Hayabusa2#'s exploration to asteroids 2001 CC21 and 1998 KY26 provides key insights into planetary defense

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Overview of Hayabusa2#:

The Hayabusa2 extended mission, nicknamed Hayabusa2# (SHARP: Small Hazardous Asteroid Reconnaissance Probe), started its mission after Hayabusa2 returned in December 2020 to the Earth with Ryugu's samples. Hayabusa2#'s operations include **flying by Near Earth Asteroid (98943) 2001 CC21** and **rendezvousing with Near-Earth Asteroid 1998 KY26**. The flyby is planned to be in 2026, and the rendezvous will be in 2031.

Mission objectives:

1. Advances in long-term deep spaceflight operation technology and science.
2. Geological and geophysical characterizations of a small fast rotation.
3. Technological and scientific developments and demonstrations for planetary defense.

Instruments:

The spacecraft has four remote sensing instruments and two deployable payloads

- **Optical Navigation Camera (ONC)** - The size of images from these imagers is 1024 pix by 1024 pix. The FOV of ONC-W1/W2 is 69 deg by 69 deg. The FOV of ONC-T is 6.27 deg by 6.27 deg.
- **Near Infrared Spectrometer (NIRS3)** - It covers the absorption bands of silicates (1.9–2.3 mm), phyllosilicates (1.9, 2.2–2.3, 2.7, and 2.9–3.2 mm) and carbonates (2.3, 2.5, and 2.8 mm).
- **Laser Altimeter (LIDAR)** - The accuracy of measurement is ±1 m at 30 m altitude and ±5.5 m at 25 km altitude.
- **Thermal Infrared Imager (TIR)** - The size of images from TIR is 344 pix by 260 pix (effective 328 pix by 248 pix). The FOV is 16.7 deg by 12.7 deg.
- **One target marker**
- **One projectile** for material sampling

References: [1] Pravec et al. (2002), https://www.asu.cas.cz/~ppravec/newres.txt. [2] Binzel et al. (2010), Met. & Pla. Sci. 39, 3. [3] Popescu et al. (2023), this issue. [4] https://www.hayabusa2.jaxa.jp/topics/20230306_2001_CC21/index.html. [5] https://www.hayabusa2.jaxa.jp/topics/20230314_2001_CC21/index.html. [6] Ostro et al. (1999), Science 285, 5427.

Overview of 2001 CC21:

The spacecraft will fly by 2001 CC21 at a speed of ~5 km/s in 2026. Given constraints on the spacecraft condition, not designed to perform a flyby operation, operational plans require assessments to maximize the proximity observations of this asteroid. Table 1 shows the physical parameters that are currently known [1, 2].

Table 1. Physical parameters of 2001 CC21

Properties	Values
Shape	Likely elongated
Equivalent diameter	~400-500 m
Spin period	5.02 ± 0.01 min
Tumbling mode	Not observed
Taxonomy	L or S

Since the end of 2022, this asteroid has been monitored, performing photometric observations [3] and occultation detections [4, 5]. The series of worldwide efforts in detecting occultation reported that t**he orbit accuracy of 2001 CC21 at the time of the flyby operation improved from 82 km (1σ) to 47 km (1σ)*** [5]. The efforts will be ongoing until April 2023.

Overview of 1998 KY26:

Radar and optical observations offered this asteroid's physical properties [6] (Table 2). No spacecraft has ever visited such small bodies. Hayabusa2# visiting 1998 KY26 will be the first mission to document the geological properties of extremely small bodies. Although many unknown parameters exist, this asteroid has likely evolved uniquely due to its distinctive condition (Figures 1-4).

Table 2. Physical parameters of 1998 KY26

Properties	Values
Shape	Spherical
Equivalent diameter	~30 m
Spin period	10.7 min
Tumbling mode	Not observed
Taxonomy	B, C, F, G, D, and P

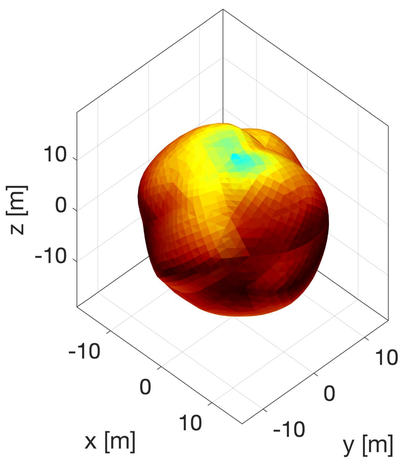

Figure 1. Slope angle. It ranges higher than 90°, meaning that centrifugal forces dominate the major area.

