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Out of the Shades – Analysis of NEO Deflection using Planetary Sunshade Sailcraft for Planetary Defence

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The latest IPCC report shows that it is unlikely that the +1.5°C target for the limitation of global warming can be achieved by the reduction of emissions on the ground alone. Several methods for active climate control have been proposed. Unlike most, solar radiation management by a planetary sunshade does not directly interfere with the Earth's atmosphere and ecosystem. Several authors have studied the mitigation of severe effects of climate change on Earth by introducing solar radiation management from space. For this purpose, over four million 9000-m²-sized sunshield sailcraft could operate as one large "occulting disk" (Fuglesang, 2021; Joan-Pau Sánchez, 2015). With a total mass of roughly 34 billion tons, these sailcraft would be positioned near the Sun-Earth Lagrange point (L_1) and, therefore, may provide a viable option for planetary defence, especially PHA deflection (Fuglesang, 2021).
This paper analyses the influence of re-directing a large number of sunshade sailcraft as kinetic impactors towards a fictitious asteroid, 2023 PDC, within the scenario created for the Planetary Defence Conference 2023.
Assuming a planetary sunshade has already been successfully deployed, the high mass already present in interplanetary space provides a significant advantage.

Therefore, our work is concerned with identifying optimal trajectories for sailcraft from this sunshield used as kinetic impactors to achieve a sufficient deflection distance from Earth (roughly one Earth radius (Sugimoto, 2014)). In this study, optimisation is a tradeoff between the manoeuvre time to improve the impact trajectory and the time to accumulate deflection from each impact.
For these calculations, the departure location of the sailcraft is assumed to be about 2.4 million kilometres sunwards from Earth, which is the optimal solar distance considering the solar radiation pressure acting on the disk (Joan-Pau Sánchez, 2015). Since many "impact-sails" are available, a high impact success rate is not mandatory, which relaxes requirements regarding sailcraft control right before the impact. In this work, the required mass and, therefore, the required number of sails colliding with the asteroid to achieve the desired deflection distance are calculated.
Due to the application of many impactors, the temporal offset between the single impacts is considered and optimised to minimise the damage resulting from the impact ejecta on the subsequently arriving sailcraft.

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