The Diffuse Interstellar Bands
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Composite Grains: Carriers of the Diffuse Interstellar Bands

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Abstract. The dust grains flowing out of the stars are most likely non-spherical and inhomogeneous; viz. porous, fluffy and composites of many very small particles glued together. We calculate the scattering, absorption and extinction efficiencies of such composite grains. The composite grains consist of host silicate spheroid and inclusions of PAHs. We study the extinction as a function of the volume fraction of the inclusions. In particular, we study the variation in the absorption peak, at the wavelength '4430Å' with the volume fraction of the PAH inclusions. We present the composite grain models and discuss the results.

1. Introduction

Recent studies indicate that the interstellar dust grains are porous, fluffy and composites of many very small particles glued together, due to grain-grain collisions, dust-gas interactions and various other processes. Since Polycyclic Aromatic Hydrocarbons (PAHs) have been suggested to form in the outflow of carbon stars (see viz. Allamandola *et al.* 1985, Cherchneff *et al.* 1991), we propose composite grain models with PAHs as inclusions, as possible candidate carriers of the Diffuse Interstellar Bands (DIBs). For a review on DIBs, see Herbig (1995).

Since there is no exact theory to study the scattering properties of the composite grains, we use Discrete Dipole Approximation (DDA) to calculate the scattering, absorption and extinction efficiencies of the composite grains (Vaidya *et al.* 2007). For more details on DDA and other approximate theories on the light scattering phenomena, see e.g. Draine (1998) and Wolff *et al.* (1998). It should be emphasized here that the composite grain model we propose, defers from the earlier cavity grain models (see e.g. Shapiro 1995) used as possible carriers for DIBs.

2. Composite Grain Model

We use the modified computer code (Vaidya *et al.* 2001, Vaidya & Gupta 2011) to generate the composite grain models. We have studied composite grain models consisting of a host silicate spheroid and inclusions of graphite or other carbonaceous materials (e.g. amorphous carbon, PAHs). As mentioned earlier we use the DDA to calculate the scattering, absorption and extinction efficiencies of the composite grains. The basic DDA method consists of replacing a particle by an array of N polarizing dipoles. Each dipole responds to the external electric field as well as to the electric field of the other N-1 dipoles (see e.g. Draine 1998). We have studied composite grain models with spheroids containing number of dipoles, N = 1824, 9640, 14440 and 25896; with volume fraction of inclusions, f = 0.1, 0.2 and 0.3. (Vaidya *et al.* 2007 and Vaidya & Gupta 2011). In this paper we show results for the composite grain models for N = 14440.

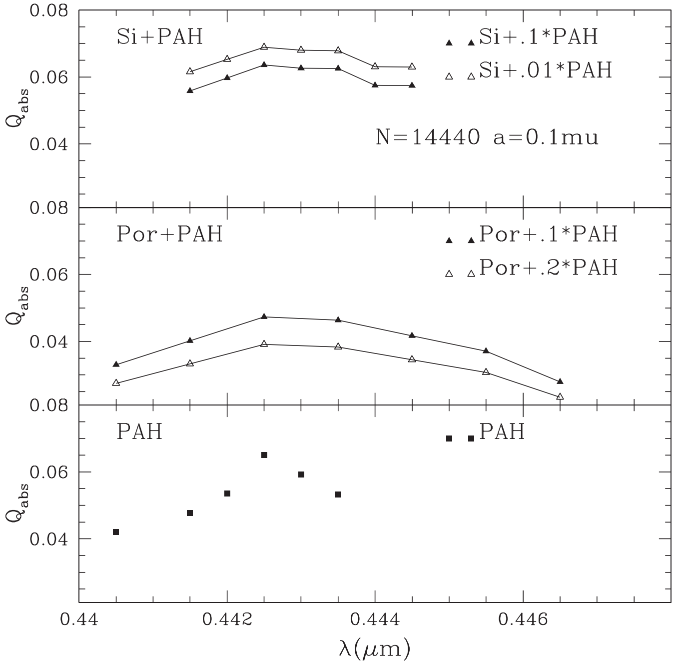

Figure 1. Absorption efficiency of composite grains with silicates and PAH inclusions (top panel) and porous with PAH inclusions (center panel). The bottom panel shows the absorption efficiency for PAH.

3. Results and Discussions

In this study, we have used the composite grain model consisting of a host of silicate spheroid and inclusions of PAHs. We have studied the absorption as a function of volume fraction of the inclusions. In particular, we study the variation in the peak absorption wavelength '4430Å', with the volume fraction of the PAH (Pentacene) inclusions. We have also studied the absorption for porous PAH. Figure 1 (top panel) shows, the absorption efficiency of the composite grains, consisting of silicate and PAH inclusions. It shows the variation in Q_{abs} with the volume fraction of PAH. The absorption efficiency increases with the volume fraction of the PAHs. The center panel shows the variation in the absorption efficiencies with the porosities of the PAH. The absorption efficiency decreases with the porosities. These results clearly indicate that absorption properties of the grains modify considerably with the inclusions and porosities. However, extensive calculations using DDA or other approximations (e.g. Effective Medium Theory – EMT) are required to compare with the observed DIB data. The bottom panel shows absorption efficiency of PAH. The optical constants are taken from Cherchneff *et al.* (1991).

4. Summary

We have studied the absorption properties of the composite grains, made up of host silicate spheroids and inclusions of PAHs. We have also studied the absorption properties of the porous PAHs. Our results clearly indicate that the wavelength of peak absorption '4430Å' varies with the volume fraction of the inclusions of PAHs. The absorption peak also varies with the porosities. In this study, we have not made any attempt to compare the composite grain models with the observed DIB absorption features. Further, extensive calculations with various grain sizes/distributions are required to compare with the observed data.

5. Acknowledgments

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