SPACE DEBRIS SYMPOSIUM (A6)
Modeling and Risk Analysis (2)

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A NEW BOND ALBEDO FOR PERFORMING ORBITAL DEBRIS BRIGHTNESS TO SIZE TRANSFORMATIONS

Abstract

We have developed a technique for estimating the intrinsic size distribution of orbital debris objects via optical measurements alone. The process is predicated on the empirically observed power-law size distribution of debris (as indicated by radar RCS measurements) and the log-normal probability distribution of optical albedos as ascertained from phase (Lambertian) and range-corrected telescopic brightness measurements. Since the observed distribution of optical brightness is the product integral of the size distribution of the parent [debris] population with the albedo probability distribution, it is a straightforward matter to transform a given distribution of optical brightness back to a size distribution by the appropriate choice of a single albedo value. This is true because the integration of a power-law with a log-normal distribution (Fredholm Integral of the First Kind) yields a Gaussian-blurred power-law distribution with identical power-law exponent. Application of a single albedo to this distribution recovers a simple power-law [in size] which is linearly offset from the original distribution by a constant whose value depends on the choice of the albedo. Significantly, there exists a unique Bond albedo which, when applied to an observed brightness distribution, yields zero offset and therefore recovers the original size distribution. For physically realistic power-laws of negative slope, the proper choice of albedo recovers the parent size distribution by compensating for the observational bias caused by the large number of small objects that appear anomalously "large" (bright) - and thereby skew the small population upward by rising above the detection threshold - and the lower number of large objects that appear anomalously "small" (dim).

Based on this comprehensive analysis, a value of 0.13 should be applied to all orbital debris albedo-based brightness-to-size transformations regardless of data source. Its prima fascia genesis, derived and constructed from the current RCS to size conversion methodology (SiBAM – Size-Based Estimation Model) and optical data reduction standards, assures consistency in application with the prior canonical value of 0.1. Herein we present the empirical and mathematical arguments for this approach and by example apply it to a comprehensive set of photometric data acquired via NASA's Liquid Mirror Telescopes during the 2000-2001 observing season.