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Interstellar grains towards Orion

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Abstract. Using discrete dipole approximation (DDA) we calculate the extinction efficiencies of the porous silicate grains. We use these efficiencies to reproduce the observed extinction in the region of star formation in Orion and find that the grain models with about 40 percent porosity fit the observed extinction reasonably well.

1. Introduction

Several studies of visual and infrared colours of the Orion stars have found large value of the ratio (R ~ 5.2) (Breger 1981; Cardelli & Clayton 1988) of total to selective extinction. These large values of R have been attributed to large grain sizes (≥ 0.2μm) in these regions of anomalous extinction. These grains could have grown larger than normal size through either accretion or coagulation (Mathis 1990). If the grains have grown large due to accretion of the material, then the core mantle grain models would be appropriate in these regions, as suggested earlier (Leger et al. 1983; Vaidya and Anandarao 1993). In the case of coagulation, a single grain consists of an assembly of small particles stuck together loosely, i.e., the particles are porous and fluffy. In order to calculate the scattering, absorption and extinction by irregularly shaped and inhomogeneous (i.e. porous and fluffy) particles approximate methods are required. The discrete dipole approximation (DDA) is one such method. Using DDA, we calculate the extinction efficiencies of the porous grains and use these efficiencies to reproduce the observed extinction in Orion.

2. DDA and extinction efficiencies

We apply DDA (Draine 1988) first to the spheroidal solid grains assumed to be made of a large number of dipoles. Then we systematically reduce the number of dipoles (i.e. we reduce the packing density) to model the porous grains. (For details on porous grain models see Wolff et al. 1994; Vaidya and Desai 1996; Vaidya and Gupta 1997). Depending on the number of dipoles N in the grain the porosity P varies between 0 and 1 (Greenberg 1990). Using the DDA we obtain the extinction efficiency Q_{ext} for the porous silicate grains in the wavelength range of 0.30μm – 3.4μm. Figure 1 shows Q_{ext} vs 1/λ for N=152,1184 and 4088 for the grain size (i) a=0.05μm (ii) 0.10μm (iii) 0.3μm and (iv) 0.5μm. For these calculations we use the optical constants (i.e. refractive indices) from Draine (1987).

