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A MULTICOMPONENT MODEL OF THE INFRARED EMISSION FROM COMET HALLEY

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We have tried to construct a coherent and consistent model to explain the observed infrared radiation from comet Halley from 3 to 160μm based on information available from collected interplanetary dust particles (IDPs) and the recent Halley flybys. We have considered carbonaceous materials as well as silicates in modeling cometary comae spectra. We used the optical constants of an α:C-H film (1) to represent the carbonaceous material and optical constants from lunar sample 12009.48 (a sample rich in olivines) to represent the silicates (2). While the carbonaceous component in comets is probably not identical to α:C-H films, the properties of the films should provide a representative behavior. An olivine-rich silicate mixture was chosen since spectral matches to the Halley 10μm silicate feature indicate that crystalline olivine is a major component of the Halley dust (3). In the visible spectral region we used $m = 1.38\text{-}0.039i$ for the silicates and data from reference (4) for the carbonaceous component. We have used both the dust grain-size distribution inferred for comet Halley (5) and a simple power law ($n \propto a^{\alpha}$) distribution in our calculations. The absorption cross-sections for spheres and core-mantle grains were done using Mie theory (6) and Guttler's theory (7) respectively. Several possible cases have been considered which can explain the observed strength of the 3.4 and 10μm features relative to the adjacent continuum and the slope of the continuum in the 4-8μm region.

Mixture of Independent Silicate and Carbonaceous Grains

The ratio of mass fraction of silicates to amorphous carbon ratio (X) of about 40 is required for the Halley dust-size distribution to fit the observations. The same is true of the power law-size distribution when α = -3.5 (Fig. 1). The 10μm feature flattens as the size of the particles increases. The presence of weak features can be seen between 6.1 and 7.1μm in the model spectra. These are due to the amorphous carbon and are present even at high values of X. The Halley spectra show that features in this spectral region may be present (3).

Composite Grains

Most of the mineral grains in IDPs are covered with a thin layer of carbonaceous material (8). We have done a number of calculations in which we take this observation into account. If we add a thin carbonaceous coating to the model silicate grains, we find that a good match can be obtained for X~8. If the coatings are assumed to be thick, then we require X>1 to produce the observed 3.4μm feature. Such a low X value is probably unreasonable given the much higher value seen in IDPs and the rarity of thickly mantled silicate grains in IDPs. Figure 2 shows the model spectrum resulting from a mixture of silicate and amorphous carbon grains (X=40, α=-3.5) compared with the observational data. The match is quite good over the entire wavelength range.

Conclusions

A model based on a mixture of coated silicates and amorphous carbon grains produces a good spectral match to the available Halley data and is consistent with the compositional and morphological information derived from IDP studies and Halley flyby data. The dark appearance of comets may be due to carbonaceous coatings on the dominant (by mass) silicates. The lack of a 10μm feature may be due to the presence of large silicate grains. The optical properties of pure materials apparently are not representative of cometary materials. The determination of the optical properties of additional silicates and carbonaceous materials would clearly be of use.

A detailed description of the model and results will appear in a forthcoming issue of *Icarus*.

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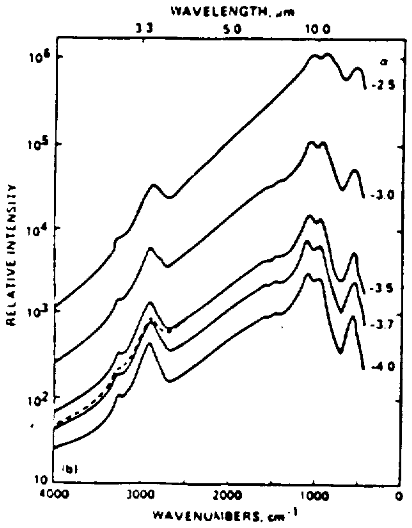

Figure 1. Emission curves for silicate and amorphous carbon mixtures for various values of α. The solid lines are for X= 40; the dashed line is for X= 80.

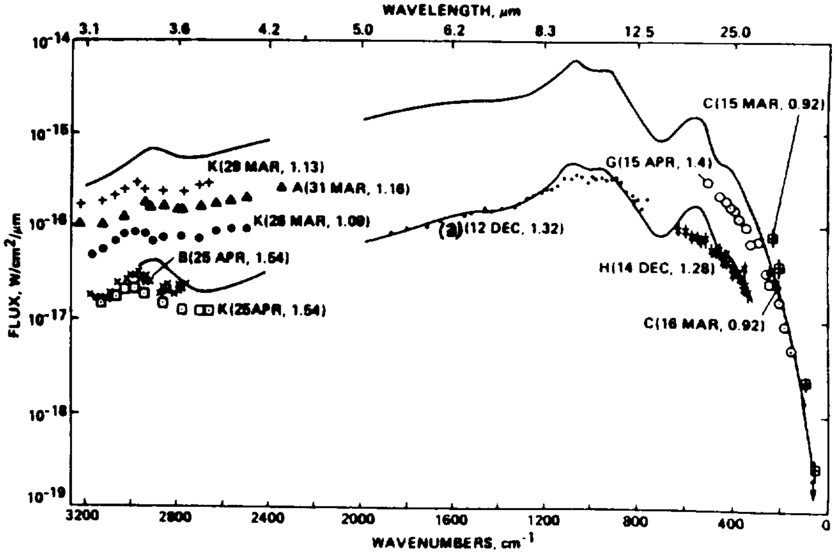

Figure 2. Comparison of the calculated and observed infrared emission from 3 to 160μm for Comet Halley. The solid curves are for r=1.32 and 0.92 AU with $\alpha = -3.5$ and X = 40. The observational data are from the numbered and lettered references in the reference list.