Dimensionality reduction algorithms can find **conserved quantities** and transforms to action angle coordinates.

Using classical machine learning to find transforms to action ange coordinates finds new conserves quantities and models chaos.

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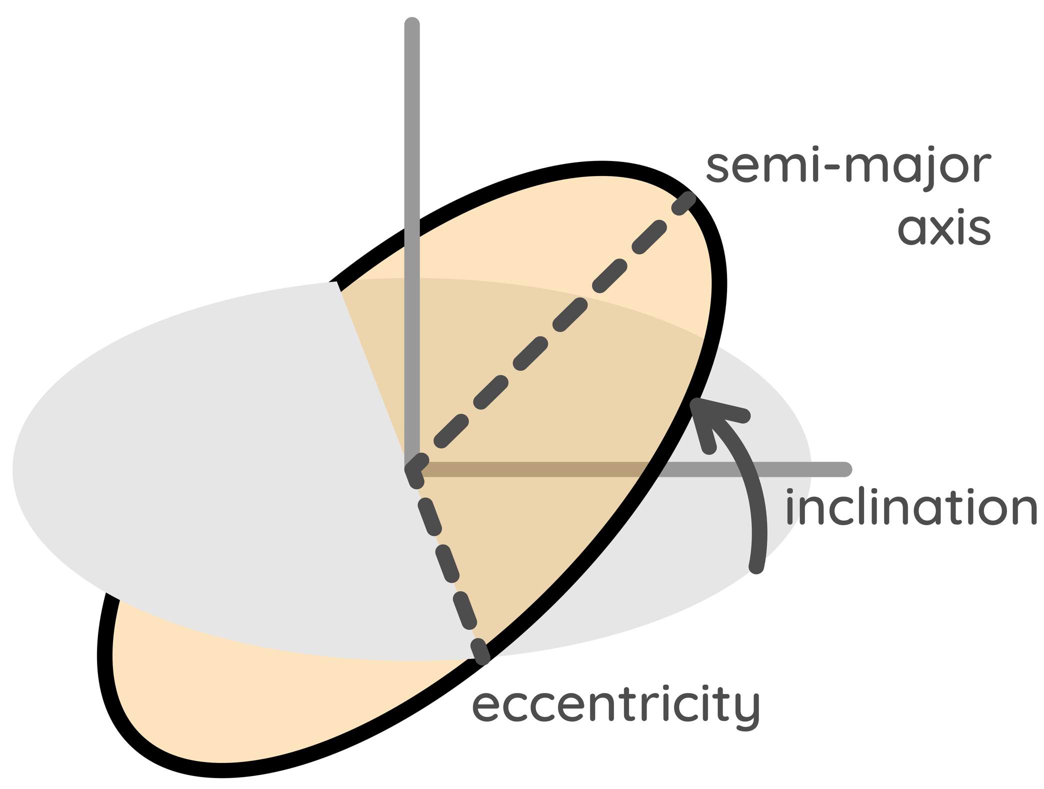
Introduction

Orbital Elements can be used to describe the motion of a celestial body.



But, they vary slowly over millions of years.

