PDC 2025
Stellenbosch, Cape Town, South Africa

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Exhaustive search of gravity assist trajectories for rapid reconnaissance and deflection of fictitious asteroid PDC2025

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Keywords: Reconnaissance mission, asteroid deflection, kinetic impactor, multiple gravity assist

The hypothetical asteroid threat exercise for the 2025 planetary defense conference includes an intriguing trajectory design challenge for possible deflection missions. The long (17 years) time span between the impact threat announcement and the possible impact date allows one to exploit multiple gravity assist (MGA) trajectories involving the inner solar system planets to allow an otherwise impossible low relative velocity rendezvous reconnaissance mission and, additionally, to improve the deflection performance of a kinetic impactor. In this work, we exploit a rapid Lambert-free sequence-independent trajectory finding algorithm [1] able to compute all possible MGA trajectories to the asteroid before the expected impact and select suitable reconnaissance and impact solutions among them. As expected, gravity assists are sine qua non for a feasible rendezvous with optimal phasing near perihelion. Additionally, the most promising solutions are characterized by multiple resonant legs. Interestingly, though, gravity assist impact trajectories (impacting almost tangentially and also near perihelion) appear to be more effective compared to direct ones for the proposed scenario. A rendezvous reconnaissance mission followed by a kinetic impact deflection mission appears to be technologically feasible with carefully designed MGA trajectories and multiple launch and arrival opportunities are available.

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Table 1: Candidate reconnaissance mission.

Body	Launch / Encounter Epoch	Launch / Arrival v_∞ [km/s]	Transfer Resonance
Earth	17-Jun-26	5.55	–
Venus	09-May-27	–	1 : 1
Venus	20-Dec-27	–	–
Earth	20-Apr-28	–	1 : 1
Earth	19-Apr-29	–	1 : 1
Earth	19-Apr-30	–	–
PDC25	28-Aug-32	1.28	–

Table 2: Candidate KI deflection mission.

Body	Launch / Encounter Epoch	Launch / Arrival v_∞ [km/s]	Transfer Resonance
Earth	12-Mar-26	3.50	–
Venus	09-Apr-27	–	–
Earth	30-Apr-28	–	1 : 1
Earth	30-Apr-29	–	3 : 2
Earth	30-Apr-31	–	–
PDC25	03-Nov-32	18.64	–

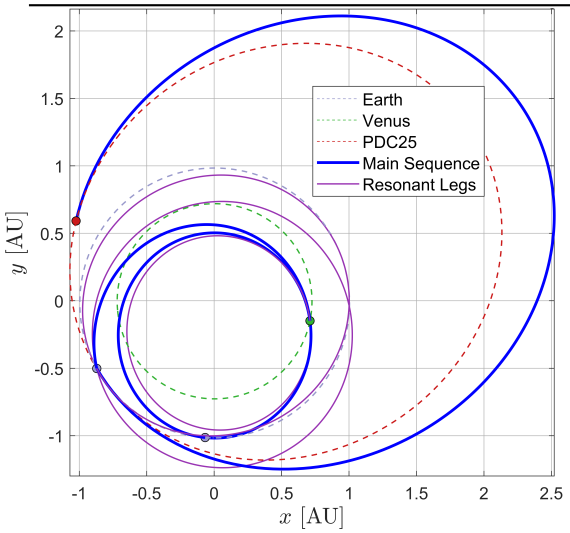

Figure 1: Reconnaissance mission trajectory. A rendezvous with the asteroid is feasible with a final 1.28 km/s delta-V burn.

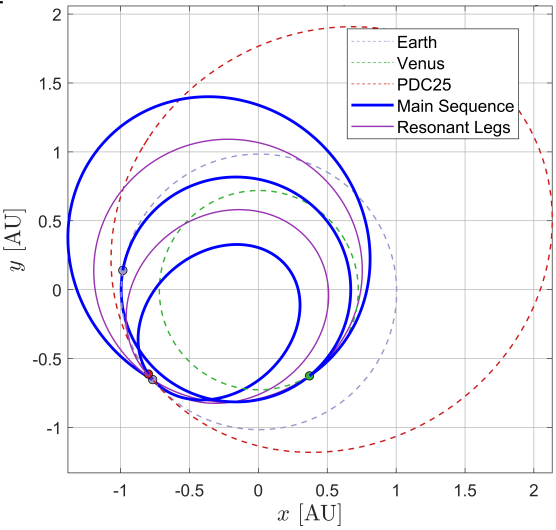

Figure 2: Deflection mission trajectory. A kinetic impact deflection of ~ 3.1 Earth radii (assuming the momentum enhancement factor $\beta = 1$) is possible with an 8.5 ton impactor launched by a Falcon Heavy.

Comments:

We would prefer an oral presentation in the "Hypothetical Asteroid Threat Exercise" session or alternatively in the "Space Mission & Campaign Design" session.

References

[1] M. Gavira-Aladro, C. Bombardelli, Lambert-Free Solution of Multiple-Gravity-Assist Optimization Problem, Journal of Guidance, Control, and Dynamics 47 (2024) 1822–1838.