Calculation of the Local Volume Emissivity

Assuming spherical grains, we calculated the interpalnetary emissivity using the measured optical properties of real materials and the size distribution of interplanetary dust. The interplanetary size distribution, from Grün *et al.* (1985), is constrained by satellite measurements of the particle flux in Earth orbit and by the lunar microcrater distribution (for pits larger than 7μm). Spectrum were calculated and averaged over the IRAS bandpasses, for comparison with the observations.

None of the materials is consistent with the overall level of the observed infrared emission. Those which best match the predicted spectra (silicates) predict an infrared emissivity roughly a factor of 2 fainter than observed. We cannot resolve this discrepancy, but we note that our calculations are consistent with the calibration of observations of Murdock and Price (1985).

Notwithstanding the problem with the overall brightness of the ZE, we can use the observed color ratios to constrain the constituent of interplanetary dust. Metallic grains of graphite and magnetite are inconsistent with the $12/25\mu$m color ratio (too hot). The size distribution obtained by using lunar microcrater counts all the way down to submicron particles is also inconsistent with the observed ZE due to substantial emission by submicron grains, which are hotter than the $\sim 100\mu$m grains which produce the bulk of the emission.

IV. References

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