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Hayabusa2 Extended Mission: Rendezvous with 1998 KY26, one of the most common but unexplored near-Earth asteroids

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Asteroids smaller than a few hundred meters in diameter are generally considered to be the most common in the inner solar system evolution; however, they are usually too faint to be detected. This prevented developing a comprehensive list of them and characterizing their physical and chemical conditions. These small asteroids may be leftovers that survived from their parent bodies' impact-driven catastrophic disruptions (and re-accumulation) or escaped from other planetary bodies during multiple processes. A better understanding of how such objects formed and evolved will constrain the material transport mechanisms in the solar system. Also, smaller asteroids frequently approach the Earth because of their highest population. Some may enter the atmosphere to cause fireball events (they explode while passing through a denser atmosphere) and impact events, leading to damage to civilization. However, it would be challenging to assess and mitigate such events without knowledge of their physical and chemical conditions.

The Hayabusa2 extended mission, led by the Japan Aerospace Exploration Agency (JAXA), is a rendezvous mission that plans to rendezvous with asteroid 1998 KY26 in 2031 and fly by asteroid 2001 CC21 in 2026. While cruising, the spacecraft will also continue to observe the zodiacal light and exoplanets. The major science objectives of this mission are (1) constraining the origin and evolution mechanism of small asteroids and (2) establishing knowledge about planetary defense.

The rendezvous target 1998 KY26 has been observed by optical observations and ground radar in detail [e.g., Ostro et al., 1999]. This is a near-Earth asteroid with a 20 m – 40 m and a spin period of 10.7 min. Also, the radar-derived shape model infers that the shape is relatively round but still has a high uncertainty. The surface color is dark, implying the potential taxonomic classes associated with a mixture of carbonaceous materials and mafic silicates (B, C, F, G, D, P) [Ostro et al., 1999]. The reported roughness at centimeter-to-decimeter scales suggests exposed bear rocks [Ostro et al., 1999].

The centrifugal force is a dominant element controlling this asteroid's geophysical properties. The bulk density should be higher than 2,800 kg/m3 to keep surface materials. If the bulk density is lower than that, the surface slope should reach 180 deg in the equatorial region, and thus particles on the surface can be lofted if there is no attraction. Identifying particles in this region will constrain the roles of cohesion. On the other hand, the polar regions may still be gravity-dominant, where small particles may preferably rest on the surface there. If particle ejection is active, those not escaping from the body may orbit for some period and eventually be accumulated in these regions. The internal structure is always tensile everywhere, although the tensile stress is low, and the bulk cohesive strength necessary to sustain the body is only ~20 Pa, which is within the reported strength of rubble pile bodies [Hirabayashi et al., 2021]. If this is the case, while the monolithic condition is favored, the rubble pile structure is still plausible. Furthermore, because of its size, the orbital and rotational conditions change due to the Yarkovsky and YORP effects in a short period [Vokrouhlický et al., 2000; Tholen, 2003; Nesvorný and Vokrouhlický, 2008].

Optical observations have shown that the fly-by target 2001 CC21 has a size of ~700 m and a spin period of ~5 h. While surface compositions are not well characterized, it may be L-type, which may be related to primordial compositions in the solar system, although an S-type is also possible. Lightcurve observations [Ries et al., 2005; Pravec, 2021, personal communication] imply that this asteroid is highly elongated, a ratio of the short axis to the long axis being ~0.6. If this is the case, and this asteroid has a rubble pile structure, the asteroid should have experienced unique re-accumulation processes after catastrophic disruptions. Physical processes such as violent impacts, mass wasting, space weathering have likely changed the surface conditions; the variations in morphologies, roughness, and chemical compositions constrain such physical processes.

This work presents an overview of science investigations in the Hayabusa2 extended mission targeting 1998 KY26 and 2001 CC21.

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