



Experimental phase function and degree of linear polarization of mm-sized and micron-sized olivine and spinel particles.

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Abstract

In this work, we present the experimental phase function and degree of linear polarization of two sets of samples consisting of forsterite and spinel particles. The size distributions of the studied samples span over a broad range in the scattering size parameter domain. This work is part of an ongoing experimental project devoted to understand photopolarimetric observations of asteroids and comets. In particular, we study the effect of the size on the scattering matrix elements, finding a strong dependence of characteristic parameters, e.g. maximum of polarization and inversion angle, on particles size.

Introduction

Polarimetric observations of dust clouds are a powerful tool in planetary science. They allow us investigating the nature and properties of solar system bodies and planetary systems in different stages of evolution, e.g. asteroids, comets, and protoplanetary disks. For example, they can be used as a reference to refine the taxonomic classification of asteroids [1, 2] or they can help in the discrimination of objects with cometary origin [3]. Some dust materials, like olivine and spinel, are remarkably interesting for the investigation and characterization of solar system small bodies. In particular, olivine is an extensively diffuse silicate mineral and spinel, a magnesium/aluminum mineral, is a characteristic component of the unusual class of presumably ancient Barbarian asteroids

as well as an important component of Calcium Aluminium rich Inclusions (CAI) found in primitive meteorites [6, 7]. Physical and optical properties of the dust, such as their refractive index, size, composition, and structure define their ability to scatter the light. Therefore, in order to study these materials, we need to experimentally characterize their photopolarimetric curves.

Measurements

We analyze six samples of olivine and spinel with different sizes. The samples denoted as Pebble consist of millimeter-sized grains and lie in the geometrical optics regime. Further, two size distributions consisting of particles smaller than 30 and 100 micrometers are produced out of the olivine and spinel bulk samples. The measurements have been performed at the IAA Cosmic Dust

Laboratory (CODULAB), Granada, Spain [4]. The instrument allows to measure the scattering matrix of a cloud of particles and can be set also to retrieve the scattering matrix of single mm-sized particles [5]. The measurements have been obtained at 520 nm for the mm-sized grains and at 514 nm for the micron-sized samples. The scattering angle covers the range from 3° to 177°.

Results

Figures 1 and 2 show the phase function and degree of linear polarization (DLP) respectively of olivine and of spinel samples.

The phase function curves show a strong dependence on particle size. We see that the micron-sized samples have lower values with a rather flat trend at side- and back-scattering regions and a strong increase in the forward direction. In contrast, the pebbles show u-shaped phase functions. The slope of the phase function at side- and back-scattering regions is stronger in the case of the spinel.

The DLP curves also show a dependence on the size. They have the typical bell shape with a negative branch at low phase angles. Spinel Pebble shows the higher maximum of polarization. The three spinel samples show a well-defined negative polarization branch with an inversion angle located

around 28° regardless of the particle size. It is interesting to note in the case of the olivine samples the inversion angle is highly dependent on particle size. The high inversion angle of Barbarian asteroids polarization curves could be related to the presence of spinel in the form of millimeter grains of regolith.

