Orbital Dynamics of Hypothetical Exomoons around HD 100777b

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Motivation

- Total number of confirmed exoplanets : **4144** as of April 2, 2020. **But no exomoons yet!**
- Only one candidate currently, Kepler 1625b-I (Teachey & Kipping 2018) around a Jupiter mass planet around Sun-like star.
- Cyclotron radio emission, photometric transit timing are promising methods for their discovery, but still to achieve required precision.
- The orbital stability of such exomoon candidates can be predicted with computational simulations.

Setup

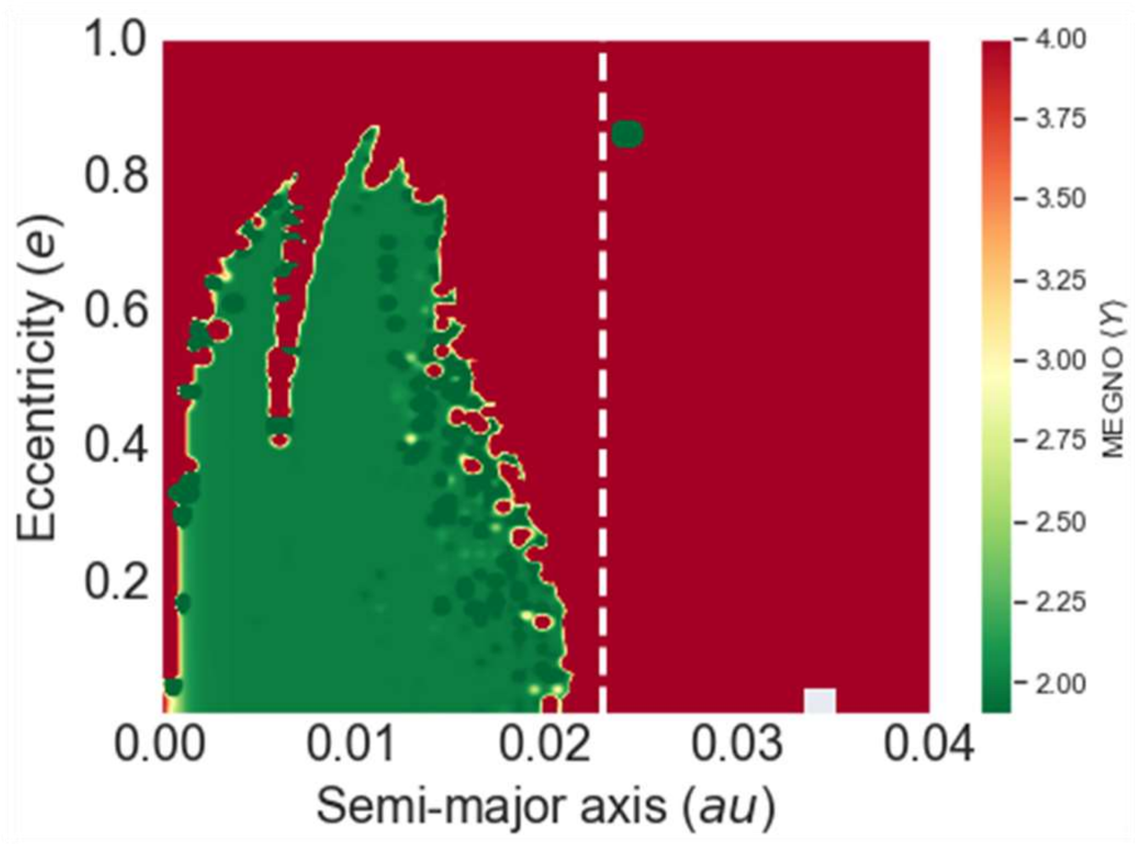
- This project studied the orbital dynamics of a hypothetical exomoon of 1 Earth-mass(M_E) placed around **HD 100777b (Laligurans) .**
- The Jupiter mass planet orbits a Sun-like star **HD 100777 (Sagarmatha)**.
- The orbital integrations were performed with the suite of N-body integrators provided in **REBOUND** python library.
- The specific integrator used for results below is IAS15. [a]

