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TO THE EXTENDED RUTHERFORD'S FORMULA AND ITS APPLICATION IN THE INTERPLANETARY MISSION DESIGN USING MULTIPLE GRAVITY ASSISTS

Abstract

Modern methods of the interplanetary mission design using multiple gravity assist maneuvers around planets are associated with the need to precise calculate a lot of virtual trajectories (i.e. of the phase beams). For their effective use it is necessary to study the structure of non-linear planetary flyby gravitational scattering and to construct the corresponding effective modeling. Gravity assist maneuvers are belonged to the one of the gravitational scattering types in the Solar system. Rutherford's formula for the scattering of charged α-particles in the Coulomb field can be easily generalized to such case of gravitational scattering. The according extended Rutherford formula (ERF) for the gravitational scattering (for gravity assist maneuvers) can be produced. The according formula in this work is presented also an its effective gravitational scattering cross-section by analogy is introduced.

Using presented approach the studying the structure of non-linear flyby gravitational scattering using the Rutherford' formula is possible also to construct the corresponding effective modeling using according regularized phase beams.

Using ERF in the modeling of phase beams of a lot spacecraft virtual trajectories for the interplanetary mission design using gravity assists sequences may be very fruitful. Using ERF we can form a non-uniformed initial tube of spacecraft virtual trajectories before flyby to produce a uniformly scattered sufficiently dense beam of virtual trajectories after flyby. As a result, the probability of the approaching least one secondary virtual test object by the target planet's sphere of action increases significantly. Due to this, it is possible to significantly reduce the required number of simulated variants for constructing the required gravity assists maneuvers sequences.

It is shown that with using of such approach, it is possible to significantly increase the efficiency of the recurrent procedure for the gravity assists chains searching for ballistic scenarios of the modern interplanetary mission design ("Laplas-P", "Interhelioprobe", etc.), required the spacecraft asymptotic velocity changing relative the secondary bodies (planets, massive Jovian moons, etc.) by the "cross planets" gravity assists performing.