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THE PROBLEM OF CLUSTERING IN LABORATORY STUDIES OF COMETARY DUST

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In trying to understand the nature of interstellar or interplanetary dust grains it is tempting to simply rely on direct laboratory measurements of grain properties such as extinction. However, until we are able to achieve agreement between directly measured extinction and the same property calculated from measured optical constants of the solid, application to astronomical observations is questionable. There are two major problems which we discuss here – the problem of what optical constants to use in the calculations, and the almost unavoidable problem of particle clustering in laboratory studies. Regarding the choice of optical constants, I personally do not believe one should use optical constants from rocks, lunar or terrestrial. It is not even clear how one properly defines optical constants for a heterogeneous aggregate such as a rock or an interplanetary dust aggregate. Regarding small particle measurements, a problem afflicting almost all laboratory measurements is the clustering of particles. Having failed in our considerable efforts to isolate particles (in infrared-transparent matrices and in low temperature solid argon, for example), we have tried to deal with the problem with a simple theory which seems to adequately describe the extinction by small, clustered particles in many cases. In terms of the relative complex dielectric function, the expression for volume-normalized extinction, averaged over orientation and ellipsoid shape factor is

$$\frac{<< \mathrm{C_{abs}} >>}{\mathrm{v}} = \mathrm{k}\ \mathrm{Im}\left(\frac{2\epsilon}{\epsilon - 1}\ \mathrm{Log}\ \epsilon\right)$$

Details and examples of this treatment are given in the monograph by Bohren and Huffman, Chapter 12. An example of the improved agreement with experimental results achieved with the CDE calculation rather than sphere theory is shown in Figure 1, where measured and calculated extinction for sub-micron quartz particles are shown. With such successes as our basis, we can suggest applying the CDE and sphere theories using measured optical constants in cases that may apply to astronomical observations. Figure 2 shows such calculations using measured optical constants of glassy carbon from Edoh. One sees that shape effects induced by clustering become significant in the far infrared, leading to differences in both the slope and the magnitudes of extinction.

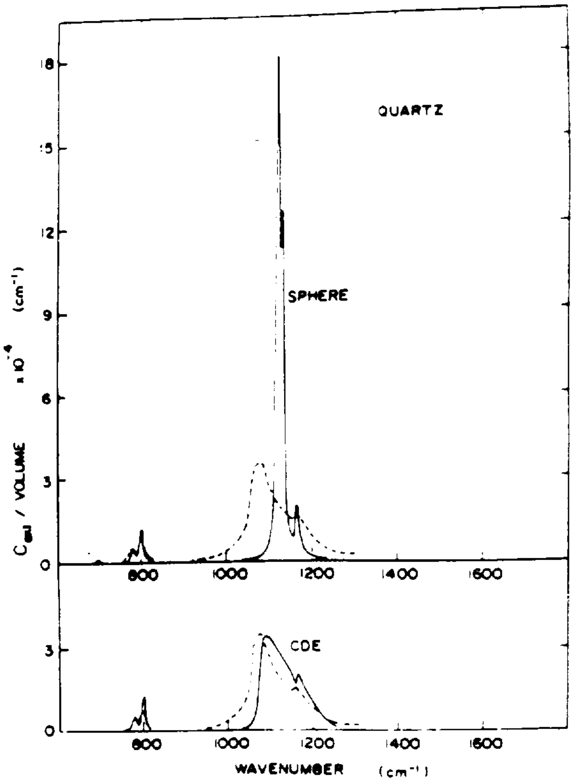

Figure 1: Measured extinction for crystalline quartz particles dispersed in KBr (dashed curves) compared with calculations for spheres (top) and for a continuous distribution of ellipsoidal shapes (bottom). From Bohren and Huffman (1983).

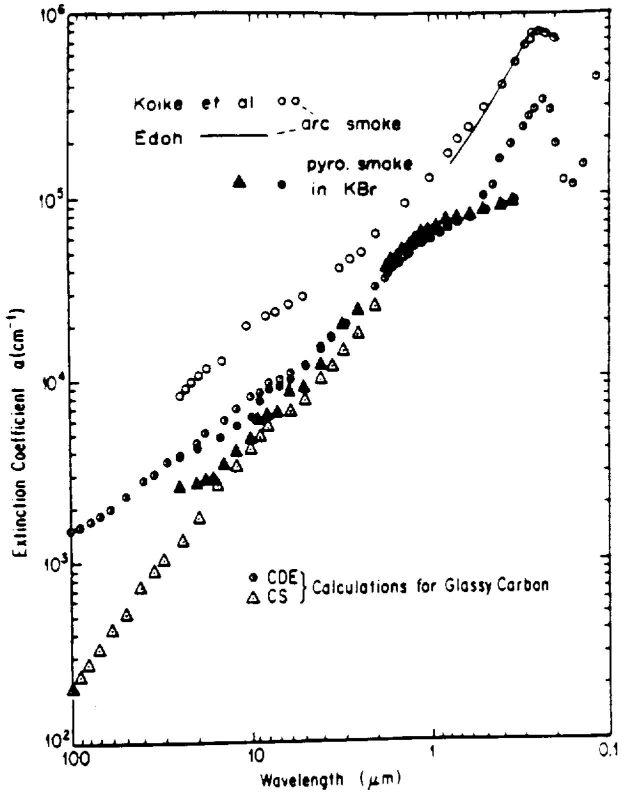

Figure 2: Comparison of various measured extinction values for carbon smoke with calculations based on optical constants for glassy carbon. Open circles are from Koike *et al.* 1980 on arc-condensed smoke. Solid circles and triangles are from Edoh (1983) on smoke from acetylene pyrolysis, and the solid line is from Edoh's measurements on arc-condensed smoke.