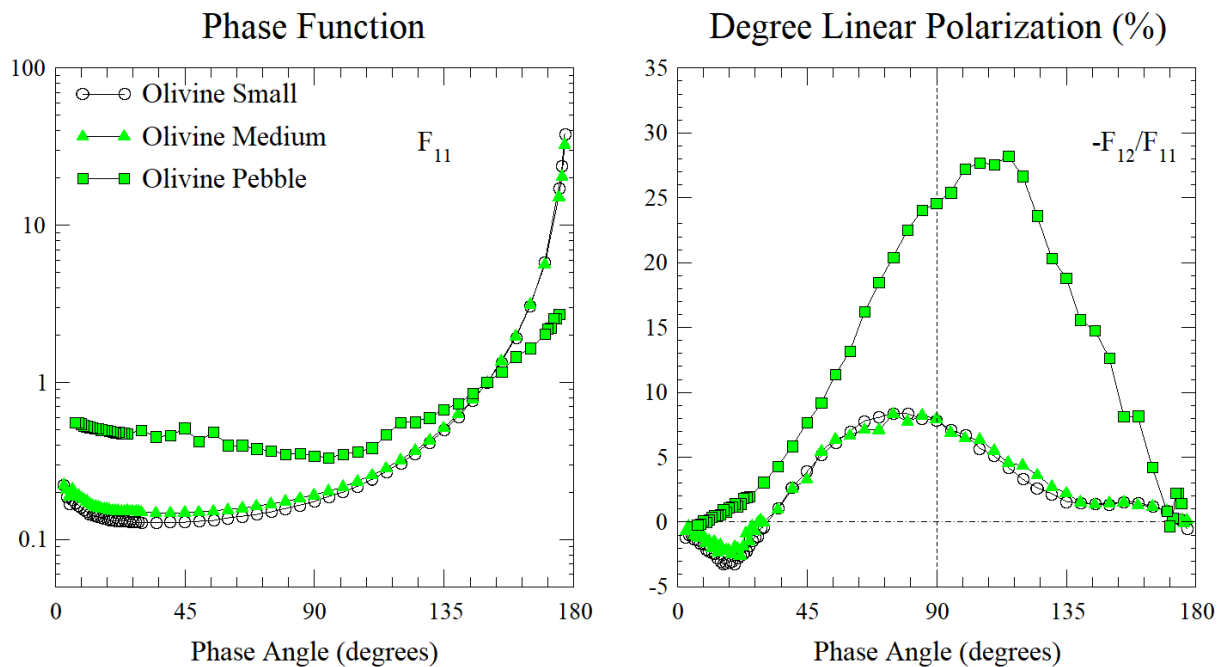


Figure 1: Phase function curves (left) and degree of linear polarization (right) for the three olivine samples.

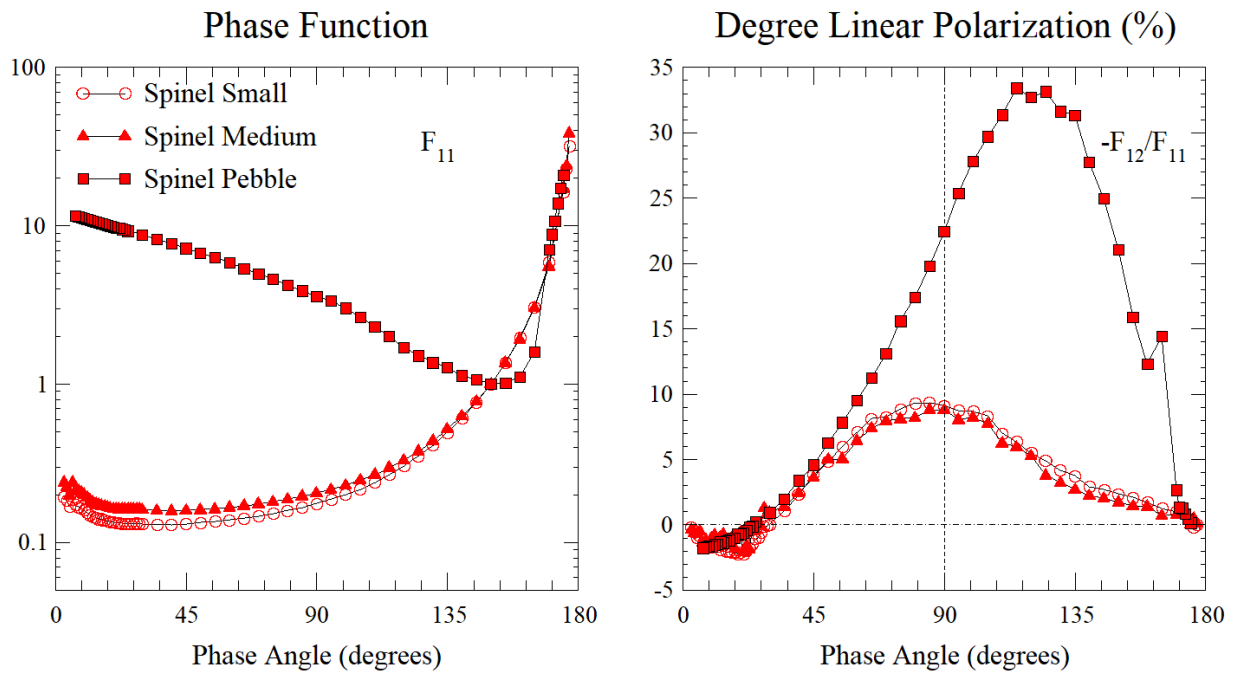


Figure 2: Phase function curves (left) and degree of linear polarization (right) for the three spinel samples.

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