

Interstellar Interceptors

Mission design for rendezvous with objects in hyperbolic orbits

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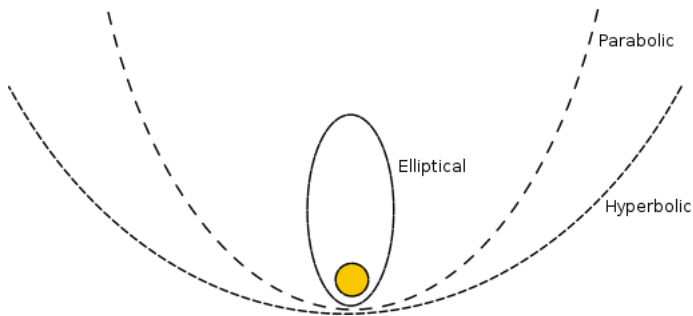
Universidad Internacional de Valencia

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What are interstellar objects?

Definition

Interstellar objects (ISOs) are asteroids, comets or planetary bodies moving through interstellar medium (ISM) without being gravitationally bound to a star.



ISOs follow hyperbolic orbits

Why are interstellar objects important?

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- Better understanding the formation of planetary systems
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- Technological motivation

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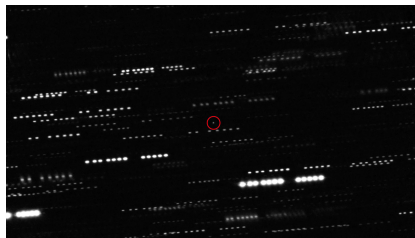
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Motivation of this work

Devise orbits for rendezvous with ISOs to study their physical properties.

Discovered interstellar objects

There are two confirmed ISOs to this day:



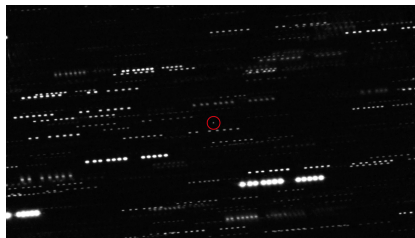
1I/'Oumuamua



2I/Borisov

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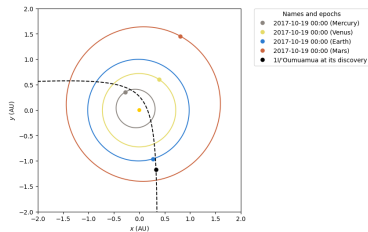


2I/Borisov

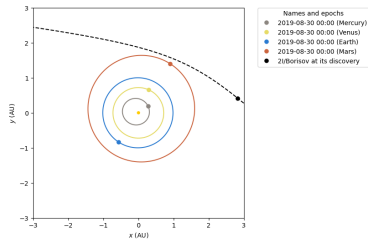
These interlopers present the following orbit attributes:

- Hyperbolic orbits
- High relative velocity
- High inclination w.r.t. the ecliptic plane
- Discovered close to the direction of the Solar Apex

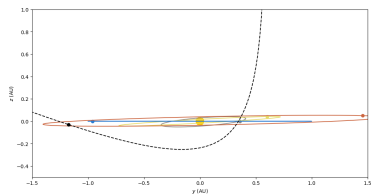
Orbits of 1I/'Oumuamua and 2I/Borisov



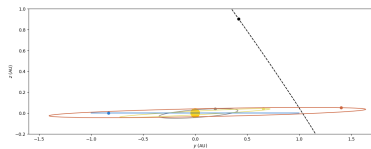
1I/'Oumuamua orbit top view



2I/Borisov orbit top view



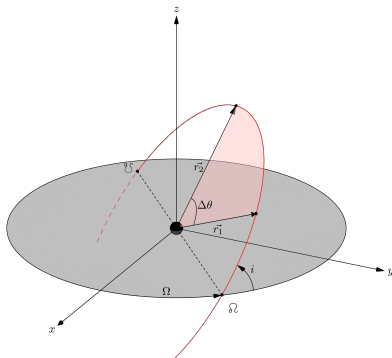
1I/'Oumuamua orbit side view



2I/Borisov orbit side view

Navigating through space: the Lambert's problem

Lambert's problem is the Boundary Value Problem (BVP) in the context of the restricted two-body problem dynamics.

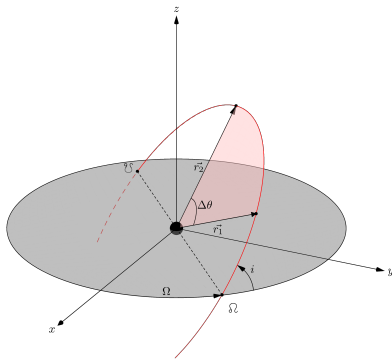


$$\ddot{\vec{r}} = -\frac{\mu}{r^3}\vec{r} \quad \left\{ \begin{array}{l} \vec{r}(t_1) = \vec{r}_1 \\ \vec{r}(t_2) = \vec{r}_2 \end{array} \right.$$

Geometry of the Lambert's problem

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Solve for the orbit which passes through \vec{r}_1 and \vec{r}_2 over a finite amount of time $\Delta t = t_2 - t_1$.