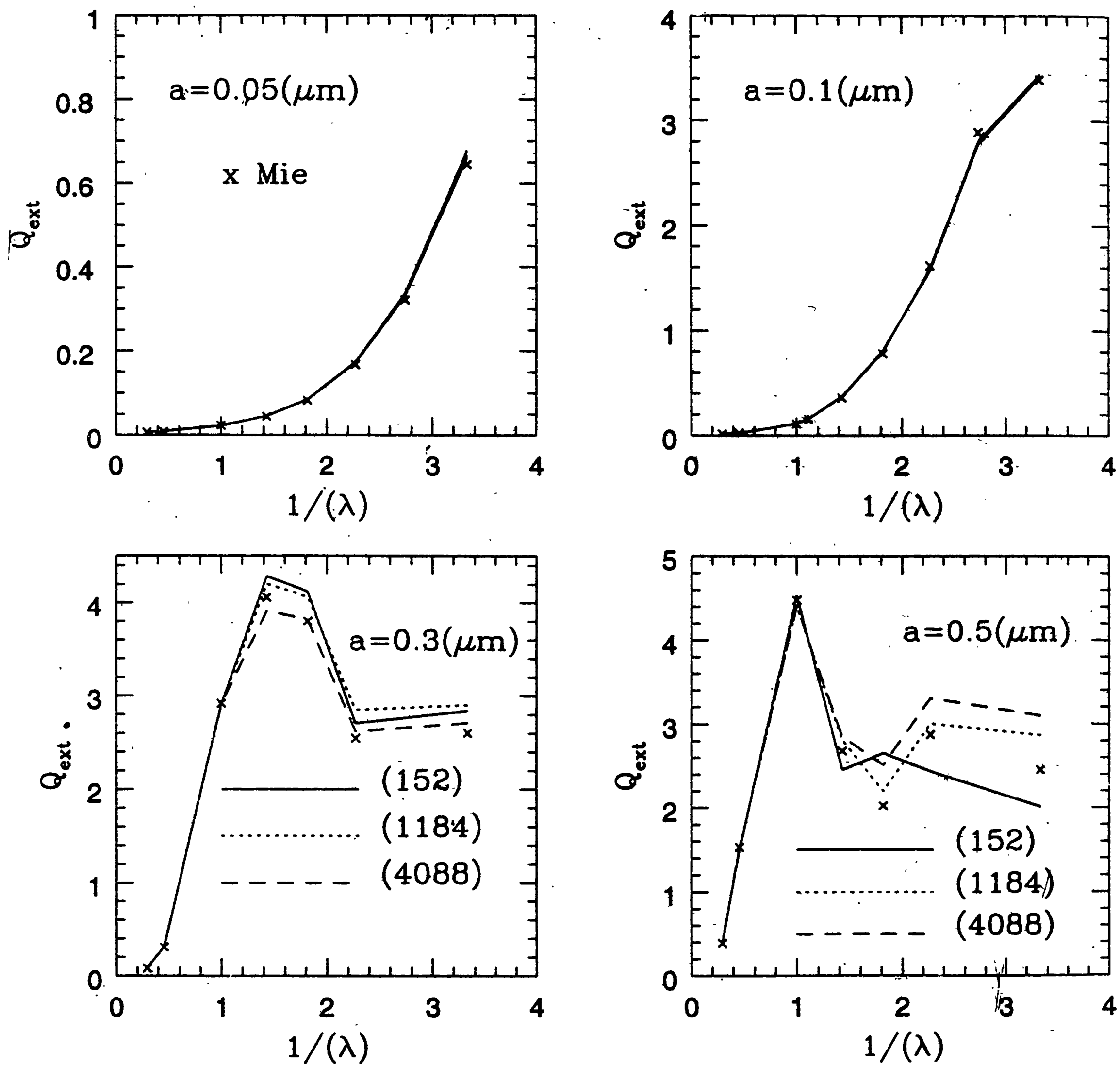

Figure 1. Extinction efficiency Q_{ext} for porous silicate grains.

3. Results

We use the results on the extinction by porous silicate grains and the power law grain size distribution (Mathis et al., 1977), $n(a) \sim a^{-3.5}$, to reproduce the observed interstellar extinction curve, viz. E(λ-V)/E(B-V) vs 1/λ for the star BR 598 (Breger 1981) in the orion region. We find that models with N=1184 and 4088 reproduce the observed extinction for this star reasonably well. Grain models with N=152 do not satisfy the validity criteria for DDA (Draine and Flatau 1994). In Figure 2 we show the observed interstellar curve with the model curve of porous silicate grains with N=1184 (i.e. about 40 percent porosity).

