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ON THE BALLISTIC CAPTURE OF ASTEROIDS FOR RESOURCE UTILISATION

Abstract

Near-Earth Asteroids (NEA) have long been acknowledged as possible targets for future space in-situ resource utilisation. Any envisioned future of large-scale space exploration and utilisation involves the development of both large space structures and a human presence in space (e.g., space solar power, space tourism or more visionary human space settlements). It is in this context that the utilisation of asteroid resources may become a more efficient alternative to the conventional approach of transporting all necessary materials from the bottom of the Earth's deep gravity well. This paper will show, by using a NEA model able to predict the statistical probability of the existence of an asteroid with a given set of orbital elements and diameter, that abundant material should be found in relatively accessible orbits. The level of accessibility of the asteroidal material can be first assessed by its hyperbolic infinite velocity at the Earth encounter. It will be shown that a large number of small objects (i.e., about a thousand objects between 1 to 10 meters diameter) could approach the Earth with hyperbolic infinite velocity smaller than 1 km/s using of very small orbital correction manoeuvres. Objects approaching the Earth at such a low relative velocity are potential targets for ballistic capture trajectories, which could insert the asteroids into high apogee orbits without the need for capture propulsion. Furthermore, not only could Earth-crossing objects potentially be captured at Earth, but also Amor-type objects. In fact, the paper will also show that a very important source of material is found to have a semi-major axis around 2 AU and an Amor-type orbit. Earth's gravity perturbation onto objects on this region could be trimmed through judicious use of small Δv manoeuvres, so that these objects could experience an accumulative large change on their semi-major axis on relatively short time. The paper will use an analytical Keplerian twist-map to approximate the dynamics of Amor-type objects in the planar circular restricted three-body problem and will show that the dynamical evolution of some objects in the mentioned region could be trimmed in such a way that they could get finally captured by the Earth's gravity with time of flights on the order of a few tens of years. This strategy could make possible the capture of relatively large objects into Earth bound orbits with an extremely small investment in energy.