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Composite interstellar grains and the 2175Å feature

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Abstract. We use discrete dipole approximation (DDA) to study the scattering properties of composite grains made up of host silicate spheroids and graphite inclusions. We calculate the extinction cross sections of the composite grains in the wavelength region 0.20–0.55 μm and study the extinction of the composite grains as a function of graphite inclusions. We present the composite grain model and discuss the results.

Keywords. Dust, extinction, abundances

1. Introduction

Recent studies indicate that interstellar, circumstellar and cometary grains are irregular in shape and that they are inhomogeneous in composition and structure. Collected interplanetary particles are non-spherical and are highly porous and composites of very small sub-grains glued together. Moreover, the interstellar polarization that accompanies extinction requires that the interstellar grains must be aligned and non-spherical. Also, the elemental abundances derived from the observed interstellar extinction do not favour a homogeneous composition of the interstellar grains.

Since there is no exact theory to study the scattering properties of composite grains, we use discrete dipole approximation (DDA) to study the extinction, scattering and absorption by composite grains. For details on DDA see, e.g., Draine (1988). Effective medium theory (EMT) can also be used to study the scattering by composite grains and a comparison of DDA and EMT methods are given by Wolff *et al.* (1998). Using DDA, we have studied the extinction of composite grains made up of a host of silicate spheroids and graphite inclusions, in the spectral region 0.20–0.55 μm for three composite grain models, with the number of dipoles $N = 9640$, 14440, and 25896. The details about the composite grain models and the computer code are given in Vaidya *et al.* (2001). We were particularly interested in studying the effect of volume fraction of the inclusions on the extinction in the spectral region from 0.20–0.25 μm. It must be noted that the most widely accepted explanation for the 2175 Å feature has been extinction by small graphite grains. Amorphous carbon grains exhibit absorption at approximately 2500 Å (Draine 1988).

2. Results and Discussion

Figures 1 (a–c on the left panel) show the extinction efficiencies of the composite grains with host silicate spheroids containing 9640, 14440 and 25896 dipoles, respectively. Within each graph three volume fractions of graphite are listed, viz. 10, 20 and 30 percent.

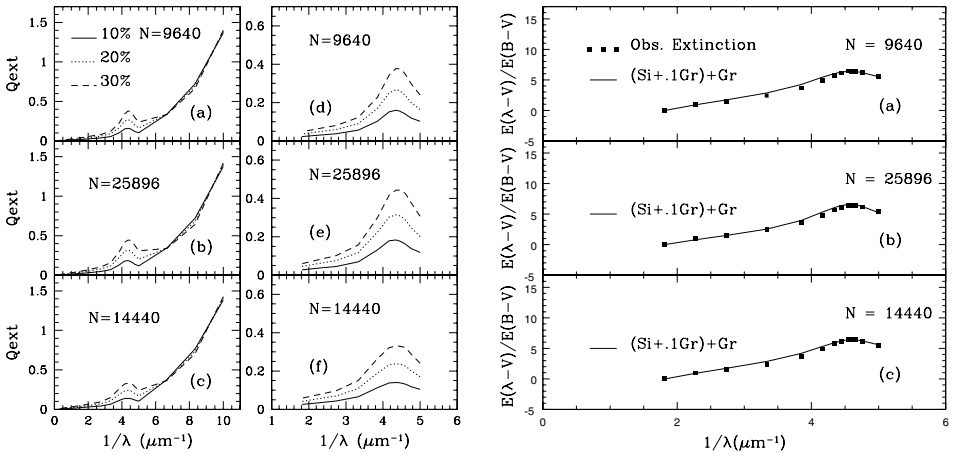

Figure 1. Extinction efficiency of the Composite Grains (left panel) and comparison with observed interstellar extinction curve (right panel).

The effect of variation of the volume fraction of the inclusions is clearly seen for all the composite grain models. The extinction increases as the volume fraction of the inclusion increases. Figures 1 (d-f on the left panel) show the extinction in the spectral region 0.20–0.30 μm. The wavelength of the peak extinction shifts with the variation the volume fraction of the inclusions. It should also be noted that these extinction curves show variation in the width of the extinction feature at 2175 Å, with the volume fraction of the inclusions. These results indicate that the inhomogeneities within the grains play an important role in modifying the 2175 Å feature. Using the extinction efficiencies of the composite grains with the MRN power law size distribution, we have evaluated the interstellar extinction curve and have compared with the observed interstellar extinction given by Savage & Mathis (1989) as displayed on the right panel of Figure 1. It was found that the composite grain models with $N = 9640$ and $f = 0.1$ fit the observed extinction curve satisfactorily. Results on all the three composite grain models and other details are given in our recent publication (Vaidya *et al.* 2007).

3. Conclusions

The results on the composite grains show that the wavelength of peak extinction varies with the volume fraction of the inclusions. These results also show the variation in the width of the 2175Å extinction feature with the volume fraction of the inclusions. The composite grain model curves with $N = 9640$ and volume fraction of 10% of graphite inclusions seem to fit the observed interstellar extinction curve reasonably well.

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