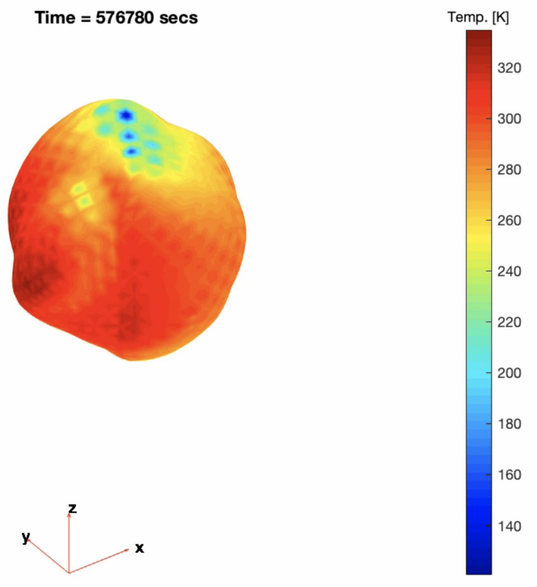

Figure 2. Surface temperature. The fast rotation likely keeps the surface temperature relatively high, even in shadowed regions, depending on surface material compositions.

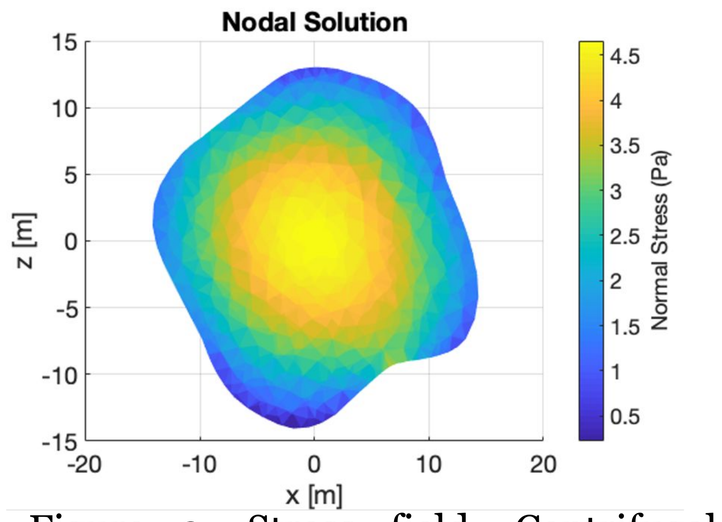

Figure 3. Stress field. Centrifugal forces give tension within the body.

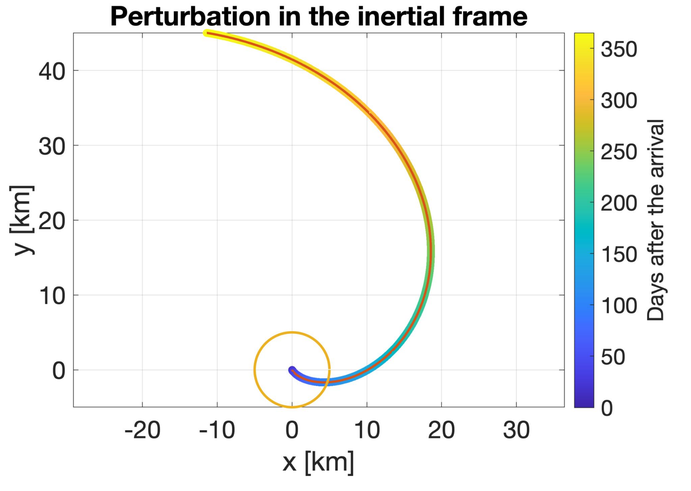

Figure 4. Yarkovsky drift. The perturbation may be remarkable during operations.