Experimentally Derived Bidirectional Reflectance Distribution Function Data in Support of the Orbital Debris Program Office

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ABSTRACT

The NASA Orbital Debris Program Office (ODPO) has used various optical assets to acquire photometric data of Earth-orbiting objects to define the orbital debris environment. To better characterize and model optical data acquired from ground-based telescopes, the Optical Measurements Center (OMC) at NASA Johnson Space Center emulates illumination conditions seen in space using equipment and techniques that parallel telescopic observations and source-target-sensor orientations.

One of the goals of the OMC is to improve the size calculation used for optical data by developing an optical-based Size Estimation Model. The current size estimation requires applying a Lambertian phase function, set albedo value, and range to the observed magnitude. The first step to improving the sampled brightness of laboratory targets is to remove aspect-angle dependencies. Then, the volume of possible object viewing angles is sampled at 21 specified combinations of azimuthal and elevation angles for each solar phase angle. Finally, the acquired images are input into an image processing program that generates approximations for the object’s Bidirectional Reflectance Distribution Function (BRDF) and phase function. The BRDF is a radiometric concept that identifies an object’s material composition by matching a BRDF approximated with photometric data collected by ground-based telescopes with a BRDF generated experimentally from a known object in the laboratory.

This paper discusses the validation of experimental BRDF and phase function approximations produced in the OMC and how the findings will be incorporated into ODPO models. A Lambertian sphere is imaged and the subsequent experimental functions are scrutinized to confirm that they correspond to an object that has an isotropic luminance. With the image processing algorithm validated, test objects with varying optical properties are then imaged to confirm that the produced photometric functions are both unique and repeatable. Once the validation is complete, the OMC will be used to evaluate a subset of fragments from a hypervelocity impact test of a mock-up satellite and assess the appropriate phase function and size estimates using BRDF measurements for a large volume of targets composed of various shapes, sizes, and materials.