[a] Rein,H. et al. 2015, MNRAS,446 1424–1437

Chaos in Orbits

- Mean Exponential Growth of Nearby Orbits (MEGNO) criterion helps us predict the dynamical stability of the exomoon.
- MEGNO determines the chaos present for the certain orbital configuration.[b]

[b] Goździewski, K. et al. 2001, A&A, 378 2



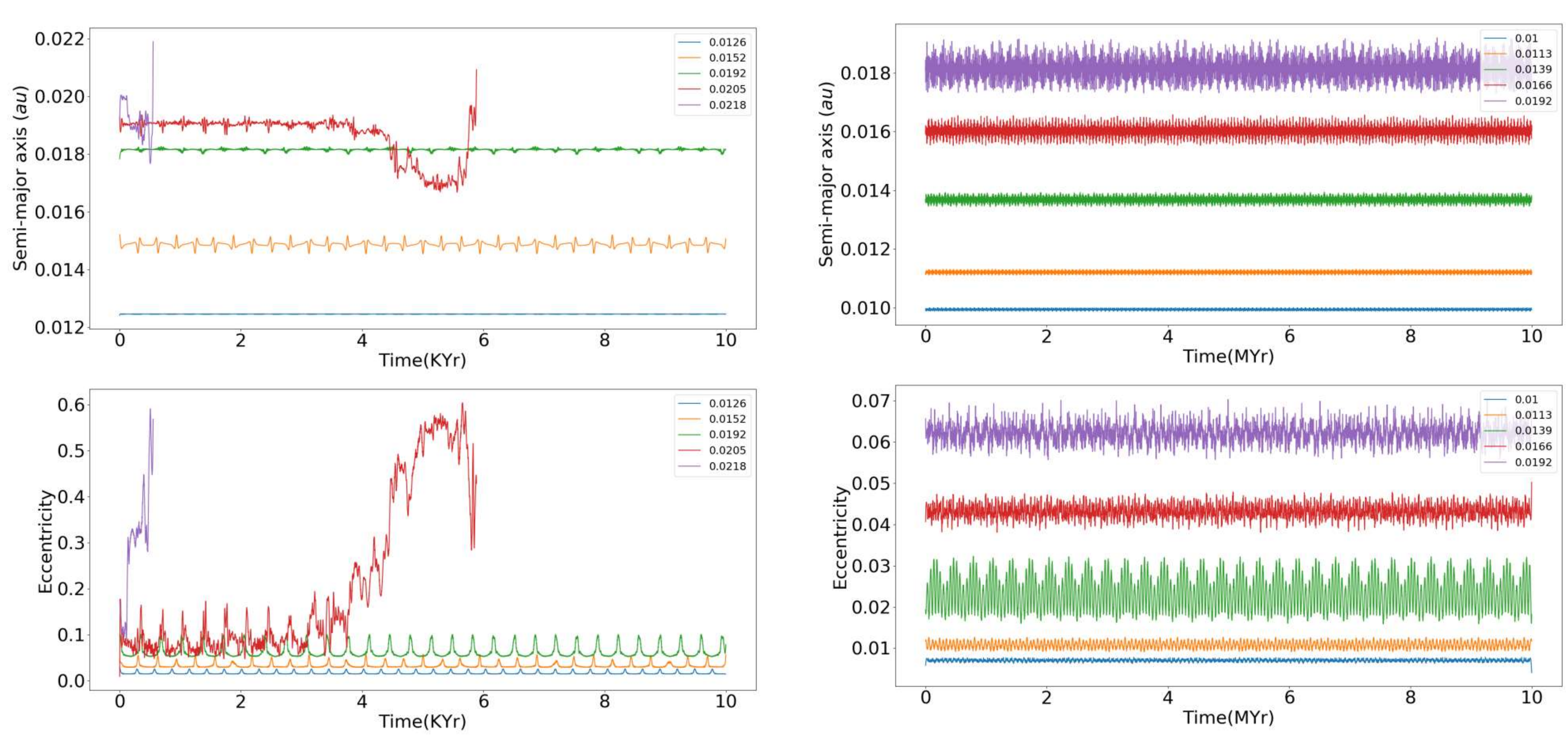
Dotted line represents the Hill's radius of planet
Roche limit for the moon is 0.001 au

