Orbit Determination of Mars-Crossing Asteroid 699 Hela

Orbital Integration Project

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Background

Asteroid 699 Hela (A910 LC)

- Mars-Crossing
- Radius $\sim$ 17km
- $H = 11.2$

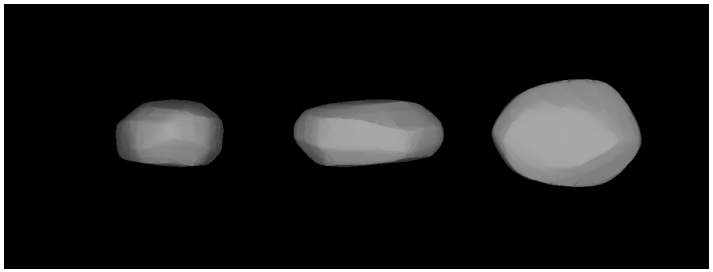


Figure 1: Cool Rock

Orbital Element	Symbol	Calculated Value
Semi-Major Axis	a	$2.61 \pm 0.12\mathrm{AU}$
Eccentricity	e	0.410 ± 0.027
Inclination	i	$15.29 \pm 0.19^\circ$
Longitude of Ascending Node	Ω	$242.50 \pm 0.12^\circ$
Argument of Perihelion	ω	$91.4 \pm 2.2^\circ$
Mean Anomaly	M	$321.1 \pm 4.1^\circ$

Table 1: Calculated orbital elements for asteroid 699 Hela at Julian Date 2460500.68896.

Perturbation Details

Orbital Element Perturbation

To create our clones, we sample new orbital elements from the calculated ones following $x' \sim \mathcal{N}(x, \delta x), x \in \{a, e, i, \Omega, \omega, M\}$.

- We create 55 clones with this method.
- We propagate these clones' orbits 50Myr into the future with REBOUND numerical integration.
- Fig. 2 displays the initial orbits.

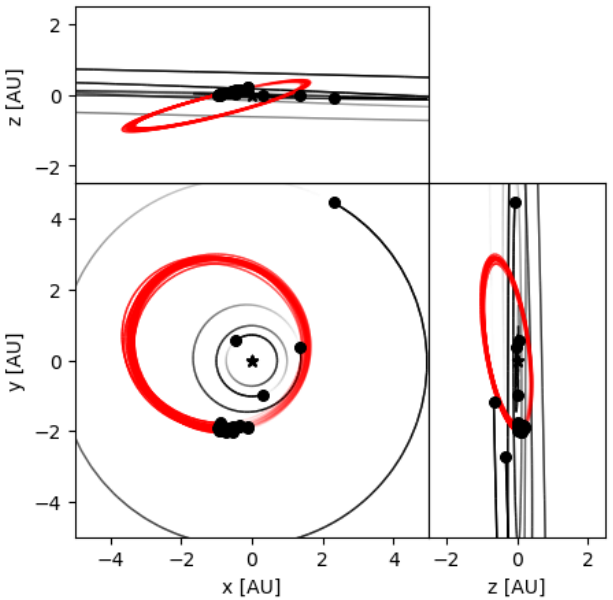


Figure 2: Initial perturbed orbits.

Fates

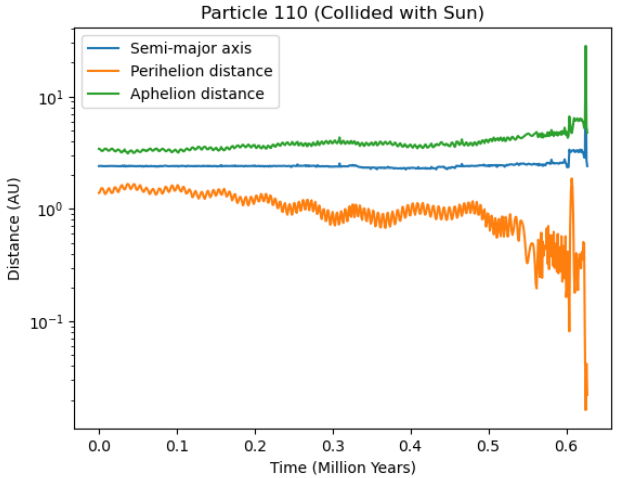
50Myr Orbit Propagation Results:

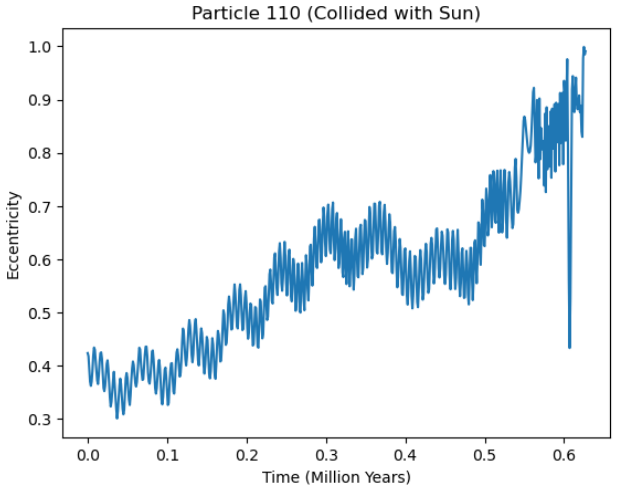
- Probably not very dangerous
- Aggregate results displayed in Table. 2

