EXPERIMENTAL RESULTS ON SCATTERING BY IRREGULAR AND METEORITIC DUST PARTICLES RELATED TO PHOTOPOLARIMETRY OF ZODIACAL LIGHT AND COMETS

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ABSTRACT. The investigations of light scattering by larger meteoritic and terrestrial single grains (size range 20 µm to 120 µm) demonstrate that the scattering properties of irregularly shaped dark opaque particles with very rough surfaces resemble the characteristic features of the empirical scattering function as derived from measurements of the zodiacal light. Purely transparent or translucent irregularly shaped particles show a quite different scattering behaviour. Furthermore irregular and multicomponent fluffy particles in the size range of a few microns were modelled by microwave analog measurements in order to explain positive and negative polarization of the light scattered by cometary dust grains.

1. INTERPLANETARY DUST

Some properties of the interplanetary dust particles are comparatively well known such as the size distribution of larger ($\gtrsim$ 5 µm) grains near 1 AU, the spatial distribution in the ecliptic, and the brightness of the zodiacal light as a function of elongation. The main contribution of the zodiacal light is produced by particles between 10 and 100 µm in size. Many of the interplanetary particles collected by aircraft in the stratosphere are non-spherical porous opaque aggregates. Each reasonable zodiacal light model has to take into account these properties.

We could investigate the scattering pattern of real cosmic materials, samples of the meteorites Allende and Murchison. Meteorite Murchison is very similar to the extraterrestrial carbonaceous chondritic materials (Brownlee, 1976). Meteorite Allende shows white inclusions imbedded in a fine-grained dark matrix.

Fig. 1a illustrates the scattering function i and the degree of linear polarization P for a dark grummy particle of the matrix of Meteorite Allende (28 µm in size). Contrary to the behaviour of absorbing spheres, the irregularly shaped particle shows an increase in intensity in the backscattering range. The degree of linear polarization reaches a maximum of about 40% at a scattering angle

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$\Theta \simeq 80°$. These are the typical scattering patterns of terrestrial highly irregularly shaped absorbing particles investigated by light scattering experiments (Weiß-Wrana, 1983) and by the microwave analoge technique (Zerull et al., 1980).

In the case of a less absorptive particle of the inclusion (diameter = 50 μm) the values of the positive degree of polarization are significantly smaller without the distinct maximum of polarization, see Fig.1b. Internal scattering processes and internal refraction are more probable for slightly absorbing agglomerates than for strongly absorbing ones. The contribution of the neutral component is greater, which significantly decreases the degree of polarization. This agrees with the scattering properties of terrestrial less absorptive fly-ash particle (Weiss-Wrana, 1983).

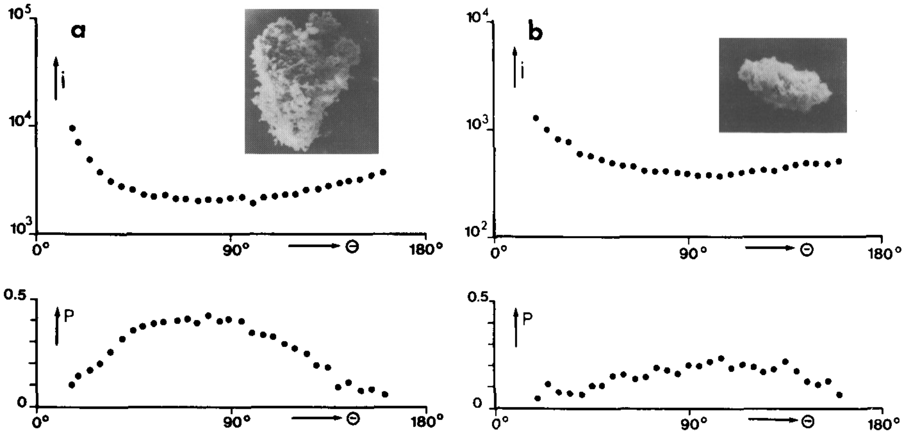

Figure 1. Total intensity i and degree of linear polarization P of meteoritic samples. a) 28 μm particle of the dark matrix of meteorite Allende. b) 50 μm particles of the white inclusion of meteorite Allende.

Fig. 2 illustrates the general shape of the empirical scattering function $\sigma(\Theta)$ and the corresponding degree of polarization $P(\Theta)$ derived from the brightness of the zodiacl light by inversion of the integration along the line of sight (Dumont and Sanchez, 1975; Leinert, 1978): The intensity is clearly enhanced toward backscattering. The degree cf linear polarization reaches a maximum cf 35% at a scattering angle $\Theta \simeq 85°$. Our light scattering experiments show that irregularly shaped opaque particles can resemble the scattering function and the corresponding polarization. Large purely transparent and translucent irregularly shaped particles like quartz and andesite cannot be the dominating component of the interplanetary particles producing the zodiacal light (for details see Weiss, 1981 and Weiss-Wrana, 1983).

