RevMexAA (Serie de Conferencias), **34**, 43–44 (2008)

OBSERVED CHANNELS IN SATURN'S F RING BY THE CASSINI SPACECRAFT AND THEIR RELATIONSHIP TO PROMETHEUS

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RESUMEN

Los anillos planetarios delgados se cree que son estabilizados por pequeñas lunas a las cuales se les llaman pastoras que orbitan dentro o cerca de los anillos y ayudan a estabilizarlos por sus influencias gravitacionales. El anillo F de Saturno (el cual se encuentra justo afuera del sistema principal de anillos) tiene como pastoras a dos lunas. Prometeo (cuyo diámetro mide 100 km) orbita justamente dentro del anillo F, mientras que Pandora (de 85 km en diámetro) se mueve alrededor de Saturno en una órbita justo fuera del anillo F. Las imágenes de la región alrededor del anillo de F captadas por la Sonda espacial Cassini y sus cámaras ISS (Subsistema de Imagen Científica) han revelado una estructura que no ha sido observada en ningún otro anillo planetario. Se han descubierto estructuras periódicas que recuerdan canales azimutales ("canales" de profundidad óptica baja) y "chorros". Nosotros reportamos estas estructuras previamente en Murray et al. (2005). Aquí usamos órbitas recientemente publicadas; la órbita de Prometeo fue tomada de Spitale et al. (2006), la órbita del centro del anillo F de Bosh et al. (2002). Las dimensiones y la masa de Prometeo fueron tomadas de Porco et al. (2006). Nosotros hemos hecho una comparación directa de los resultados numéricos previos reportados por Murray et al. (2005) y nuestro modelo numérico para la misma configuración, y hemos encontrado una excelente concordancia entre ellos.

ABSTRACT

The narrow rings are thought to be stabilised by small shepherd moons that orbit in or near the rings and stabilize them by gravitational influences. The narrow F ring of Saturn which lies just outside the spectacular main rings is tended by two small shepherds. Prometheus (100 km in diameter) orbits just inside the F ring, while Pandora (85 km in diameter) moves around Saturn just outside the F ring. Images from the Saturn F ring region obtained by the Cassini Imaging Science Subsystem (ISS) cameras have revealed structure never seen before in a planetary ring. Periodic structures such as azimuthal gaps, channels of low optical depth and streamers have been discovered. We reported these features previously in Murray et al. (2005). Updated orbits are used here. The orbit of Prometheus has been taken from Spitale et al. (2006), the orbit of the F ring core from Bosh et al. (2002). The dimensions and mass of Prometheus have been taken from Porco et al. (2006). We made a direct comparison between the previous numerical results using the orbits reported in Murray et al. (2005) and our model for the same configuration, and we find an excellent agreement.

Key Words: planets: rings — planets and satellites: formation

1. INTRODUCTION

The azimuthal channels reported for the first time by Porco et al. (2006) have captured the imagination of scientists since they were first discovered by the Cassini's spacecraft ISS in July 2004. They have been explored numerically by Murray et al. (2005) who found an excellent agreement between the the reprojected Cassini's ISS images and their numerical model via a direct comparison. Since then, updated ephemerides have been published for Prometheus (Spitale 2006); these include two years more of Cassini data compared with the ephemerides that we used before (Jacobson & French 2004). Then the question arises of whether using the new ephemerides may change substantially the location and shape of the F ring azimuthal channels.

2. NUMERICAL SIMULATION

The initial conditions for our numerical simulation have been calculated using recently published ephemerides. We used Spitale (2006) for Prometheus and Bosh (2002) for the F ring. Precessing ellipses were assumed in order to evolve the orbits to coincide with JD 2453187.7 (corresponding to July 1st, 2004), which is the Saturn orbital insertion (hereafter SOI)

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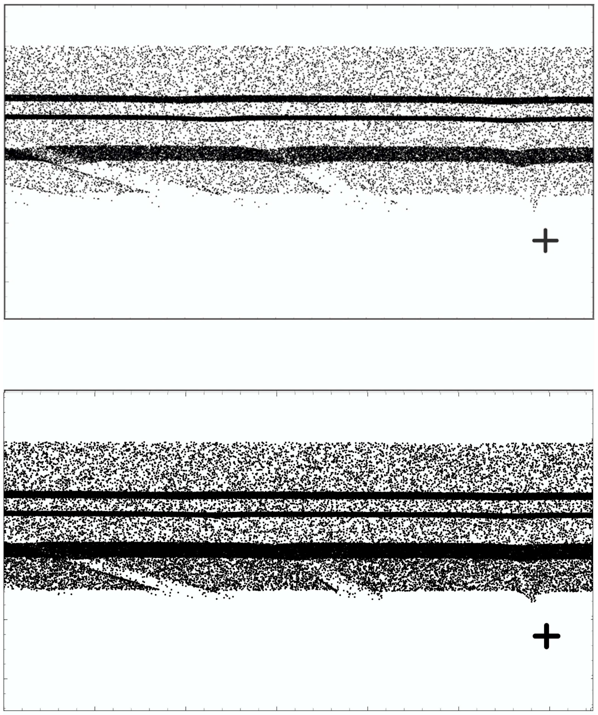

Fig. 1. Comparison between the two numerical models with $M = 285°$. (top) The plot shows the system in the same configuration as the one reported by Murray et al. (2005). (bottom) The plot shows the numerical results obtained for the same configuration as the one above, except that the initial conditions for the Prometheus' mass have been taken from Spitale (2006). In both cases the corresponding numerical model had a mean anomaly of 285°. The cross (+) denotes the position of Prometheus' centre. In each case the longitude range covers 7° and the radial range 1,500 km. A total of 200,000 and 240,000 test particles were included in the plot above and in the plot below, respectively. In this particular configuration, the model predicts a brightening of each channel on the side furthest from Prometheus, that can be clearly appreciate in both plots.

of the Cassini spacecraft. The Prometheus mass is taken from Spitale (2006).

We performed a numerical integration including 240,000 test particles, a massive Prometheus, and Saturn. We integrated the orbits using the Runge-Kutta-Nyström RKN12(10)17M integrator by Brankin et al. (1989). The higher version was used here.The results of the integration for the SOI configuration are shown in Figure 1.

It is possible to notice that there is an excellent agreement between the two numerical integration. This lets us conclude that the updated ephemerides have little effect on the system. It is important to point out that although the location and shape of the channels seems to remain the same, the channels' width has changed.

3. CONCLUSIONS

The numerical integrations performed here show that the new ephemerides have little effect on the general shape and location of the azimuthal channels. This good agreement gives us confidence in our numerical models. It also shows how robust are our models. The width of the channels has changed slightly, and further research is necessary.

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