- MEGNO value calculations were done over a 100x100 grid for an integration period of 10,000 years.
- The lower MEGNO value represents greater stability.
- A MEGNO value of two implies quasi-periodicity while values near and greater than 4 imply chaos. [c]

[c] Satyal, S. et al. 2013, MNRAS, 433 3

Orbital Evolution of moon

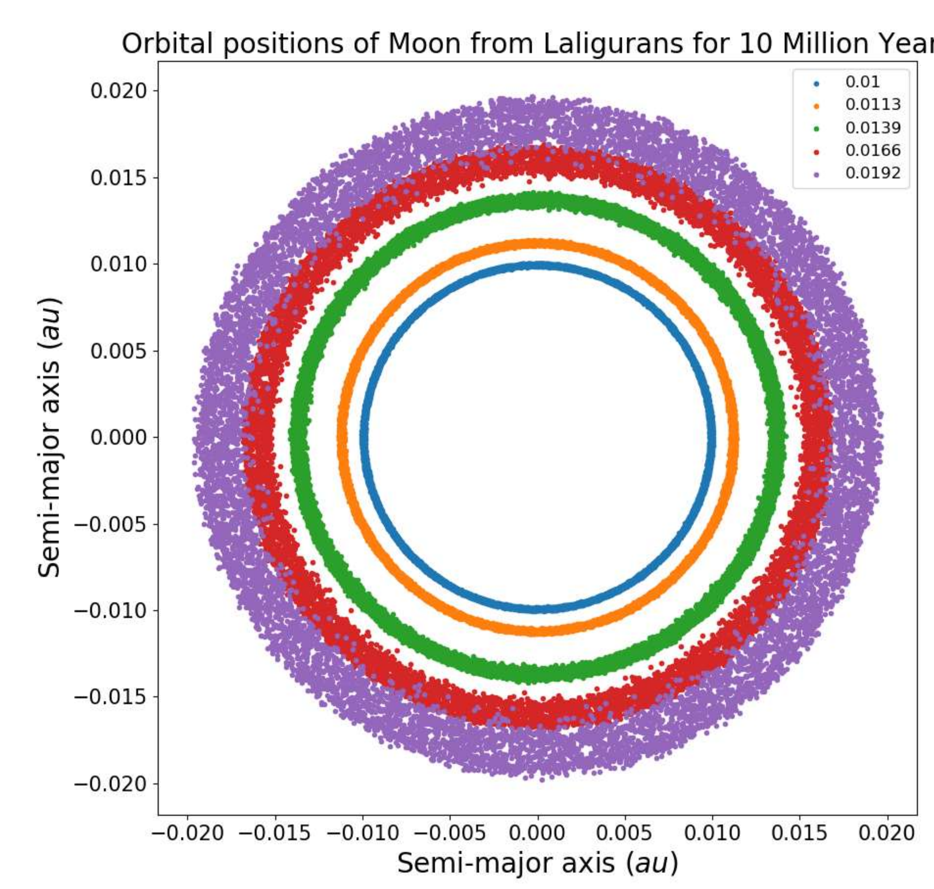
- Points were taken within the chaotic (red) and quasiperiodic (green) regions. Direct orbital simulations were performed to generate time series plots.
- Results for stability and instability(ejection/collision) are in line with predictions by MEGNO .



- Time series of semi-major axis and eccentricity of moon show stable orbits within the green region for the full 10 Million years.
- Ejections have been shown in red region within 10,000 years.
- Chaotic behavior starts from 0.021 au onwards which is near the Hill's radius of planet.

Moon Orbits

Two-dimensional plots of moon orbits provide further confirmation.



Future Work

- Exploration of Kirkwood-like gaps encroaching green region near eccentricities of 0.4.
- Exploring the same for a satellite resembling Earth's moon.

Acknowledgements

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References: REBOUND documentation: https://rebound.readthedocs.io/en/latest/
Murray and Dermott. Solar System Dynamics.CUP,2000 Rein, H. et al. 2012, A&A, 537 A128
Naming of HD 100777 system: http://www.nameexoworlds.iau.org/nepal