Using the experimental data of 7 different terrestrial and 3 meteoritic particles covering the size range of 20 to 120 μm and taking into account the size distribution (Giese and Grün, 1976) and the composition of the collected interplanetary particles (Brownlee et

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al., 1976) the scattering behaviour of a polydisperse mixture was calculated (Weiss-Wrana, 1983).

As demonstrated in Fig. 2 the scattering patterns of the particle mixture resembles the characteristic features of the zodiacal light quite well.

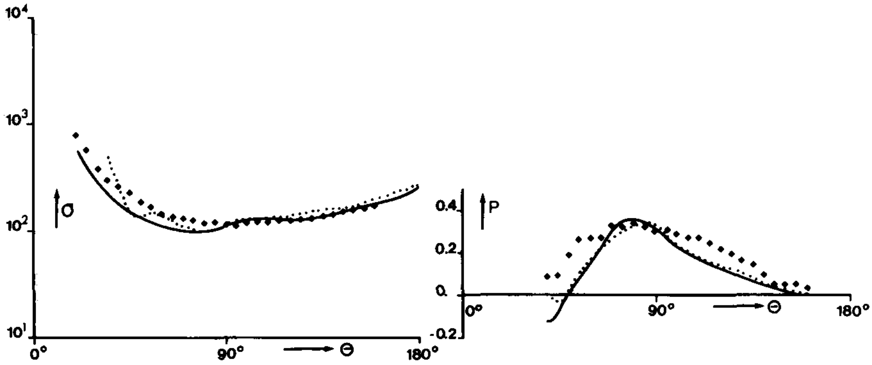

Figure 2. Zodiacal light model: Empirical scattering function σ and degree of polarization P of the interplanetary dust compared with experimental data (light scattering) of a particle mixture of 10 irregularly formed particles (rhombs) in the size range between 20 µm and 120 µm (Weiss-Wrana, 1983). The dotted line corresponds to the data of Dumont and Sanchez (1975), the solid ones to Leinert's data (1978, 1983).

2. COMETARY DUST

Recent photopolarimetric measurement of Comet West give some impressions about the variation of the brightness and linear polarization of sunlight scattered by dust in the cometary coma over a considerable region of scattering angles. Fig. 3 shows the intensity measured by Ney and Merrill (1976) and the degree of polarization as averaged by Zerull and Giese (1983) over the measured quantities of different observers (Merrill, 1976; Isobe 1978; Michalsky, 1981; Kiselev, 1981). The significant features not only of comet West but also of other ones are: The intensity is clearly enhanced toward backscattering. The degree of linear polarization reaches a positive maximum of 25-30% at a scattering angle $\Theta \simeq 90°$ and has a neutral point at $\Theta \simeq 160°$ followed by a branch of slightly negative polarization to about -5%.

Assuming that the main distribution of cometary grains has a size of just a few microns these scattering features can be explained by our microwave analog experiments (Zerull and Giese, 1983). As demonstrated in Fig. 3 a polydisperse mixture of five small two-components fluffy particles containing dielectric and absorbing constituents show the same scattering characteristic. Purely

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irregularly nonabsorbing compact and fluffy particles cannot resemble the optical properties in the visible, they show rather isotropic scattering for larger scattering angles and no pronounced polarization (Zerull et al., 1980).

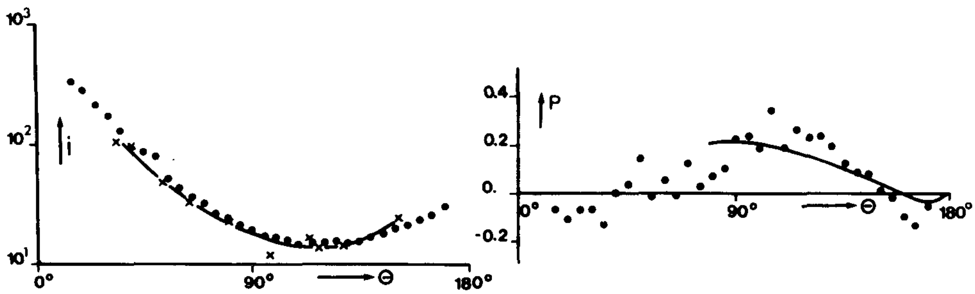

Figure 3. Cometary dust model for comet West: Observed intensity (solid line with crosses, Ney and Merill, 1976) and degree of polarization (solid line, as averaged by Zerull and Giese, 1983) compared with experimental data (microwave analog experiment) of a polydisperse mixture of two-component fluffy particles (index of refraction m = 1.5 and m = 1.65 - 0.25i) corresponding to 2 to 4 µm in size in the visible (dots).

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