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A KINETIC-IMPACTOR DEMONSTRATION MISSION TO CHANGE THE SPIN OF AN ASTEROID

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ABSTRACT

Introduction: We present a concept for a kinetic impactor demonstration mission, which aims to change the spin rate of an asteroid. The mission would determine the efficiency of momentum transfer during an impact, and help mature the technology required for a kinetic impactor mission, both of which are important precursor measures for a future space mission to deflect an asteroid by collisional means in an emergency impact hazard situation. Furthermore, the data gained from the mission would be of great benefit for our understanding of the collisional evolution of asteroids and the physics behind crater and ejecta-cloud development.

Estimating the effect: Changing the spin rate of an asteroid requires less impact momentum for the change to be measureable by Earth-based observers than changing the asteroid's orbit around the sun. Using Itokawa as an example (Fig. 1), an estimate of the order of magnitude of a possible change in the spin period with such a mission using the law of conservation of angular momentum results in a spin-period change of 8 minutes (1%), which could be detectable by Earth-based observatories. Detailed computer modeling of the impact is in progress.

Mission types: The mission can be designed in several ways:

1. An impactor spacecraft and a reconnaissance spacecraft, which characterizes the asteroid before, during and after the impact. The dual-spacecraft concept would allow more scientific information to be obtained, such as reflection spectra of the freshly exposed, less-weathered, subsurface material in the impact crater.

2. A two-part spacecraft, which separates before impact into an impactor and a flyby imager. The flyby imager would observe the impact and the resulting ejecta cloud.
3. An impactor spacecraft only.

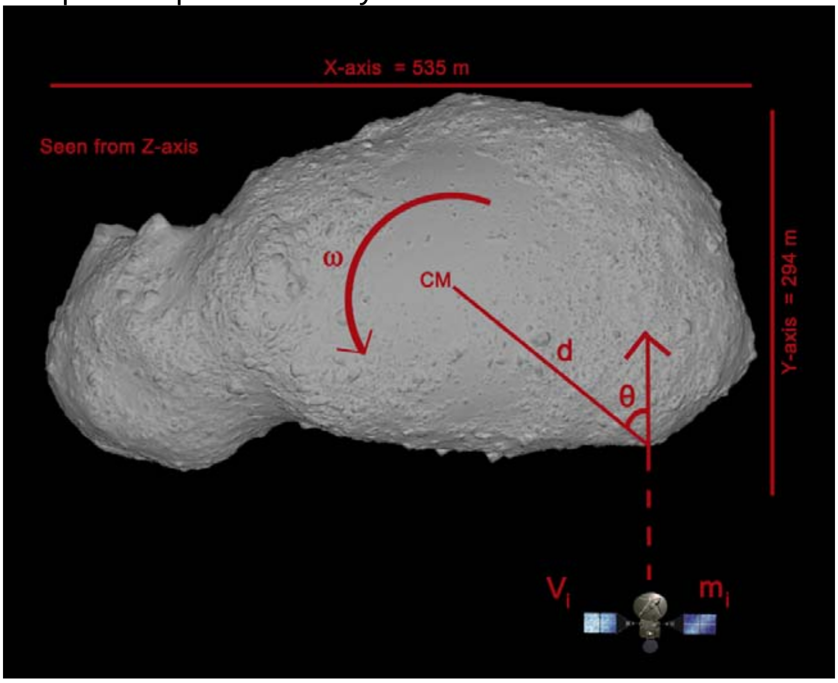

Figure 1. Illustration of a kinetic impactor changing the rotation period of an asteroid. *Credit: Robert Gaskell produced the shape-model of Itokawa used.*

In the absence of a reconnaissance spacecraft the change in the spin period could be measured from Earth-based telescopes. However, the lack of a reconnaissance spacecraft would reduce the scientific return. Using a previously visited asteroid as a target would partially compensate for this since some scientific context for the mission would already be available. Possible targets in this case could include (25143) Itokawa, (101955) Bennu and 1999 JU3.

Asteroid target shape: For optimum transfer of angular momentum, taking into account the momentum enhancement from impact ejecta, the velocity vector of the impactor should be as near to perpendicular as possible to both the local surface and the direction of center-of-mass, with d maximized (see fig. 1), requiring a significantly elongated asteroid shape. (Itokawa is expected to have the most elongated shape of the three). In general, an elongated shape also gives a larger lightcurve amplitude, which should make it easier for Earth-based observers to measure the change in the spin rate.

Conclusion: Preliminary studies show that a mission concept in which an impactor produces a change in the spin rate of an asteroid could provide valuable information for the assessment of the viability of the kinetic-impactor asteroid deflection concept.

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