SysNova: Binary Asteroid Orbit Modification

KABOOM: Kinetic Asteroid-Binary-Object Orbit Modification

Challenge Analysis Executive Summary

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SysNova Technology Reference Study No.: 12/X03
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Motivation:

We study a low-cost interplanetary mission to demonstrate the capability of artificially modifying the orbit of a small (250 ton) binary asteroid body. The targeting spacecraft survives the slow (~1 m/s) impact to carry out the orbit modification measurement afterwards.

Methodology:

A novel impacting method is employed that makes use of a relatively simple “pogo-stick” elastic appendage allowing to ideally double the transmitted momentum and minimise the residual rotation of the spacecraft after the manoeuvre. First the underlying physical aspects of the concept as well as the main criteria for the selection of the target asteroid to be deflected are analysed. Next, an assessment of a technology demo mission for the deflection of a small secondary asteroidal body using the proposed pogo-stick concept is conducted. This involves the interplanetary trajectory analysis and design, the terminal guidance and navigation for impacting the small asteroid, a preliminary design analysis of the pogo-stick mechanism, and a preliminary system design of the mission. Last, a possible technology readiness roadmap for the development of the proposed concept and the improvement of its performance is outlined.

Results:

- Novel impacting method that makes use of a relatively simple “pogo-stick” elastic appendage.
- Very small binary asteroids may face dynamical instability against environmental perturbations.
- Asteroid 2011CG2 is a "potentially binary" candidate target for a VEGA-based interplanetary mission.
- Improvement in binary asteroid ground-based detection capabilities is crucial for the mission.

Highlights:

The main highlight of the study is perhaps the novel pogo-stick impact method based on a passive single leg and a simple spring mechanism. The concept allows to ideally double the transmitted momentum and minimise the residual rotation of the spacecraft after the manoeuvre. Multiple impacts are possible and would allow increasing the overall transmitted momentum making the concept suitable for deflecting larger asteroids. Ground-based experiments to increase the TRL of the concept are required and can be conducted in existing facilities in Europe.

