S7-89

169718

13

N89-13357

LIGHT SCATTERING OF LARGE ROUGH PARTICLES APPLICATION TO COMETARY GRAINS

P. L. Lamy and J. M. Perrin

Laboratoire d'Astronomie Spatiale
Marseille, France

While the electromagnetic field scattered by a spherical particle is classically obtained by the Helmhotz equation

$$\nabla^2 \varphi(\mathrm{r}) + \mathrm{n}^2 \mathrm{k}^2 \varphi(\mathrm{r}) = 0$$

where n is the complex index of refraction and k, the wave number, the general case of an arbitrary particle may be investigated in the general framework of the interaction of a wave with a scattering potential. The wave function $\varphi(\mathrm{r})$ then satisfies the Schrödinger equation

$$\nabla^2 \varphi(\mathrm{r}) + \mathrm{k}^2 (1 - \mathrm{V/E}) \varphi(\mathrm{r}) = 0$$

where E= hc/λ is the energy. Note that the spherical case is recovered by taking V = $(1\text{-}n^2)E$. This equality still holds for a rough particle, but the index of refraction n is modified, for instance, by introducing a distribution of the Fermi type (Chiappetta, 1980; Perrin and Lamy, 1986). The general solution of the Schrödinger equation is written

$$\varphi(\mathrm{r}) = \mathrm{e}^{\mathrm{ik \cdot r}} + \mathrm{e/r}^{\mathrm{ikr}} \mathrm{f}(\theta)$$

where the first term represents the incident wave and $f(\theta)$, the amplitude of the scattered wave. The main disadvantages of this approach are its restriction to large particles (a $\sim\lambda$; practically a $\geq 6\ \lambda$) and its scalar nature preventing the calculation of the polarization. However, Perrin and Lamy (1986) have shown to avoid the second limitation and retrieve a vectorial description. They proved that in the case of large spheres when the ad hoc assumptions are satisfied, the expression of the scattering amplitude $f(\theta)$ may be approximated by an expansion series on a continuous basis which is analogous to the classical expansion series in partial waves, i.e., on a discrete basis. The analogy may be generalized, and the ratio of the two components $f\| (\theta)$ and $f\perp (\theta)$ for a rough particle obtained by taking the ratio of the reflectivities for the two directions of polarization. These reflectivities involve the simple and double reflections calculated following the method developed by Wolff (1980) for rough surfaces. Figure 1 shows how well the model is able to reproduce the experimental result obtained on a rough particle of magnetite by Weiss (1981). In general, the intensity scattered by rough grains is characterized by a broad diffraction lobe, a flat behavior at intermediate scattering angles and backscattering enhancement. The polarization shows a broad maximum at θ equals 60 to 90° (its value depends upon the absorption) and a negative branch in the interval 160 to 180° approximately. This is most likely the correct explanation for the similar feature observed in comets in general and P/Halley in particular (Lamy *et al.*, 1987). More implications of rough particles, in particular in the infrared, are discussed in the summary section of this report.

References

Lamy, P. L., Grün, E., and Perrin, J. M. (1987), *Astron. Astrophys.*, in press.

Perrin, J. M. and Lamy, P. L. (1986), *Optica Acta*, **33**, 1001.

Weiss, K. (1981), Ph.D. Thesis, Ruhr-Universität Bochum and Report BMFT-FB-W81-047.

Wolff, M. (1980), *Icarus*, **44**, 780.

C-3

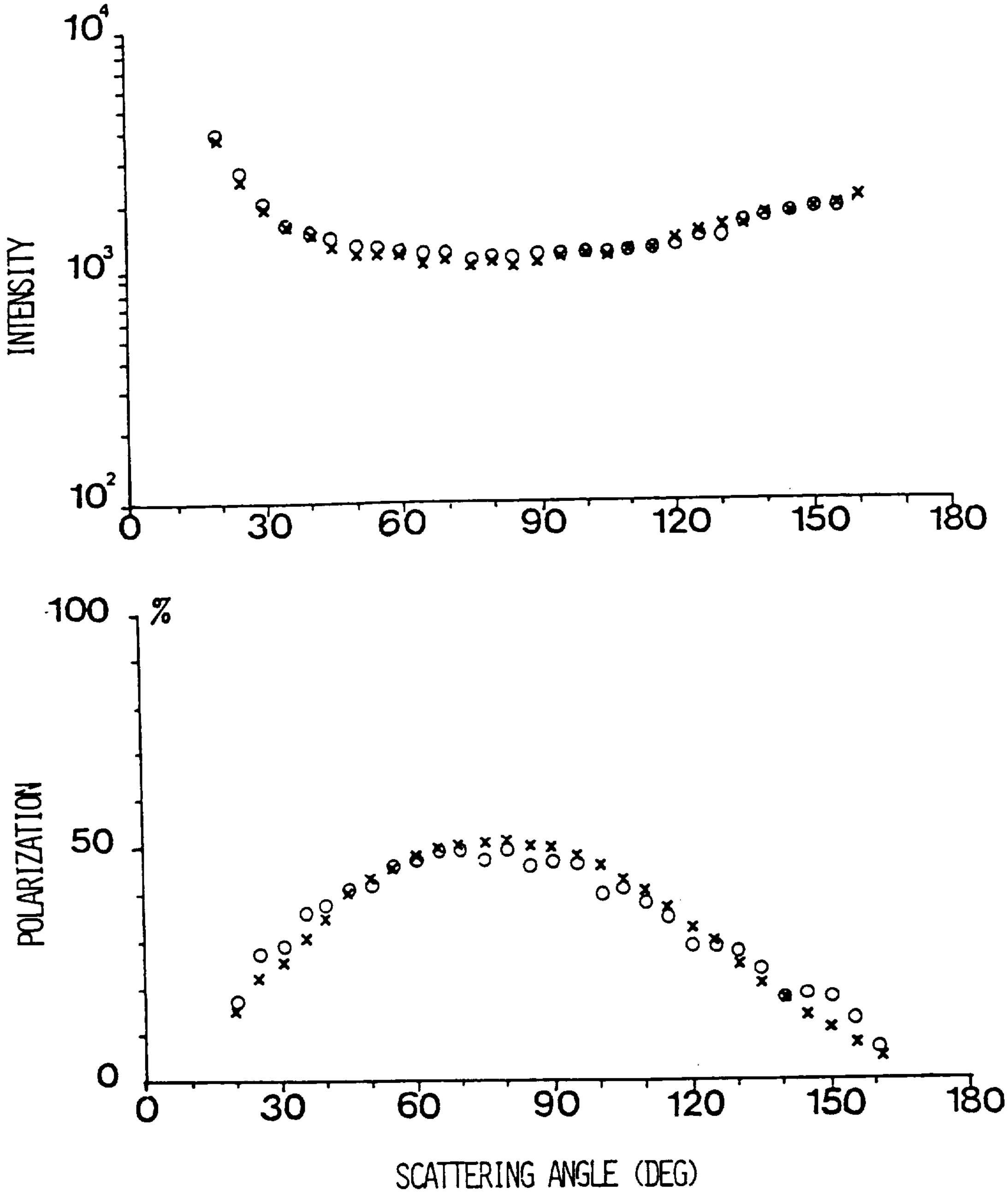

Figure 1. Total scattered intensity (top) and polarization (bottom) for a rough particle of magnetite: comparison of the experimental results (o) and the calculated results from the present model (x).