

Evaluations Using Clouds of Tiny Cosmic Dust Particles

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ABSTRACT

We talked about the existence of cosmic dust particles in this article, which are composed of different elements like carbon, oxygen, iron, and other atoms heavier than hydrogen and helium. Star formation depends on cosmic dust particles, which are the building blocks of planets and people. Dust that has fallen to Earth or exists in space is known as cosmic dust, sometimes known as extraterrestrial dust or space dust. The majority of particles of cosmic dust have sizes between a few molecules and 0.1 mm (100 μm). We refer to larger particles as meteorites. Cosmic dust is thought to be the remnants of asteroidal or cometary collisions that can be linked to collisions that took place during the Big Bang.

Keywords- Big Bang, Mars, planets, galaxies, and solar systems; cosmic dust particles.

I. INTRODUCTION

The dust that is present in space is called cosmic dust. These particles contain molecules as small as one micron, but they are more than just fine dust particles. Refractory mines contain a small but densely packed area of cosmic dust. As an illustration, the local bubble's interstellar medium had a dust density of roughly ten to the minus six grains per cubic meter, with each grain having a mass of roughly tens to the negative power of seventeen masses [3, 7]. Cosmic dust particles can affect radio communications, weather patterns, and even phytoplankton in the oceans by acting as fertilizer. They can also provide essential information about the atmospheres of other planets[4, 6].

II. DUST PARTICLES IN SPACE

Through laboratory measurements, we have been able to identify some general trends in the

scattering behavior of a set of real samples of cosmic dust particles. As an illustration, we compare the measured scattering matrix elements in Figure 1. According to the scattering angle of JSC Mars-1, an analog of Martian dust (JSC stands for Johnson Space Center), The <1mm size fraction of palagonitic tephra, or glassy volcanic ash changed at low temperatures, makes up the JSC sample. At 488 and 647 nm, the measurements were carried out at the IAA-CODULAB [1]. Lorenz-Mie calculations at the corresponding wavelengths are presented alongside the experimental data. We use the estimated refractive index and number size distribution of the JSC Mars-1 sample for the Lorenz-Mie calculations. $m(448 \text{ nm}) = 1.52 + i0.01$ and $m(647 \text{ nm}) = 1.50 + i0.01$ in particular [3]. The Amsterdam-Granada Light scattering Database [2] provides tables containing the size distribution and measured scattering matrices of the JSC Mars-1 sample. These tables are freely accessible.

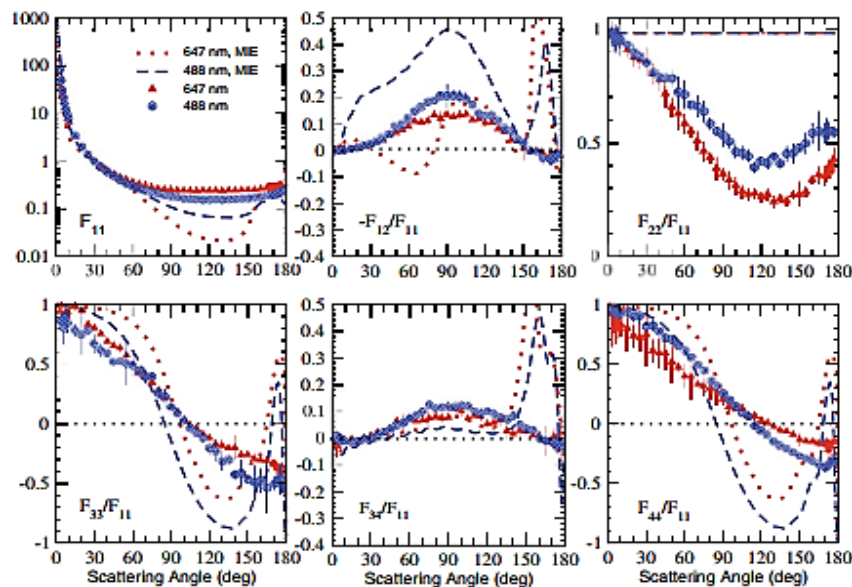


Fig. 1: measured scattering matrix elements for the JSC Mars-1 Martian dust analog sample as functions of the scattering angle at 488 nm (circles) and 647 nm (triangles). The Lorenz-Mie calculations for spheres at 488 and 647 nm, respectively, are represented by dashed and dotted lines, respectively. We utilized the same size distribution and refractive index for the Lorenz-Mie calculations as the JSC Mars-1 sample

In accordance with the request to cite the publication in which the data were published [1]. The behavior of naturally occurring, irregularly-shaped dust particles cannot be replicated using the scattering pattern for spherical particles, as Fig. 1 illustrates. Specifically, at side-scattering angles, there are significant discrepancies between the calculated and experimental phase functions ($F_{11}(\theta)$ element), and these differences are noteworthy. Additionally, for incident unpolarized light, the measured degree of linear polarization displays positive values at almost all scattering angles, peaking in the $[90-100]^\circ$ region and exhibiting a negative branch in the backward direction. This is a common behavior for irregular mineral dust, as demonstrated by numerous examples at the Amsterdam-Granada Light Scattering Database [6] and by Muñoz et al. (2004), for example. Conversely, the computed $-F_{12}(\theta)/F_{12}(\theta)$ compares with the experimental data to produce a significant overestimation at almost all scattering angles at 488 nm, but an underestimation in the forward lobe at 647 nm. Furthermore, the measured results for the JSC Mars-1 dust analog strongly deviate from 1 at almost all measured scattering angles, whereas the $F_{22}(\theta)/F_{11}(\theta)$ for spherical particles is equal to 1 at all scattering angles. There are also notable discrepancies between the measured and calculated values for the remaining scattering matrix elements. Comparable discrepancies are discovered for numerous additional irregular cosmic dust samples, demonstrating that the Lorenz-Mie theory is not always reliable. Direct application of the experimental data is also possible, for example, through comparison with astronomical observations of light scattered under single scattering circumstances. Furthermore, experimental scattering matrices are used

