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NEAR EARTH ASTEROIDS DEFLECTION MISSION USING ELECTRIC SOLAR WIND SAIL KINETIC IMPACTOR

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ABSTRACT

Asteroids with orbits that allow them to enter the Earth's neighborhood and cross Earth's orbit are classified as Near Earth Asteroids (NEAs). The probability of NEA's collision with the Earth is sufficiently low, but they may present a threat to our planet in future. To mitigate the threat posed by such asteroids, many approaches have been put forward by several scientists. A kinetic impactor (KI), which sends a spacecraft to impact against the target asteroid with hyper velocity, is one of the most efficient way to make the asteroid away from the Earth collision route. However, it can require much propellant to achieve the enough change in the asteroid orbit.

We propose to accelerate the spacecraft by using electric solar wind sail (E-sail) which generates the thrust by using the interaction between the charged thin conductive tethers and the natural solar wind plasma stream [1]. A conceptual sketch of the E-sail is provided in Fig. 1. Since the E-sail can generate the thrust without consuming any reaction mass, it can be an attractive system to yield high impact velocity and deflection distance required by KI.

Since the E-sail is large propulsion system containing many kilometer-long tethers, we propose a new type of orbital maneuvering strategy in which the sail's attitude is not actively changed [2]. Instead the attitude is fixed in the inertial frame, only the electric potential of conducting tethers is changed. Compared with the previous method in which the direction of the thrust force is changed by changing the attitude of the large E-sail, our method can reduce the energy to control the trajectory of the E-sail.

E-sail KI is performed on virtual impact scenarios created from several listed NEAs. The trajectories of the E-sail which are generated by using the locally optimal steering law are optimized by using non-linear optimization technique to achieve an impact against the virtual asteroid. Figure 2 provides an example of the optimal mission. In this case, a 1,000 kg projectile is accelerated by an E-sail and impact to a 3.3×10^{9} kg asteroid. The achievable deflection distance is 8,347 km on b-plane at the predicted collision date and this value is equal to 106% of Earth radius. In the paper, we also explain other cases that are performed on other impact scenarios.

The thrust force of the E-sail depends on the distance from the Sun, because it is determined by the condition of the plasma particles contained in the solar wind. The paper will focus on this characteristics, and the group of the asteroid which should be deflected by E-sail KI is also explained.

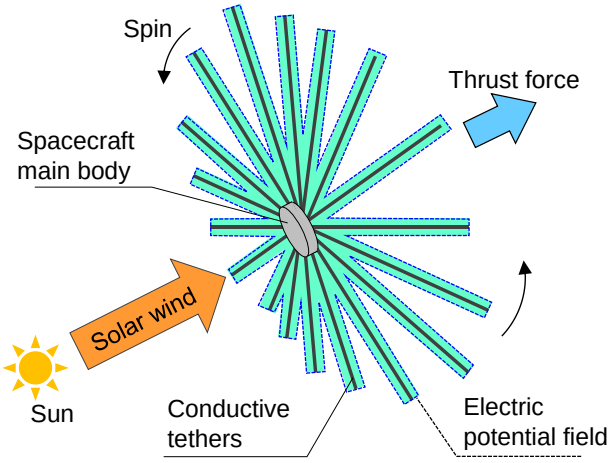

Figure 1: A conceptual sketch of the E-sail.

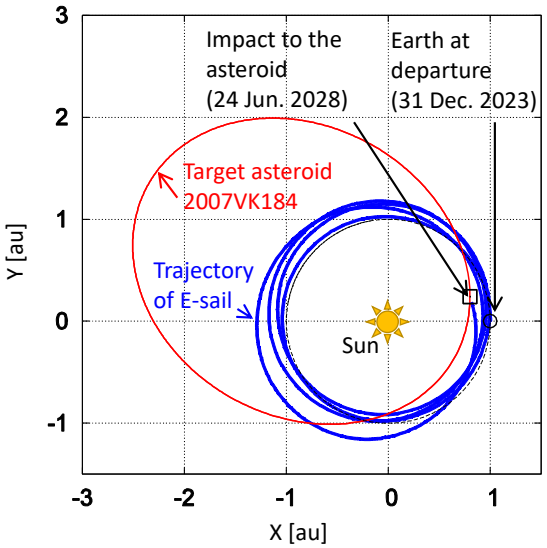

Figure 2: An example of the E-sail KI mission.

References

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