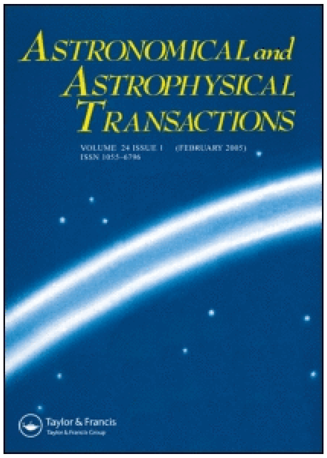

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INTERPRETATION OF INFRARED ABSORPTION BANDS USING INHOMOGENEOUS GRAINS

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INTERPRETATION OF INFRARED ABSORPTION BANDS USING INHOMOGENEOUS GRAINS

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A study of the two deepest dust bands – 3 μm water ice band and 10 μm silicate band – in the spectra of young stellar objects and stars is presented. Using the model of silicate core–ice mantle spheroids, the restrictions on the grain shape and size are obtained. It is found that the observed dependencies between the bands' widths and their ratio may be explained if the size of dust grains $r_V \lesssim 0.35$ μm where r_V is radius of a sphere with the same volume as a spheroid.

Keywords: Infrared band; YSO

1 INTRODUCTION

Numerous dust features are observed in absorption spectra of young stellar objects (YSOs) and stars embedded into molecular clouds (Boogert *et al.*, 2000; Bowey *et al.*, 1998; Brooke *et al.*, 1999; Gibb *et al.*, 2000; Palumbo *et al.*, 1997; Pendleton *et al.*, 1999; Smith *et al.*, 2000; Teixeira and Emerson, 1999; Tielens *et al.*, 1996; Whittet *et al.*, 1983; 1996). Almost all of them are attributed to various ices and silicates. The strongest in the near-infrared (IR) are the 3 μm-band of water ice and the 10 μm silicate band.

In this paper, the attempt is made to interpret the observations of several bands simultaneously using the model of inhomogeneous non-spherical dust particles. Non-sphericity of dust grains follows on from the observations of linear polarization in dusty bands enhanced in comparison with the surrounding continuum (Hough *et al.*, 1989; Smith, 1999).

2 MODEL

We assume that dust grains are coated spheroids consisting of a silicate core and ice mantle. Their optical properties were calculated using the exact method and in the Rayleigh approximation. The exact solution to the light problem for confocal core–mantle spheroids was obtained by Farafonov *et al.* (1996), using the method of separation of variables. The expressions for extinction cross-sections in the Rayleigh approximation are given by Draine and

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Lee (1984). The range of the applicability of the Rayleigh approximation for coated spheroids in the near-IR was studied by Somsikov and Voshchinnikov (1999). The optical constants of silicates and ice were taken from the database of optical constants (JPDOC; see Henning *et al.*, 1999).

The model of core–mantle spheroids can be described by three parameters: (1) the aspect ratio of the mantle a/b, where a is the major semiaxis and b is the minor one; if one varies the ratio a/b, the particle shape is changed from spheres ($a/b \simeq 1$) to needles (prolate spheroids) and to disks (oblate spheroids); (2) the size parameter $2\pi r_V/\lambda$, where r_V is the radius of equi-volume sphere and (3) the ratio of the core volume to that of the total particle $V_{\mathrm{core}}/V_{\mathrm{total}}$.

In our calculations, the arbitrary in space orientation of particles (3D-orientation) was assumed. Other cases of grain alignment do not change the conclusions.

3 RESULTS

We analysed the dependencies of widths of the 3 μm and 10 μm bands (FHWM) on the ratio of optical depths at their centres. The observational data were taken from papers cited in Section 1. Figure 1 shows the observations and theoretical dependencies. The variations of the 3 μm band can be well reproduced if the particle size is $r_V \lesssim 35$ μm (Fig. 1a) with either particle shape (Fig. 1b). The behaviour of the 10 μm band can be explained if the particles from the core "astronomical silicate" (astrosil) are used (Fig. 1d). They may have rather large aspect ratio. The particles with the olivine core give a narrow 10 μm band which was observed for several objects only (Fig. 1c). Our model of inhomogeneous particles

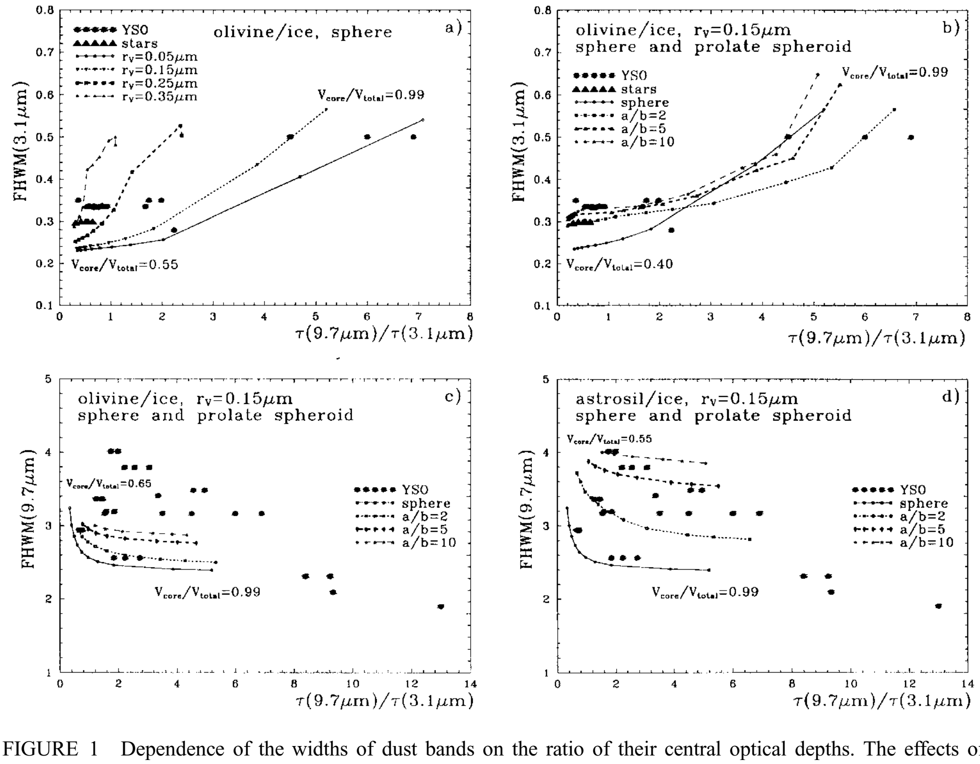

FIGURE 1 Dependence of the widths of dust bands on the ratio of their central optical depths. The effects of variation of particle size (panel *a*) and the particle shape and chemical composition of the core (panels *b–d*) are illustrated. The ratio $V_{\mathrm{core}}/V_{\mathrm{total}}$ is changed from the initial value shown at each panel with the step 0.05.

suggests that the difference between objects may be related to the presence of the particles with different thickness of icy mantle.

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