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ENERGY-ACCOMMODATION COEFFICIENT AND DRAG COEFFICIENT MODELING FOR STELLA AND STARLETTE

Abstract

Energy-accommodation coefficient is an important factor in estimating satellite drag coefficients. Relevant work done over the last decade involving energy-accommodation has predominantly been in the 150-500 km altitude range. The 2009 collision of Iridium 33 and Cosmos 2251 at an approximate altitude of 790 km showed the need for accurate satellite drag modeling at higher altitudes. This paper presents a step toward modeling energy-accommodation coefficient in the 500-1000 km altitude range. The variation of energy-accommodation coefficient with solar (F10.7) and geomagnetic (Ap) activity is examined. Energy-accommodation coefficients for Stella and Starlette are derived using Bird's analytical solution for drag coefficient of spherical satellites. Drag coefficients obtained from GEODYN (NASA Goddard Space Flight Center's Precision Orbit Determination and Geodetic Parameter Estimation Program) orbit determination using SLR-tracking data for Stella and Starlette, average estimated drag coefficients for Stella derived by Pardini et al. (2004), and drag coefficient of 2.52 on an aluminum sphere derived by Harrison and Swinerd (1995) were used for a qualitative analysis to extract the accommodation coefficients. Harrison and Swinerd derived molecular surface reflections midway between diffuse and specular. NRLMSISE00 was used as the base density model for this analysis. This paper also examines the ability of Direct Simulation Monte Carlo (DSMC) methods to estimate satellite drag coefficients with partial accommodation. Results show a bias in accommodation coefficients extracted using average estimated drag coefficients derived by Pardini et al. Energy-accommodation coefficient varies in the range of 0.1-0.28 for Stella and 0.29-0.58 for Starlette using the drag coefficient of 2.52. Negative values for accommodation-coefficients are derived using GEODYN's fitted drag coefficients with the mean close to the mean obtained using a drag coefficient of 2.52. Accommodation coefficients vary sharply with solar activity but only moderately with geomagnetic activity. Results indicate that accommodation coefficients fall with a rise in solar activity. Results also show that Monte Carlo methods perform well in estimating drag coefficients with errors less than 2%. The bias in accommodation-coefficients derived using average estimated drag coefficients by Pardini et al. are the result of MSISE-90 as their density base model. The errors in the accommodation coefficients derived using the GEODYN fitted drag coefficients are because of the absorption of density errors by the drag coefficients in the orbit estimation. DSMC provides a plausible method for determining drag coefficients for non-spherical satellites with estimates for energy-accommodation coefficient.