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Brightness and polarimetric phase functions for analogues of cometary dust as compared to 67P dust observations from Rosetta and various remote observations

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Abstract

Rosetta experiments have provided a ground truth about cometary dust particles composition, size and structure. They allow comparisons between their properties and those of previously suggested analogues. These had been suggested from experimental simulations (with PROGRA2 experiment) of the light scattering properties of 67P/Churyumov-Gerasimenko and other comets, observed from the Earth or its environment. The brightness phase curves obtained by OSIRIS multi-wavelength observations have provided further comparisons and allowed us to point out most relevant analogues. We summarize these comparisons and present new results related to polarimetric phase functions for the same samples and for various comets.

1. Introduction

The properties of the light scattered by cometary dust particles depends upon their properties (e.g. size, morphology, porosity, geometric albedo and thus composition), while the geometry of observations gives access to brightness and polarization phase functions [e. g., 1]. As established by Rosetta, dust particles in the coma of 67P are a mixture of minerals and organics (about 50%); their albedo is low and they consist of hierarchical aggregates with various porosities [e.g., 2]. Numerous relatively large particles were found (in the hundreds of microns range), built of smaller assemblages down to 10s nanometers-sized grains.

2. Light scattering with PROGRA2

The PROGRA2-vis instrument is dedicated to retrieve the brightness and linear polarization phase functions of levitating dust particles in the visible domain [3-4]. The levitation is obtained by two methods: (i) for compact particles below 20 μm and fluffy aggregates, the particles are lifted through an air draught technique, (ii) for compact particles above 20 μm and mixtures of particles with different properties, the measurements are conducted under microgravity conditions during parabolic flights.

We consider here samples, which reproduce physical properties of cometary materials pointed out by Rosetta dust experiments and/or deduced from polarimetric remote observations. We also present new results with samples suggested by the quite low albedo of the dust derived by VIRTIS-M on 67P [5-6].

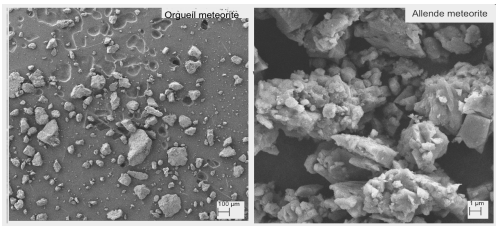

Figure 1: SEM images of two carbonaceous meteorites, suggested as analogues for cometary materials.

3. Brightness phase functions

The phase functions measured for the coma particles by the Rosetta/OSIRIS experiments and their remarkable flattened u-shape [7] have been compared to the phase functions deduced from simulations (using PROGRA2-vis) with different samples having properties relevant to those of cometary dust [8]. A satisfactory fit for phase functions obtained just before 67P perihelion is obtained for a crushed

sample of Orgueil carbonaceous meteorite (Fig. 1), leading to a porous -structure built of aggregates in a size range of tens of μm. Satisfactory fits were also obtained for mixtures of materials simulating the interplanetary dust population, which main component seems to originate from JFCs [8, Fig. 5].

4. Polarimetric phase functions

It is now possible to consider the linear-polarization phase functions obtained for different comets, 67P, as well as other JFCs, Halley and new comets (Fig. 2), updated from [9]. We discuss their physical properties deduced from the observations and experimental simulations in comparison to 67P dust properties [10]. The different coma regions are also considered. Using samples as close as possible to cometary particles, we suggest some properties for the dust (e.g. sizes of grains and particles [9], [10], [11], [12] by comparison to the cometary phase curves characteristics.

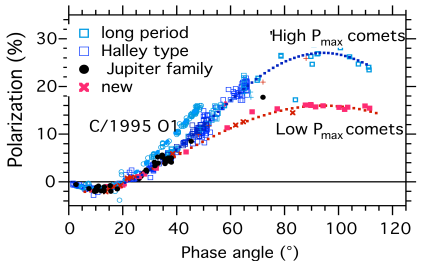

Figure 2 : Com**etar**y polarimetric classes as compared to different orbital classes. P_{max}: the amplitude of the positive branch depends upon the albedo and the sizes.

5. Summary and Conclusions

With the PROGRA2 experiment, we have studied some samples which can be considered as analogues of cometary particles. Carbonaceous meteorites seem to be interesting analogues if the shape of the brightness phase functions are compared to OSIRIS Rosetta results. Their polarimetric phase functions are also in agreement with remote observations. Samples with lower albedos such as coals and Fe-sulfides are currently studied. Large hundred micrometers sizes with large porosities of dark materials seems to be in good agreement with observations when minerals and organics are mixed.

In the context of the now-selected ESA Comet Interceptor mission, it is of interest to better interpret differences between phase functions of comets of different origins in terms of differences in their dust properties.

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