SysNova: Contactless Asteroid Modification System

MOSAIC: Modification of the Orbit of a Small Asteroid with Ionic Collisions

Challenge Analysis Executive Summary

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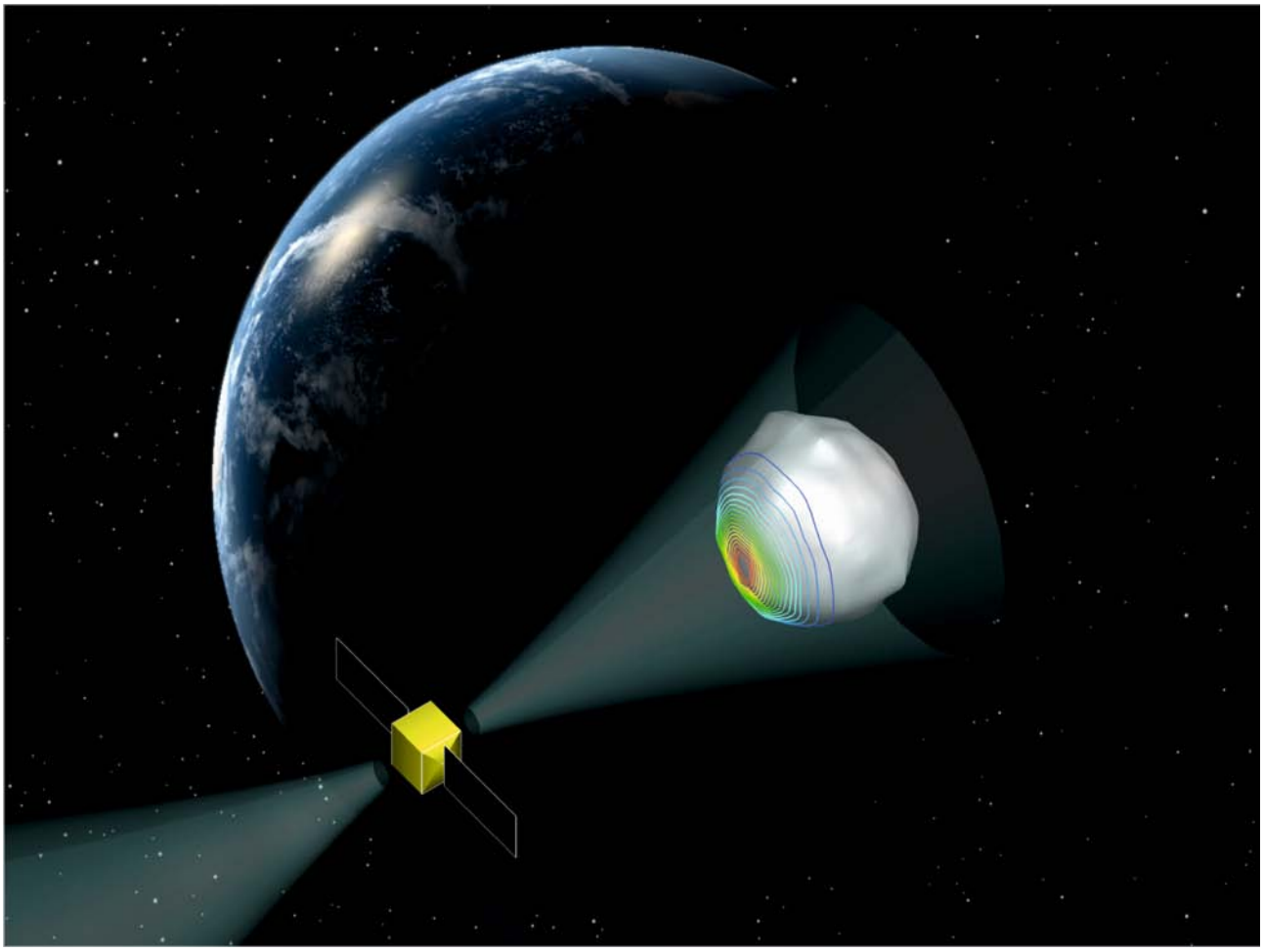

Motivation:

We study a low-cost interplanetary mission to demonstrate the capability of modifying the orbit of a small (130 ton) asteroid with contactless momentum transfer. The reduced size of the object allows low-delta-V transfer to existing NEOs and greatly simplifies the deflection phase.

Methodology:

The recently proposed ion beam shepherd (IBS) contactless deflection method is employed, in which the asteroid is deflected by a flux of impinging ions emitted by a state-of-the-art ion thruster. First the underlying physical aspects of the concept as well as the main criteria for the selection of the target asteroid to be deflected are analysed. Next, an assessment of a technology demo mission for the deflection of a small asteroid using the IBS concept is conducted. This involves the interplanetary trajectory analysis and design, the terminal guidance and navigation for rendezvous with the small target, a detailed analysis of the most critical aspects of the IBS concept (i.e. backsputtering contamination) and a preliminary system design of the mission. Last, a possible technology readiness roadmap for the development of the proposed concept and the improvement of its performance is outlined.

Results:

- Deflection requirements can be met with an IBS S/C based on a small RIT-10 Artemis ion thruster.
- Backsputtering contamination drives the maximum IBS-asteroid distance but is not a showstopper for the mission.
- Asteroid 2006 RH120 is the current best candidate target for a VEGA-based interplanetary mission.
- The asteroid rotation can be stopped in less than 20 days by offsetting the ion beam footprint from the asteroid centre.

Highlights:

One interesting highlight of the study is the fact, not previously investigated, that the IBS concept can be used to despin a small asteroid with reasonable fuel and time resources. This could be relevant to missions in which a physical contact with the asteroid (i.e. for surface or subsurface investigation, sample return, etc.) is required. A more detailed investigation is needed to assess the requirements in terms of sensors and actuators in order to control the asteroid attitude to a full despin.