Determining Long Term Behavior of Asteroid 2007 KN4 Via Numerical Integration Techniques

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Introduction

Predicting the behavior of Near-Earth Asteroids is important to determine the possibilities of Earth-asteroid collisions and allow for preparations in such cases.

In order to track the orbit of Asteroid 355256 (2007 KN4) and subsequently model its probable behavior over the next fifty million years, the Method of Gauss was primarily utilized after extracting positional data from captured images.

Methodology

- A Celestron C-14 with CCD telescope imaged the asteroid over the course of six weeks.

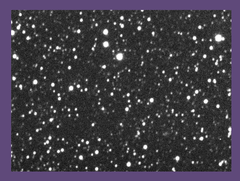

Fig. 1. Raw astronomical image of 2007 KN4 captured by the Celestron C-14 at Etscorn Observatory.

- The Method of Gauss determined the orbit of the asteroid by calculating the six orbital elements, as well as the position and velocity vectors, using data extracted from images taken during three observations.
- Monte Carlo, a numerical integration technique executed to improve the accuracy of the data, randomly samples the errors in data to create a normal distribution of possible position and velocity vectors.
- A Numerical Integration Program from the Solar System Exploration Research Virtual Institute (SSERVI) simulated the long-term behavior of 994 asteroid particles.

Results

The orbital elements calculated for 2007 KN4 based on the Method of Gauss are:

- Semi-major axis (a) = 3.307 AU
- Eccentricity (e) = 0.627
- Orbital Inclination (i) = 12.686o
- Angle of Ascending Node (Ω) = 232.669°
- Argument of Periapsis (ω)= 50.629°
- Mean Anomaly (M) = 0.619° (Precessed to July 21 6:00 UT 2019)

The 99.9% Confidence Intervals generated by the SSERVI's Numerical Integration Program give the probabilities for future of 994 test particles of 2007 KN4 in 50 million years:

- Probability of Leaving Solar System: 0.742 ±0.046
- Probability of Colliding With the Sun: 0.238 ±0.044
- Probability of Colliding With Jupiter: 0.0121 ± 0.0035
- Probability of Colliding With Venus: 0.001± 0.001
- Probability of Remaining in Solar System: 0.0060± 0.0025

Based on the confidence intervals, Asteroid 2007 KN4 is most likely going to be ejected from the solar system within the next fifty million years.

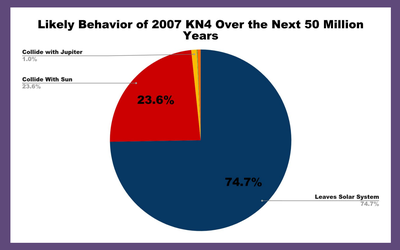

Fig. 2. Predicted behavior distribution of 2007 KN4 over the next 5o million years based off of the confidence intervals constructed from the Method of Gauss.

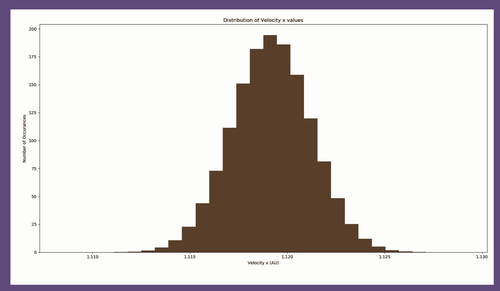

Fig. 3. The normal distribution of the *x*-component of the velocity vector for Asteroid 2007 KN4 generated from the Monte Carlo method.

Conclusion

After observing Asteroid 355256 (2007 KN4), a normal distribution of its orbital elements was determined through the Method of Gauss coupled with the Monte Carlo Method. The calculated orbital elements classified it as an Amor asteroid, which crosses Mars' orbit in close proximity to that of Earth.

By numerically integrating the data through a SSERVI program, the most likely behavior of this asteroid over the next 50 million years was determined to be ejected out of the solar system, with little probability of a collision with Earth.

Future Work

- Improve the quality of the images and data through more accurate telescopes and data processing methods.
- Increase the number of asteroids that can be processed by automating numerical integration programs.
- Employ Method of Laplace as an alternative to Method of Gauss to compare accuracy of results.

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