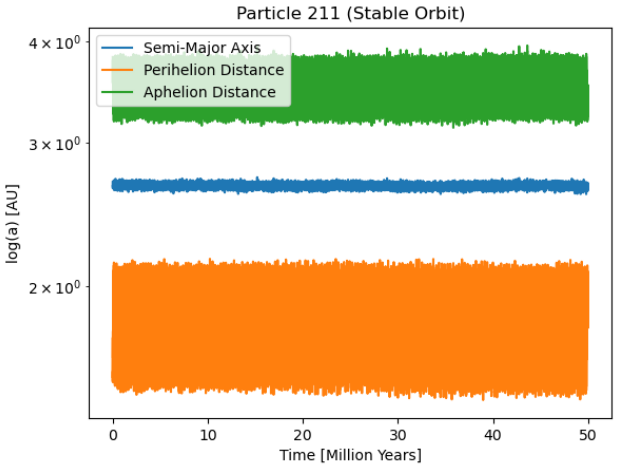
Class	Number	Probability
Still Orbit Sun	45	81.82%
Left Solar System	9	16.36%
Collided with Sun	1	1.818%
Total	55	100%

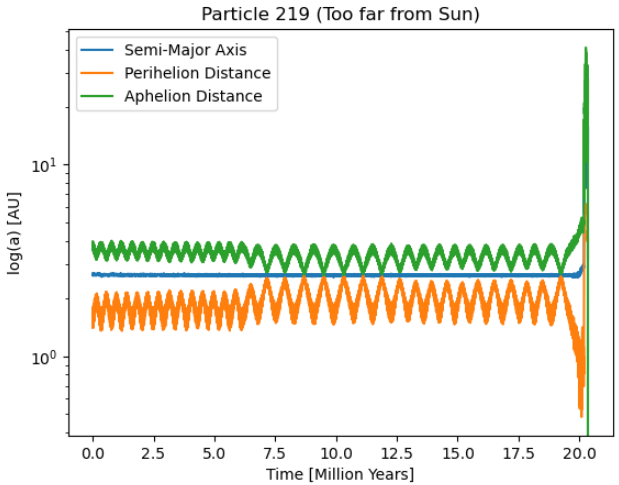
Table 2: Fates of 55 test particles after 50Myr.

Graphs and Stuff

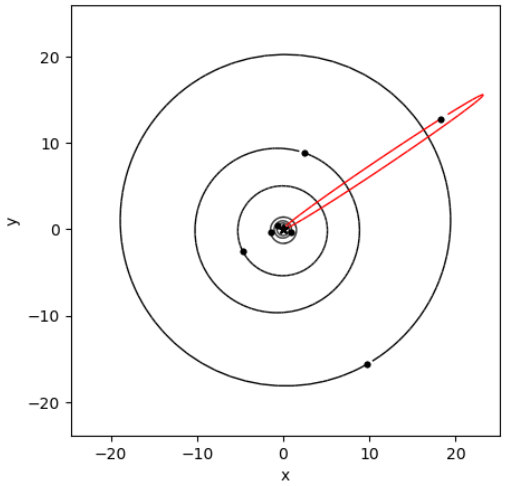


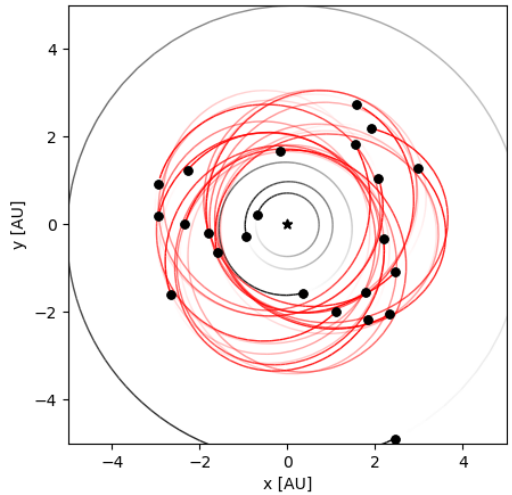


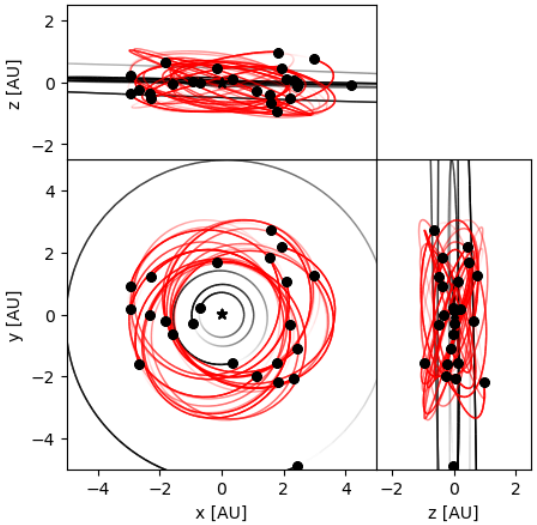


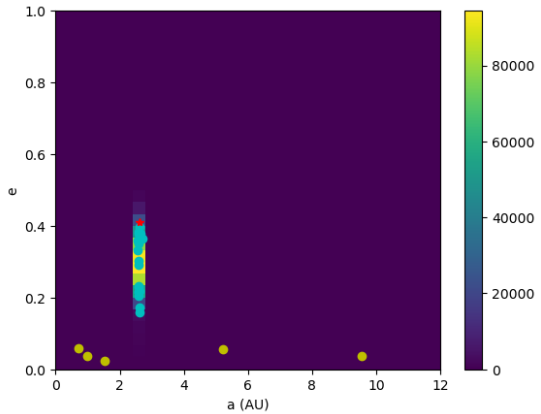


Graphs and Stuff 2









Analysis

- Most likely fate is a stable orbit
- Slight chance of leaving orbit or collision with the sun
- Differences in runs can be caused by experimentation with different uncertainties (Lyapunov time of asteroid is probably on the order of 10^4yrs, which is $<<$ 50Myr)
- No hit earth :)

Figure 3: 699 Hela after a long time colorized