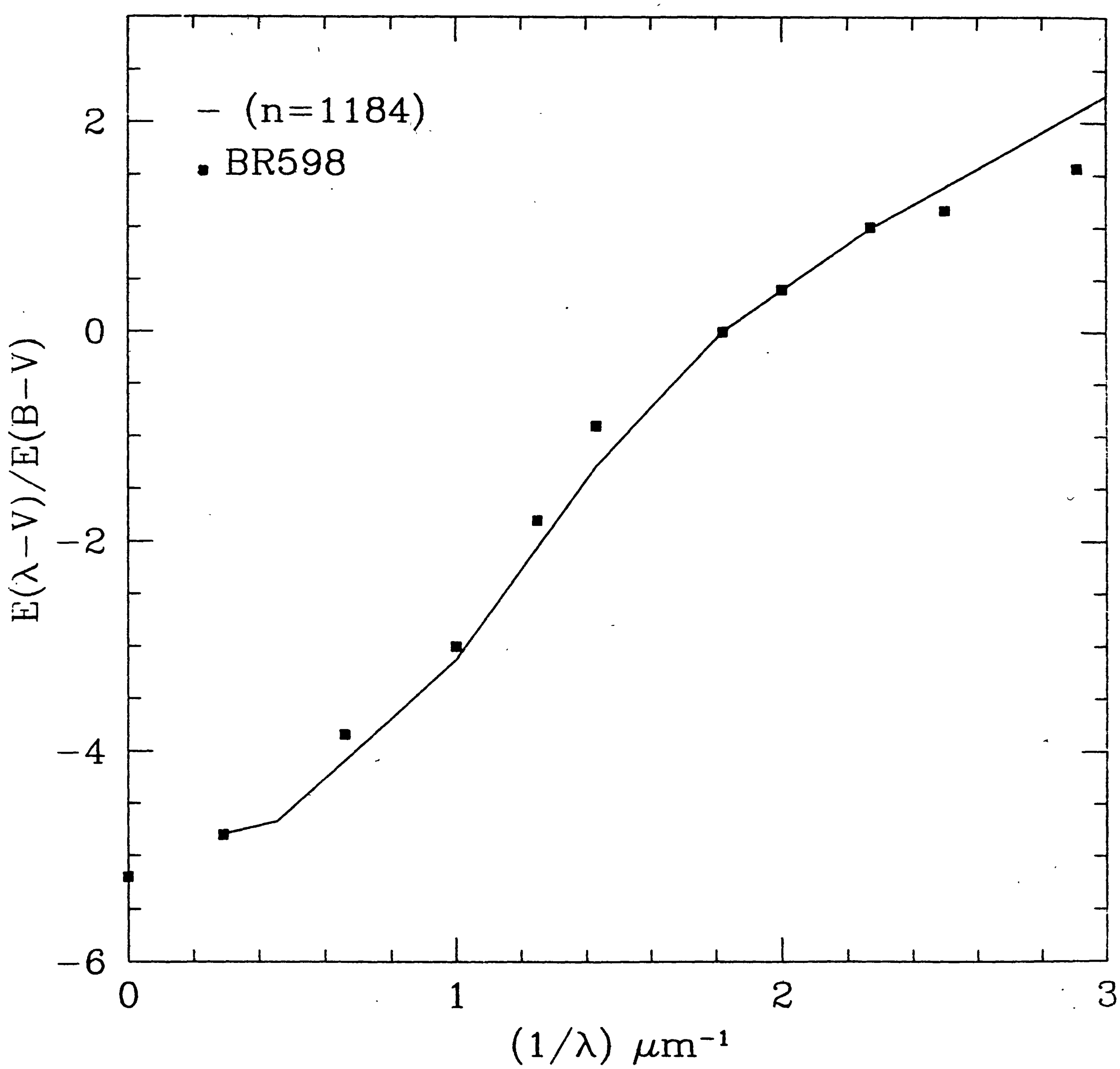

Figure 2. The model extinction curve for the star BR 598 in the Orion Complex using porous grains with about 40% porosity.

Conclusions

We have shown that the porous silicate grains with about 40 percent porosity reproduce the observed extinction toward Orion at wavelengths greater than 3000 A reasonably well. These results indicate that if the grains are porous in the regions of star formation and in the HII regions then these grains would exhibit anomalous extinction.

References

Breger M., Gehrz R. D., Hackwell J. A., 1981 ApJ, 248, 963.

Cardelli J. A., Clayton G. C., 1988, AJ, 95, 516.

Draine B. T., 1987, Princeton Observatory Preprint No. 213.

Draine B. T., 1988, ApJ 333, 848.

Draine B. T., Flatau P. J., 1994, J.O.S.A., 11, 1491.

Greenberg J. M., 1990, in Comet Halley vol.2, ed. Mason J., 105.

Leger A., Gautheir S., Defourneau D., Rouan D., 1983 A&A, 117, 164.

Mathis J. S., 1990, ARAA, 17, 73.

Mathis J. S., Rumpl W., Nordsieck K. H., 1977, ApJ, 217, 425.

Vaidya D. B., Anandarao B. G., 1993, B.A.S.I., 21, 591.

Vaidya D. B., Desai J. N., 1996, ASP conf. ser., 104, 433.

Vaidya D. B., Gupta R., 1997, A&A, 328, 634.

Wolff M. et al., 1994, ApJ, 423, 412.