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# PRELIMINARY DESIGN OF THE HAYABUSA2 EXTENDED MISSION TO THE FAST-ROTATING ASTEROID 1998 KY26

**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 diameters of tens of meters are more common than larger asteroids and thus more frequently approach Earth. Collisions of such bodies with the planet may possibly induce non-negligible impacts on regional population centers. However, ground-based observations of such small bodies provide only limited information, which necessitates close-proximity observations for detailed characterization. Visiting and detailing decameter-sized asteroids are, therefore, imperative for planetary science and planetary defense. For this reason, the Hayabusa2 extended mission is designed to explore the near-Earth asteroid 1998 KY26 as small as 20–40 m in diameter. Hayabusa2 completed its nominal sample-return mission to the asteroid Ryugu and is currently on its way to rendezvous with the asteroid in 2031.

The extended missions will face unique operational challenges because many different forces influence spacecraft dynamics. In particular, the spacecraft motion around 1998 KY26 is subject to significant perturbation due to solar radiation pressure (SRP). A non-dimensional SRP magnitude defined in the normalized Hill three-body problem, which is commonly denoted by $\beta$, fell between $10^{-2}$ and $10^{2}$ in the previous small-body missions, whereas it reaches on the order of $10^{3}$ for the Hayabusa2 extended mission in the vicinity of 1998 KY26. This situation implies that the extended mission must deal with stronger SRP perturbation than any other small-body missions. In addition, 1998 KY26 is a fast rotator with a

spin period of 10.7 min, leading to the centrifugal force to overcome the asteroid gravity; therefore, the spacecraft experiences an upward net acceleration with respect to the asteroid-fixed frame, even near the surface, which poses difficulties in synchronizing the spacecraft orbit with the asteroid rotation.

This paper presents preliminary mission design for the Hayabusa2 extended mission to the fast-rotating asteroid 1998 KY26. The research goal is to plan asteroid proximity operations, such as hovering, orbiting, observations, and landing, that can be achieved with the remaining fuel and payloads. To achieve this goal, the orbital motion of the spacecraft in the distinctive dynamical environment is investigated in detail. Consequently, this research expands possibilities of rendezvous missions targeting extremely small bodies.