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The structure of the co-orbital stable regions as a function of the mass ratio

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In the past years, astronomers have discovered many non-planetary structures in extrasolar systems such as a comet (Kiefer et al. 2014), an asteroid belt (Moro-Martín et al. 2008), an exoplanetary ring (Kenworthy & Mamajek 2015), and more recently the formation of an exomoon (Isella et al. 2019). But, although the search for exotrojans has not had success so far (e.g. Lillo-Box, J. et al. 2018), they must be as common as they are in the Solar System.

Co-orbital systems were widely studied, and there are several works on stability and the formation of these structures. However, for the size and location of the stable regions, authors usually describe their results but do not provide a way to find them without numerical simulations and, in most works, the mass ratio value range is small. In the current work, we aimed to study the structure of co-orbital stable regions for a wide range of mass ratio systems and built empirical equations to describe them. It allows estimating the size and location of co-orbital stable regions from a few system's parameters.

In our recently published work (Liberato & Winter 2020), we have distributed thousands of massless particles in the co-orbital region of a massive secondary body adopting the planar circular restricted three-body problem. Using the N-body integrator Mercury (Chambers 1999) with the Bulirsh-Stoer integrator, we performed numerical simulations for a wide range of mass ratios (μ) for $7\text{x}10^5$ orbital periods of the secondary body.

We divided the results into two groups, the horseshoe and tadpole stable regions. We found that the horseshoe regions upper limit is between $9.539 \times 10^{-4} < \mu < 1.192 \times 10^{-3}$, which correspond to a minimum angular distance from the secondary to the separatrix between 27.239° and 27.802°. We also found that the limit to exist stability in the co-orbital region is about $\mu = 2.3313 \times 10^{-2}$. That value is much smaller than the predicted by the linear theory, but we haven't studied the stability for mass ratio values greater than 2.785×10^{-2}. We have fitted polynomial functions to our results to describe the stable region parameters to represent estimates of the maximum angular and radial widths of the co-orbital stable regions for any system with $9.547 \times 10^{-5} \leq \mu \leq 2.331 \times 10^{-2}$.

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