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Calculation and experimental verification of driving force for ablation of irregular asteroid by pulsed laser

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ABSTRACT

Laser ablation of asteroids is a planetary defense technology that can effectively deal with the threat of asteroids with long-term warning time. Its basic principle is to focus high-energy laser on the surface of the target asteroid, so that the material on the surface of the target asteroid will be vaporized or plasma, and the reaction force generated by the reverse injection of vaporized or plasma material will drive the asteroid away from the original threat orbit, so as to achieve the goal of defense. One of the advantages of laser ablation of asteroids is that it can achieve accurate control of asteroid orbits. To achieve accurate control of asteroid orbits, it is required to accurately obtain the driving force generated by laser ablation of target asteroids. For regular targets whose laser irradiation surface is plane or spherical, the interaction force between the laser and the target can be accurately obtained through experiments and theoretical calculations. However, real asteroids usually have irregular shapes, and their composition and internal structure are complex. How to accurately obtain the force generated by laser ablation is the key to achieve accurate control of asteroid orbit. In this paper, an accurate calculation method of laser ablation force based on finite element grid is proposed to solve the problem of pulsed laser ablation force on irregular shaped asteroids. This method is based on the high-precision geometric model of the target asteroid. The finite element mesh model of the target asteroid is obtained by meshing the geometric model. For the asteroid finite element mesh model, the corresponding material properties can be set for different mesh areas. The mesh size of the finite element mesh model can be further refined according to the different laser irradiation areas. In the laser irradiation area, a single grid can be approximated to a plane, and the force can be calculated by the interaction theory of plane material. The vector sum of the force generated by multiple grids is the force generated by laser ablation of irregular target asteroids. In order to verify the accuracy of the calculation method, a laser ablation force measurement experiment is designed for a specific irregular target, and the experimental results are compared with the calculated results. The accuracy of the calculation method is verified through experiments.