to investigate the validity of computational techniques dedicated to simulating the scattering behavior of real polydisperse irregular particles, e.g. Moreno et al. provide an intriguing example pertaining to Martian dust. It is common practice to obtain the dispersion function of Martian dust particles at a given wavelength by utilizing Pollock and Cosey's (1980) semi-empirical theory for non-spherical particles [5]. The efforts have been concentrated on calculating the phase function of Martian dust particles using more complex model particles, specifically cylinders [4]. Nevertheless, Wolff et al. [8] noted that when comparing the computed phase functions for a size distribution of cylinders with Martian dust observations, there is a significant overestimation of the phase function close to the back-scattering direction. When the phase function of natural dust particles is obtained experimentally in a laboratory setting, however, that overestimation is not observed [6]. The experimental phase function for a basalt sample, as shown in Fig. 2, exhibits a high degree of agreement with the findings from Wolff et al [8]. By contrast, the observations for Mars are not reproduced by any of the computed phase functions (Lorenz Mie for spheres or cylinders). Furthermore, spectropolarimetry seems to be a potent diagnostic tool for determining the makeup of Martian dust based on our experimental data. The measured degree of linear polarization for the JSC Mars-1 samples and basalt is shown in Fig.3. The 488 and 647 nm wavelengths were used for the measurements. The basalt sample has a red polarization color and a refractive index that exhibits a nearly flat wavelength dependence in the visible (the maximum of $F_{12}(\theta)/F_{11}(\theta)$ shows higher values at 647 nm than at 488 nm). On the other hand, the JSC Mars-1 exhibits blue

polarization color and shows a significantly higher imaginary part of the refractive index at 488 nm than at 647 nm. The polarization color of particles is therefore directly correlated with their refractive index. Particles exhibiting a red polarization color are those whose imaginary part of the refractive index has a flat dependence at visible wavelengths, while particles exhibiting a blue polarization color are those whose refractive index is significantly higher at blue wavelengths than at red wavelengths.

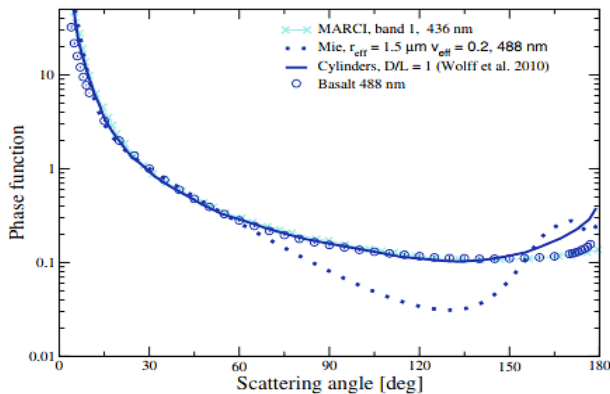
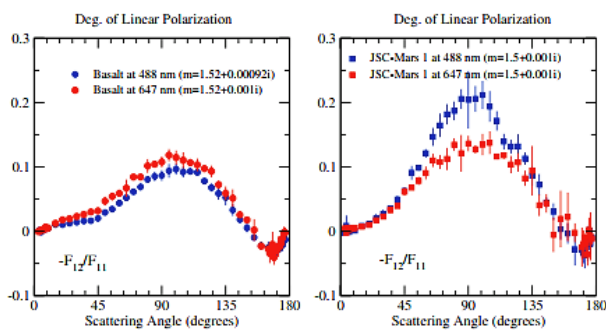


Figure 2: Pseudo emission phase function at 436 nm (intersection) from MARCI band 1 (Wolff et al., 2010). Along with our measurements for the Martian dust analog, basalt, at 488 nm (circles), we also present the calculated phase functions for spheres (dotted line) and cylinders (solid line) from Dabrowska et al. (2015)



The degree of linear polarization was measured at 488 nm (blue symbols) and 647 nm (red symbols) as a function of the scattering angle in Figure 3. A basalt sample is represented in the left panel, and the JSC Mars-1 sample is represented in the right panel.

III. CONCLUSIONS

Thus, for the JSC Mars-1 dust analog sample, the scattering matrix elements were determined as

functions of the scattering angle at 488 nm (circle) and 647 nm (triangle). The Lorenz-Mie calculations for spheres measuring 488 and 647 nm are represented by dashed and dotted lines, respectively. We have utilized the same size distribution and refractive index for the Lorenz-Mie calculations as the JSC Mars-1 sample. The scattering angle was used to determine the degree of linear polarization at 488 nm (blue symbols) and 647 nm (red symbols). The pseudo emission phase function from MARCI band 1 at 436 nm (intersection) of the JSC Mars-1 sample is shown in the right panel, while the left panel corresponds to the basalt sample. We also present our measurements for the Martian dust analog, basalt, at 488 nm (circles), and the calculated phase functions for spheres (dotted line) and cylinders (solid line).

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