A STATISTICAL ANALYSIS OF DUST FEATURES IN THE IRAS LOW RESOLUTION SPECTRA

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ABSTRACT. Using the IRAS catalog of low resolution spectra (LRS), we have analyzed the silicate features in emission and absorption, the carbon-rich emission features and the featureless spectra, in the range 8-22 μm. The sample sizes are large enough to allow average properties to be established (e.g. energy distributions), as well as correlations between luminosities, excesses, colors and coordinates, and histograms and galactic distributions, all with a good degree of confidence.

1. METHOD

Select a group of spectra in the LRS data bank. Normalize the fluxes F_λ to 1 at a suitable w.l. λ_o (say 10 μm) and obtain $\mathfrak{F}_\lambda \equiv F_\lambda/F_{\lambda o}$. For each λ, take the geometric mean of all normalized fluxes, over the spectra of the sample. This gives $\mathfrak{F}_\lambda$, which is our "average profile" for the sample. This procedure improves S/N in proportion to the sample size. We also compute Σ_λ, the (geometric) std.dev. of $\mathfrak{F}_\lambda$. It is an estimate of the dispersion of the spectral profiles in the selected sample. When the spectra of a given class are grouped in sub-classes according to their brightness (e.g. flux at 8 or 10 μm) so that Σ_λ, in each sub-class, remains reasonably small (< 25%), the following general, gross trends are observed: bright objects are more evenly distributed in longitude (l) and/or latitude (b), hence are closer to the Sun ; weak objects are restricted to the bulge direction, hence are farther from the Sun ; also, they are generally redder.

2. PARTICULARS OF VARIOUS SPECTRAL CLASSES

2.1. Class 1 (featureless spectra)

On a colour-colour diagram, F_{12}/F_{25} vs. F_8/F_{12}, 3 distinct sub-classes are distinguished among the 445 brightest objects:
a) 2000 < Tc < 3000 K : 212 objects with spectra $\propto \lambda^{-4}$ and nearly uniform distributions in l and b ; these are probably photospheres.

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b) 500 < Tc < 1000 K : 199 objects grouped towards the bulge, with a Sic-like bump around 11.3 μ in their spectrum, indicating C-rich envelopes (which considerably increases the proportion of such shells as compared with silicate shells).
c) Tc < 500 K : 34 objects towards the inner galactic arms ($|b| < 10°$), with non-thermal spectra and SiC bumps.

2.2. Classes 2 and 6 (silicate features at 10 and 18 μm)

There is a clear change of spectral profile as a function of brightness: as the latter decreases, one notices a counter-clockwise tilt (reddening) of the spectra, the 10- and 18- μm excesses become stronger and narrower and the objects tend to cluster towards the galactic bulge. Objects with $F_8 < 11$ Jy and $|b| < 2.5°$ are roughly grouped along the tangents to the arms. 10- μm excesses larger than any observed from earth (> 10) are found among the faintest objects. On the other hand, if bright objects ($F_8 < 22$ Jy, i.e. in the Sun's vicinity) are grouped according to their relative 10-μm excess, ε_{10}, and a histogram in b^{II} is drawn for each group, then it is found that the std.dev. of b^{II} from its mean decreases rather steadily from 24 to 8° as ε_{10} increases from 1 to 10 (the average $\varepsilon_{10} \approx 1.5$). Thus, the distribution of ε_{10} in the Galaxy seems to follow the same general trends as the metallicity of stars.

In previous work, Pégourié and Papoular (1985) have derived empirical optical efficiencies (Q_{abs}) for silicate dust observed from Earth, with the help of suitable radiative transfer models. We used the same Q's to model the average spectra of subgroupsof classes 2 and 6. The optimum parameters (star and dust temp. T_*, T_d ; dust optical thickness at 10 μm, τ ; average grain radius, a ; star and internal shell radii, r_*, r_1) are given here for a) the brightest objects of class 2 ($F_{12} >$ 60 Jy), and b) class 6: a) $T_* = 3500$ K, $T_d(r_1) = 450$ K, $\tau(r_1/r_*)^2 = 29$, a = 1.6 μm ; b) $T_* = 1000$ K, $T_d(r_1) = 550$ K, $\tau.(r_1/r_*)^2 = 3.4$, a = 1.5 μm. The fits are satisfactory.

2.3. Class 4 (carbon-rich CS shells)

Assuming a power-law underlying continuum between 10 and 13 μm, the relative excess $\varepsilon(\lambda)$ can be extracted. Its average profile over the class is quite similar to Russel and Stephen's laboratory measurement of SiC extinction. (M. Cohen, 1984, MN 206), 137). However, if subclasses are formed again according to brightness, a clear trend appears: as F_8 decreases, the SiC feature strength $\varepsilon_{11.3}$ increases (up to 3, from an average of 0.4). Also, weaker features are broader; the change in energy distribution mainly takes the form of a growing bump (between 11.5 and 12 μm) upon the red wing of the SiC feature : ε_{12} varies by ≈ 30%. Finally, a bump grows between 8 and 8.5 μm, in rough correlation with $\varepsilon_{11.3}$, as F_8 decreases. The galactic distribution of class 4 is rather uniform in l but quite peaked about b = 0 ($\sigma_b \approx 5°$).

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