# Mine those asteroids: Strathclyde team finds easy 12

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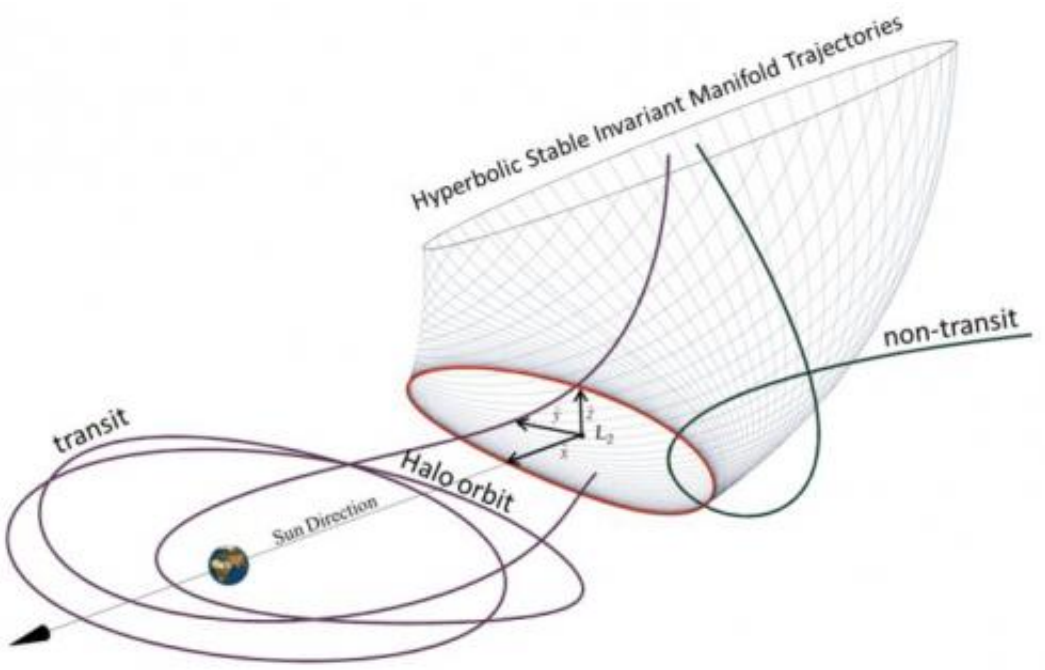


Schematic representation of the four categories of motion near the L2 point (represented by the set of axes in the figure): periodic motion around L2 (i.e., halo orbit), hyperbolic invariant manifold structure (i.e., set of stable hyperbolic invariant manifold trajectories), transit trajectory and non-transit trajectory. Credit: arXiv:1304.5082 [math.DS]

(Phys.org) —Researchers at the University of Strathclyde in Glasgow have identified twelve easily retrievable objects among the population of near earth objects (NEOs). In their paper published this month in

*Celestial Mechanics and Dynamical Astronomy*, authors D. García Yárnoz, J. P. Sánchez, and C. R. McInnes discuss the 12 asteroids that could be easily mined for valuable resources using existing spacecraft technology. Their article, "Easily Retrievable Objects Among the NEO Population," focuses on near earth objects, about which other researchers tend to discuss in terms of the threats these pose in destruction. Authors of this paper, however, are concerned about being able to harness the positive benefits if the objects can be successfully exploited.

"Asteroids and comets are of strategic importance for science in an effort to understand the formation, evolution and composition of the Solar System. Near-Earth Objects (NEOs) are of particular interest," they said, "because of their accessibility from Earth, but also because of their speculated wealth of material resources."

While they are not the first team to talk about how NEO resources may be exploited, the authors are pointing out that, out of these NEOs, they can identify a family of EROs—Easily Retrievable Objects. These EROs can be transported from "heliocentric orbits into the Earth's neighborhood at affordable costs." The problem to transfer an asteroid to an Earth or Moon centered orbit can be decoupled into the initial phase of inserting the asteroid into a stable invariant manifold, they said, and then provide the maneuvers required to continue the transit into the Earth system.

The Strathclyde team searched through a database of about 9,000 NEOs for candidates and they found 12 that could be retrieved by changing velocity by less than 500 meters per second.

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The authors said that the approach they would use for retrieval may also serve as a robust search and ranking methodology for future retrieval candidates that can be automatically applied to the growing survey of

NEOs. "The possibility of capturing a small NEO or a segment from a larger object would be of great scientific and technological interest in the coming decades," they stated. "It is a logical stepping stone towards more ambitious scenarios of asteroid exploration and exploitation, and possibly the easiest feasible attempt for humans to modify the Solar System environment."

As *MIT Technology Review* pointed out in discussing their findings, "None of the 12 ERO asteroids are new to astronomers; in fact one of them became briefly famous when it was found to be temporarily orbiting the Earth until 2007. But until now nobody had realized just how easily these bodies could be captured."

The authors of the article stated that "The paper presents a list of 12 EROs, with a total of 25 trajectories to periodic orbits near L2 and 6 near L1 below a cost of 500 m/s, and the number of these objects is expected to grow considerably in the coming years."

**More information:** Easily Retrievable Objects among the NEO Population, arXiv:1304.5082 [math.DS] arxiv.org/abs/1304.5082

**Abstract**
Asteroids and comets are of strategic importance for science in an effort to understand the formation, evolution and composition of the Solar System. Near-Earth Objects (NEOs) are of particular interest because of their accessibility from Earth, but also because of their speculated wealth of material resources. The exploitation of these resources has long been discussed as a means to lower the cost of future space endeavours. In this paper, we consider the currently known NEO population and define a family of so-called Easily Retrievable Objects (EROs), objects that can be transported from accessible heliocentric orbits into the Earth's neighbourhood at affordable costs. The asteroid retrieval transfers are sought from the continuum of low energy transfers enabled by the

dynamics of invariant manifolds; specifically, the retrieval transfers target planar, vertical Lyapunov and halo orbit families associated with the collinear equilibrium points of the Sun-Earth Circular Restricted Three Body problem. The judicious use of these dynamical features provides the best opportunity to find extremely low energy Earth transfers for asteroid material. A catalogue of asteroid retrieval candidates is then presented. Despite the highly incomplete census of very small asteroids, the ERO catalogue can already be populated with 12 different objects retrievable with less than 500 m/s of {Delta}v. Moreover, the approach proposed represents a robust search and ranking methodology for future retrieval candidates that can be automatically applied to the growing survey of NEOs.

via Arxiv Blog