Dynamical modeling and characteristic analysis of orbits around a comet

Yuchen He[1][0000-0003-2653-7837] and Yue Wang[2][0000-0001-9172-0895]

[1] School of Astronautics, Beihang University, Beijing 102206, China
[2] School of Astronautics, Beihang University, Beijing 102206, China
heyuchen@buaa.edu.cn

Abstract. As a frontier field of deep-space explorations, the study of comets is of great value to planetary scientific research, resource exploration, and planetary defense. To date, only the ESA's Rosetta successfully orbited its cometary nucleus due to the special orbital dynamical environment in the vicinity of a comet. Therefore, the stability of the orbits around a comet is an important issue in the exploration mission design. The parameters of Rosetta's target, comet 67P/Churyumov-Gerasimenko, are used in this study on the orbital dynamics around a comet. The most significant perturbation around a comet is the aerodynamic force caused by the coma gas. However, the current numerical models are too complicated for analytical studies and the current spherical harmonic model is too simple to reflect the real distribution of the coma gas field accurately. To overcome the disadvantages of current models, we simplify the sophisticated numerical coma gas model, the Direct Simulation Monte Carlo (DSMC) model, into a new spherical harmonic model, which is suitable for both numerical simulations and analytical studies. By considering the perturbative effects of coma gas, solar radiation pressure (SRP), and non-spherical gravity of the comet nucleus, the orbital dynamical model is established. Then, with a global search method, stable orbits around 67P/Churyumov-Gerasimenko are searched and their characteristics are analyzed. It is found that the perturbative effect of the coma gas reduces the stability of the orbits. As the distance between the comet and the sun increases, the stable orbital region will gradually shift from low inclinations to higher ones, and all of the stable orbits are heliotropic. According to the results, some candidate exploration orbits around the comet are identified.

Keywords: Comet exploration, Coma gas field, Aerodynamic force, Global search, Orbital stability.