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DYNAMICAL ENVIRONMENT AROUND THE FAST-ROTATING ASTEROID 1998 KY26 WITH APPLICATIONS TO THE HAYABUSA2 EXTENDED MISSION

Abstract

Small-body missions have been launched worldwide in the past quarter-century. Nevertheless, sub-hectometer-sized asteroids have yet to be explored in detail and thus are one of the missing links in understanding the elements building rubble pile asteroids and the supply and depletion process in the small-body population. Moreover, asteroids with sizes of tens of meters are common and thus more frequently approach Earth to possibly induce destructive impacts on regional population centers. The investigation of decameter-sized asteroids is, therefore, imperative for planetary science and planetary defense. However, ground-based observations of such small bodies provide only limited information, which necessitates close-proximity observations for detailed characterization. Hence, the Hayabusa2 extended mission is designed to explore the near-Earth asteroid 1998 KY26 with a diameter as small as 20–40 m. Hayabusa2 completed its nominal sample-return mission to the asteroid Ryugu and is currently on its way to rendezvous with 1998 KY26 in 2031. Rendezvous missions to small bodies face operational challenges because many different forces influence spacecraft dynamics. In particular, the spacecraft motion around sub-hectometer-sized asteroids is subject to significant perturbation due to solar radiation pressure (SRP). A nondimensional SRP magnitude defined in the normalized Hill three-body problem, which is commonly denoted by β, falls between 10^{-2} and 10^{2} in the previous small-body missions, whereas it reaches on the order of 10^{3} for Hayabusa2 in the vicinity of 1998 KY26. This situation implies that the Hayabusa2 extended mission must deal with stronger SRP perturbation than did any other small-body missions. In addition, because the Hill radius is small, the spacecraft motion may also be affected by solar gravity. Furthermore, 1998 KY26 is a fast rotator with a spin period of 10.7 min, leading to the centrifugal force to overcome the asteroid gravity; consequently, the spacecraft experiences an upward net acceleration with respect to the asteroid-fixed frame, even near the surface, which poses difficulties in monitoring one

area for a long period (i.e., synchronizing the spacecraft orbit with the asteroid rotation). This paper investigates the distinctive dynamical environment around the fast-rotating asteroid 1998 KY26. First, we calculate the potential field around the asteroid and the resultant perturbing accelerations acting on Hayabusa2. Then, the orbital motion of the spacecraft is computed for various initial conditions, offering insight on possible operations in the proximity of 1998 KY26, such as hovering, orbiting, and landing. This research expands the possibilities of rendezvous missions to extremely small bodies.