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LONGWAVE SPECTRAL DEPENDENCE OF EMISSION FROM WARM DUST CLOUDS

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Observations (Gordon and Jewell, 1987) of the continuum emission from warm dust clouds at 230 GHz, or 1300 μm, enable us to determine the frequency dependence of the optically thin, longwave emission. Integrating the emission over the solid angle of the clouds gives a flux independent of the beam size and of the internal temperature structure of the clouds. The frequency resolving power of 64 allows us to correct these fluxes for the contribution of free-free emission from nearby HII regions—at the price of reduced sensitivity, of course. We (Gordon, 1988) combine these observations with similar observations made by others in the submillimeter and far infrared regimes to determine the continuum spectra of the dust clouds.

To determine mean characteristics for these clouds, we fit these spectra with the simple transfer equation,

$$F_\nu = \Omega B_\nu(T)\,(1 - e^{\tau})\,, \tag{1}$$

where the optical depth is modeled by

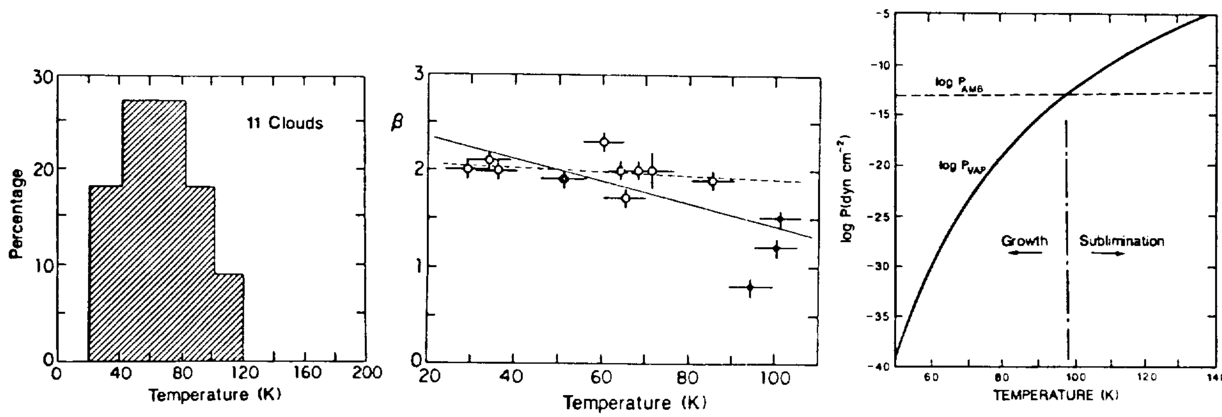
$$\tau = (\nu/\nu_o)^{\beta}\,. \tag{2}$$

Here F_ν is the integrated flux at frequency ν; Ω, the solid angle of the source; $B_\nu(T)$, the frequency form of the Planck function at a temperature T; ν_o, the frequency at which the average opacity of the cloud τ is 1, and β, the frequency dependence of the opacity and emissivity. At millimeter and submillimeter wavelengths where usually $\tau \ll 1$, the flux $F_\nu \propto \nu^{\beta+2}$.

The first result is that the color temperature T may represent an average dust temperature for a cloud. Our fits to Eq. (1) show the derived solid angles of the sources, Ω, are only $\leq 10\%$ of the actual solid angles subtended by the clouds. Most are $\leq 3\%$. Interpreting these values as filling factors, we suggest that the clouds are highly fragmented on angular scales much less than the 0.5–1.0 arc min beamwidths normally used to map the clouds. The implication of this fragmentation is that the FIR photons may be able to escape from the clouds so that the continuum spectra may represent the distribution of photons within the cloud in spite of substantial opacities of the cloud fragments, and therefore that the color temperatures T may also represent the temperatures of the dust grains averaged over the clouds.

Under the assumption that the continuum spectra *do* represent the real distribution of flux within the clouds and the color temperatures T of Eq.(1) may be indicative of the dust temperatures, Fig. 1 shows the distribution of these dust temperatures for the 11 clouds observed. The lower limit probably results from the sensitivity limit to our observational technique, but the upper limit may be an intrinsic property of dust clouds in general. For example, the upper limit may mean that photons with $\lambda \leq 46\mu$m — the wavelength of the maximum of $B_\nu(110\text{ K})$ — may have difficulty escaping from the cloud fragments, or that the cloud has a regulatory mechanism to maintain its average color temperature below 110 K.

The longwave spectral dependence of the flux may tell us something about the average property of the dust grains. Fig. 2 shows the variation of β as a function of T. It appears that $\beta \approx 2$ for all but the warmest clouds, those of OMC-1 indicated by the filled circles.



(*left*) **Fig. 1**—The histogram of color temperatures. (*center*) **Fig. 2**—Opacity exponent β plotted against color temperature. The broken line is a least squares fit to all but the OMC-1 data. (*right*) **Fig. 3**—The ambient pressure of H_2O for OMC-1 and the vapor pressure of ice plotted against temperature. The regions of the growth and sublimation of the ice mantles are marked.

Because β is lower for each of the components of OMC-1, we believe the explanation lies in something unusual about the cloud's dust grains and not just the presence of a cold cloud along the line of sight. Fig. 3 is a plot of the vapor pressure of ice (van de Hulst, 1949) against the ambient pressure of H_2O, where we assume a density of 8 molecules per cm^3 (Phillips *et al.*, 1978; Waters *et al.*, 1980) which may be an appropriate density for OMC-1. At temperatures greater than the intersection temperature (98 K) of the 2 curves, ice mantles will sublime. At lower temperatures, they will grow. The average T for OMC-1 is $\approx$ 100 K. Could the lower βs for OMC-1 result from evaporation of ice mantles, thereby altering the grain emissivities (Aannestad, 1975) from the normal characteristics of most grains in the ISM? Under these condition, the time required for the evaporation of the ice mantles would be $\approx$ 5000 yr, a short time compared to the lifetime of the contiquous HII region, the Great Nebula in Orion.

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