**Discussing Results of "Solar and planetary destabilization of the Earth-Moon triangular Lagrangian points" by Jack J. Lissauer and John E. Chambers**

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Lissauer and Chambers' paper describes simulations performed to identify the lifetimes of massless "test" particles orbiting the triangular (L4 and L5) Lagrangian points of the Earth-Moon system, using 4-body simulations of the Earth-Moon-Sun system and simulations including effects from the Moon, Sun, and all 8 planets.

While "trojans" have been found orbiting these points in other 3-body systems, none have been observed at the Earth-Moon triangular points. The authors found that, for a variety of initial conditions near the L4 and L5 points, particles could survive for the entire length of billion-year long simulations when only the Earth-Moon-Sun effects were modeled. However, when all 8 planets were included in the simulation, particle lifetimes did not exceed roughly 3 million years.

The authors identified three possible explanations for the destabilizing effect of the planets. The first was that the periodically higher eccentricity of the Earth's orbit (caused by planetary perturbations) caused the Lagrangian points to be unstable. However, even with simulations using a high orbital eccentricity for Earth, particles were able to survive for longer than 100 million years. The second explanation was that *increasing* eccentricity destabilizes the Lagrangian points, which was hypothesized based on observations that more particles seemed to be lost when Earth's eccentricity was varying upward. Simulations found that constantly artificially increasing the Earth's eccentricity could shorten the particle lifetimes to only 830,000 years. Based on this, the authors conclude that the planetary effect of periodically increasing Earth's eccentricity is the most likely root explanation for the short lifespan of the particles in the simulations (and also for the lack of objects found by astronomers). However, they do not indicate whether any tests were done to analyze the third possible explanation: that direct planetary disturbances could have a resonance effect that destabilizes these points.

The Sun-Moon-planetary numerical simulations were performed using the RADAU integration algorithm. I will attempt to reproduce the results of this "moderately efficient, highly accurate, high-order integrator" (for a miniscule subset of test cases) using a different simulation. I will explore setting up the 4-body (Earth-Moon-Sun) case and the full planetary case using FreeFlyer or possibly the HNBody integration package.

The authors point out that the exact "triangular points are not necessarily the locations of the most stable orbits," due to effects like Earth's orbital eccentricity. They provide the initial epoch and a table of initial conditions that were used and indicate which phase spaces had the longest lifetimes; I will use these initial conditions in my simulation attempts as well.

An interesting follow-up analysis would be to determine whether artificially increasing Jupiter's orbital eccentricity causes a similar destabilizing effect on its trojan population.

**References**

Lissauer, J.J., Chambers, J.E., 2007. Solar and planetary destabilization of the Earth-Moon triangular Lagrangian points. Icarus, Volume 195, Issue 1, p. 16-27.
http://www.ai-solutions.com/freeflyer/
http://janus.astro.umd.edu/HNBody/