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THE EVECTION RESONANCE: SOLAR AND OBLATENESS PERTURBATIONS

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Abstract. Among resonances commonly influential to the dynamics of satellites, the evection resonance introduces an important correction to the precession frequency of the satellite, as it is well known for the Moon's problem. However, the dynamic of the resonance itself, which is important for satellites stability and capture topics, including its libration and circulation regions, and its elliptic and hyperbolic points, has not been extensively studied. Here we investigate its dynamic with an improved analytic model, making comparisons with previous works, and resort to numerical methods and integrations to study and localize the different features of the resonance. This resonance is found in the outer orbital region near the orbital stability limit. However we also study and localize an other libration region that can be found much more closer to the parent planet when its oblateness is taken into account in the model.

Keywords: celestial mechanics, planets and satellites: general

1 Introduction

The dynamics of the evection resonance $\alpha = \lambda' - \varpi$ (λ' being the longitude of the perturbing body and ϖ being the longitude of pericenter of the satellite) has been studied using an expansion of the solar disturbing function for the first time by Yokoyama et al. (2008). Their results detailled the shape of the resonance for the prograde and retrograde cases, and the apparition in semi-major axis of its elliptic and hyperbolic points.

However, numerical simulations show that resonant orbits can be found closer to the planet and seem to follow different dynamics that the ones predicted by the analytical model. We have thus extended the model of Yokoyama et al. (2008) to upper orders and use a numerical method to precisely determine the dynamics of the resonance (Frouard et al. 2010). In addition, we found that the resonance can be found closer to the planet by taking into account its oblateness.

2 Solar perturbations

We show in Fig.1 the dynamical portrait of the resonance applied to a prograde satellite of Jupiter using the analytical model. This model is developed in Legendre polynomials ; the upper panels of the figure show the dynamics as given by the 2^{nd} polynomial (Yokoyama et al. 2008), while the bottom panels show the modification due to the inclusion of the 3^{nd} polynomial. This term has an important impact on the dynamics and makes the resonance assymetric. This dynamic is closer to the real one but is displaced in semi-major axis. The real locations of the elliptic and hyperbolic points of the resonance as given by the numerical method are shown on Fig.2 (left).

3 Oblateness of the parent planet

Resonant orbits can be found closer to the planet when its oblateness (here we use the $J2$ approximation) is taken into account. An example is shown on Fig.2 (right).

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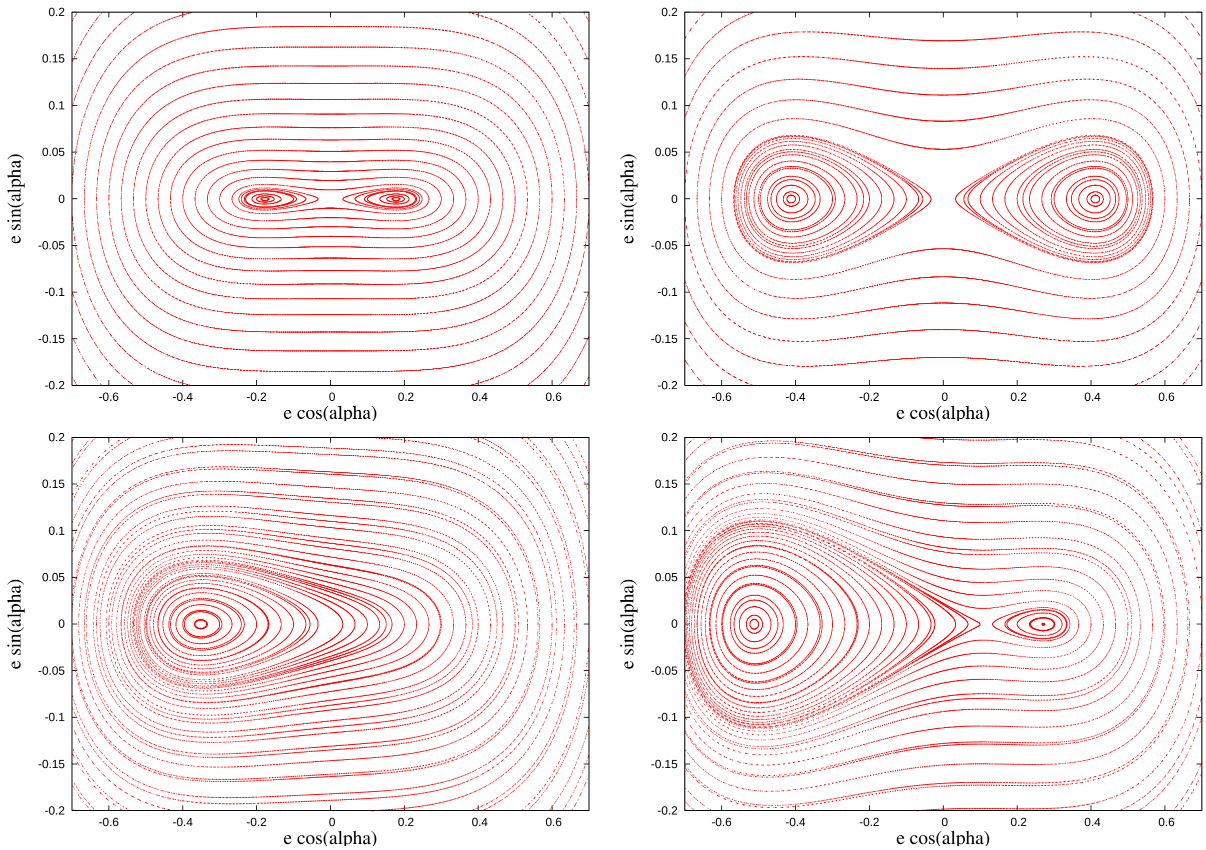