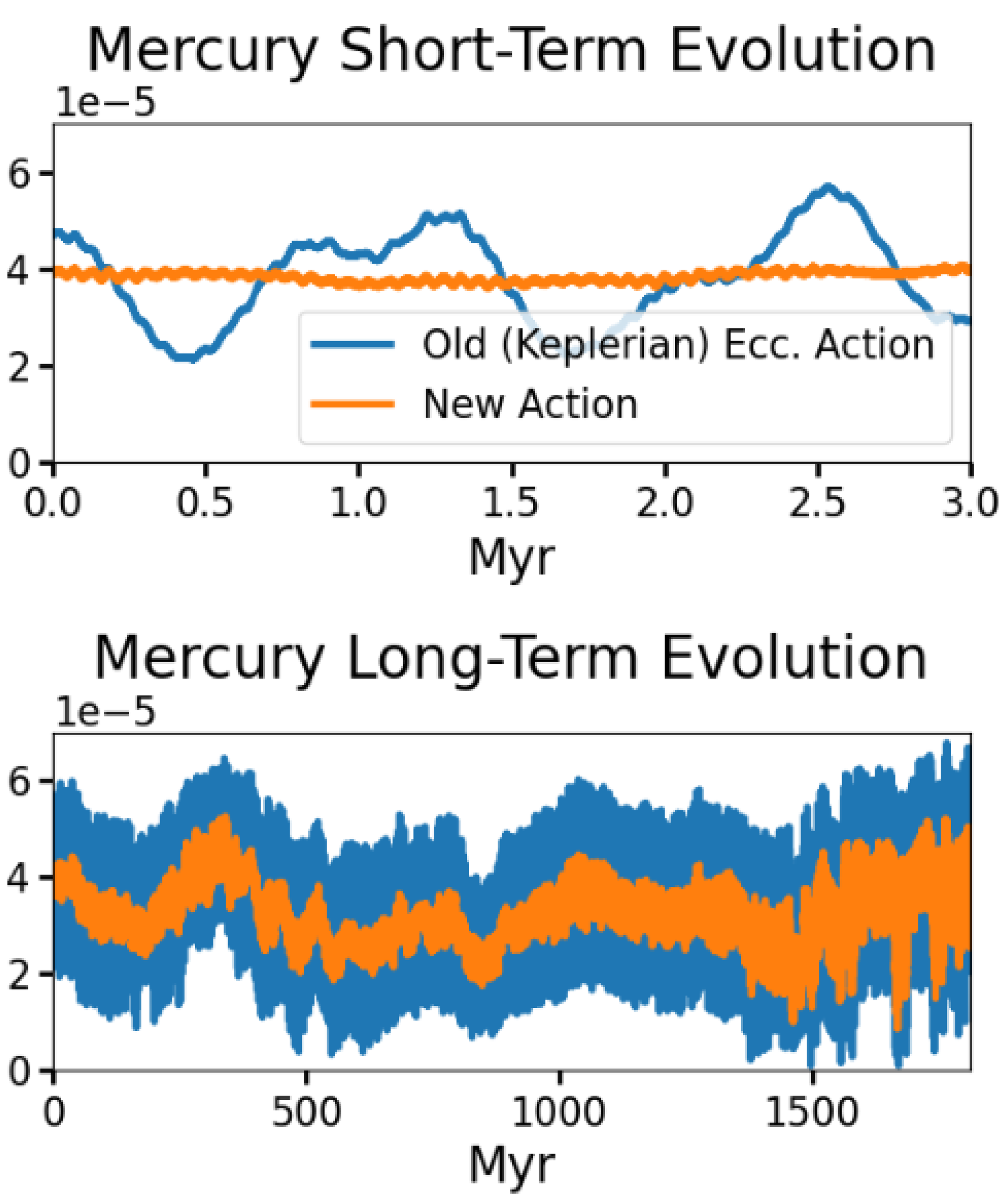
If we find combinations of elements that are conserved over time (like energy), those tell us about chaos in the system.

Methods

Building off of existing work [1], use a multi-step transformation:

1. Rotation Matrix (strong -> weak coupling)
2. Eliminate resonant frequencies
3. Linear projection onto dimsions with least variance
4. Nonlinear transformation...

Results



Blue: time varying orbital elements
Orange: optimized transformation

Long term changes to transformed coordinate describe chaos

Discussion

Next we are investigating non-linear transformation learning, by modifying existing dimensionality reduction algorithms (LLE, tSNE, UMAP) to project on manifolds that minimize rather than maximize variance.

[1] Mogavero, F., Hoang, N.H., & Laskar, J. (2023). Timescales of Chaos in the Inner Solar System: Lyapunov Spectrum and Quasi-integrals of Motion. Physical Review X.

POEL Lab

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