

Daphnis' Chaotic Orbit

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1 Daphnis' discovery

Cassini has changed our knowledge about Saturn system with its discoveries. One of those is Daphnis, an almost 8 km in size moon, orbiting inside the Keeler gap. Its existence was inferred from the observation of waves in the edge of the gap, and from images taken by Cassini in 2005 the moon was resolved.

2 Orbital motion

After the discovery, image sequences taken at different epochs of Cassini mission were used to derive Daphnis' orbit. Through a preliminary longitudinal analysis based on Cassini astrometry, it was noted that the longitude of Daphnis did not match the expected position when considering a propagation of its initial orbit. Here we aim to improve the astrometric data to follow the satellite orbit in order to better understand Daphnis' movement.

3 Astrometry

We first performed the astrometry of Daphnis based on Cassini's Narrow Angle Camera images, covering the period from 2006 to almost the end of the mission. It was revealed that the satellite actually experienced two changes in semimajor axis during the timespan that Daphnis was observed. Figure 1 shows the residual longitude relative to a circular orbit with the initial semimajor axis. The variation in the expected longitude can be related to changes in semimajor axis: an increase of $\Delta a = 107$ m in 2010 and a drop of $\Delta a = -57$ m in early 2016. These changes are large enough to not be attributed to errors in the orbit determination, therefore the satellite experienced some perturbation that altered its orbit at least twice during the Cassini time.

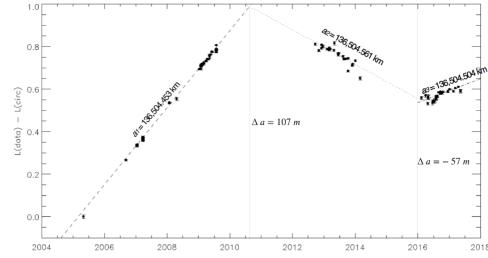


Figure 1: Daphnis residual longitude relative to a circular orbit. The dots are the astrometric data and the lines indicate the expected longitude.

4 Numerical integration

To analyze the orbital evolution of Daphnis, we performed numerical simulations taking into account the gravity field of Saturn (with its gravitational harmonics up to J_6), the perturbation of the nearby satellites Atlas, Prometheus, Pandora and also Mimas. Our results show that Daphnis is in a chaotic orbit due to more than one nearby resonances with the satellites Atlas and Prometheus.

We also compute the Lyapunov indicator to verify the chaotic motion of the moon, and the estimated characteristic time is only few years.

This is a new result about the puzzling motion of Daphnis, contributing to understand why the satellite changed orbit twice since its discovery by Cassini.

Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001 and FAPESP (Proc. 2016/24561-0). The authors also thanks to Hartmann Grant and Cassini Mission for the financial support.