Fig. 1. Analytical averaged model. Dynamics of the evection resonance for a prograde satellite using a model up to the 2^{nd} order polynomial for $a = 0.19$ AU (**top left**) and $a = 0.2$ AU (**top Right**), and up to the 3^{rd} order polynomial for $a = 0.19$ AU (**bottom left**) and $a = 0.2$ AU (**bottom right**).

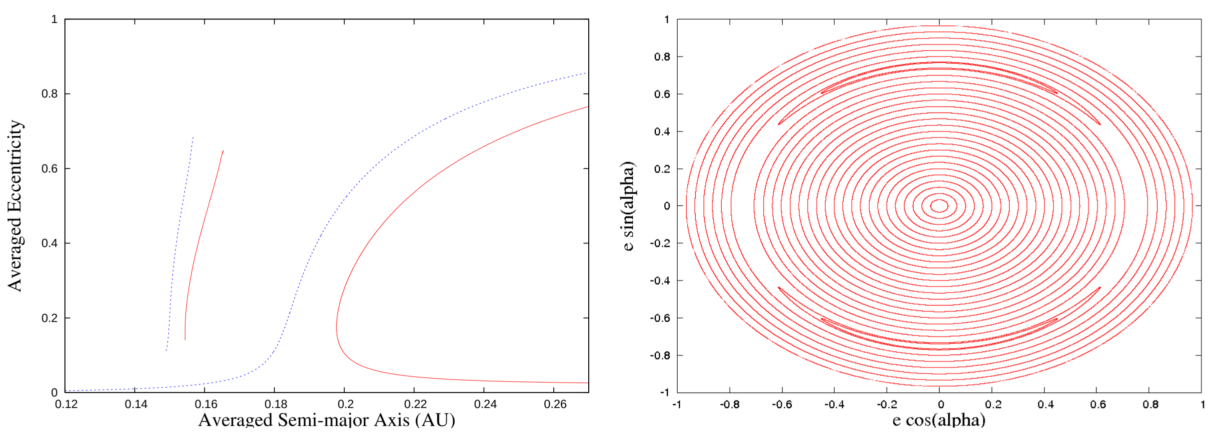

Fig. 2. Left : Location of the evection resonance for prograde satellites with the numerical method (in averaged elements) (the two left curves) and with the analytical model (the two right curves). The island $\alpha = \pi$ is indicated by the dot line, the island $\alpha = 0$ by the solid one. **Right** : Dynamical portrait of the evection resonance for a Jovian satellite with semi-major axis $a = 0.00515$ AU, taking into account the Jupiter's J_2

4 Conclusions

We have investigated the dynamics of the evection resonance and have shown with analytical and numerical methods its location. We also report the presence of the resonance closer to the planet due to its oblateness.

References

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