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NEUTRAL ATMOSPHERE DRAG AT THE ALTITUDE OF LARES AND AJISAI

Abstract

LARES (LAser RElativity Satellite) was launched, at the beginning of 2012, into a nearly circular orbit with an altitude of about 1454 km and with an inclination of 70 deg. Having a radius of 18.2 cm and a mass of 386.80 kg, this completely passive sphere, covered by corner cube laser retro-reflectors, is the densest object in orbit, with an area-to-mass ratio of $2.69 \times 10^{-4} m^2/kg$. The analysis of the ranging normal points, acquired by the International Laser Ranging Service (ILRS), over a time span of about 3.7 years, associated with a precise orbit determination with the GEODYN II (NASA/GSFC) code, revealed an average semi-major axis decay rate of approximately 1 meter per year, corresponding to a non-conservative net force acting nearly opposite to the velocity vector of the satellite and with a mean along-track acceleration of $-1.444 \times 10^{-11} m/s^2$. In spite of the smallness of the acceleration, the extremely good orbit determinations available made possible the use of LARES as a powerful tool for investigating the behavior of the neutral atmosphere around 1500 km, an altitude for which accurate satellite measurements are scarce and the dominant atomic species are helium and hydrogen. By means of an ad hoc ISTI/CNR software code, the neutral drag perturbation acting on LARES was then investigated with six thermospheric density models (JR-71, MSIS-86, MSISE-90, NRLMSISE-00, GOST-2004 and JB2008). Adding to this, a further independent analysis was carried out by analyzing the orbital decay of another passive spherical satellite, Ajisai, just 40 km higher than LARES, but at an inclination of 50 deg and with an area-to-mass ratio about 20 times greater. Based on the available data and results, it was concluded that most (nearly 99%) of the observed secular semi-major axis decay of LARES was due to neutral atmosphere drag. This conclusion was fully consistent with the predictions, uncertainties and range of applicability of the thermospheric neutral density models available. Moreover, several mechanisms were investigated in order to account for the differences found between the average drag coefficients of LARES and Ajisai, leaving latitudinal atmospheric density biases as the most probable cause. A significant role of charged particle drag at the altitudes considered was instead excluded.