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Resonant dynamics of close-in small Saturnian satellites and application to Pallene (S XXXIII)

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In this work we explore the orbital vicinity of the small moon Pallene through numerical integrations and phase space mapping. The results reveal that Pallene's orbit is currently located close to mixed inclination-eccentricity type associated with the 19:16 Enceladus-Pallene resonance.

Spitale et al. (2006) suggested that Pallene's orbit is disturbed by a 19:16 resonance with Enceladus with a critical angle given by $\psi_1 = 19\lambda_E - 16\lambda_P - \varpi_P - 2\Omega_P$, where λ represents the mean longitude, ϖ is the pericenter longitude, Ω is the longitude of the node ascending and the subscripts P and E refer to Enceladus and Pallene, respectively.

Muñoz-Gutiérrez et al. (2022) show that ψ_1 and $\psi_2 = 19\lambda_E - 16\lambda_P - \varpi_E - 2\Omega_E$ angles circulate with approximate periods of 3,870 and 9,130 days, respectively, indicating that Pallene's current orbit is not effectively trapped into the 19:16 resonance.

In this work, we mapped Pallene's orbital vicinity using spectral analysis. We constructed a dense grid of initial conditions varying the osculating semi-major axis and the osculating eccentricity of tens of thousands of Pallene clones perturbed by Enceladus. The physical parameters and initial conditions for each satellite were obtained from *Horizons* (https://ssd.jpl.nasa.gov/horizons/) considering the initial date January 1, 2016.

Figure 1(a) represents the dynamical map for 30,000 Pallene clones considering Enceladus as the main perturber. We can observe two vertical structures limited by darker bands (chaotic regions) which represent the domains for the Ψ_1 and Ψ_3 ($\psi_3 = 19\lambda_E - 16\lambda_P - \varpi_P - \Omega_E - \Omega_P$) multiplets associated with the 19:16 resonance. Our mapping shows that the orbit of Pallene (dark star) is close to the Ψ_2 multiplet associated with a type of corotation inclination resonance and a more detailed view of this region can be seen in Figure 1(b).

Figure 2 shows the temporal variation for geometric angles ψ_1, ψ_2, and ψ_3, for several initial conditions (a_0, e_0) of Pallene clones indicated in Figure 1(a) and in the plots (see Figure 2(d-f)).

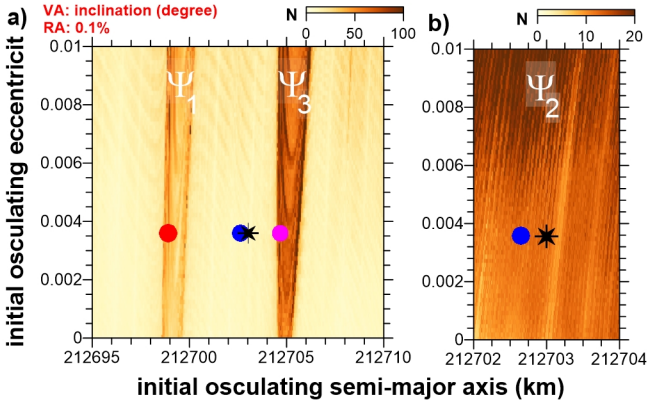

Figure 1. (a) Dynamical map of the Pallene vicinity revealing the 19:16 resonance multiplets. (b) A zoom into the domain of the multiplet Ψ_2.

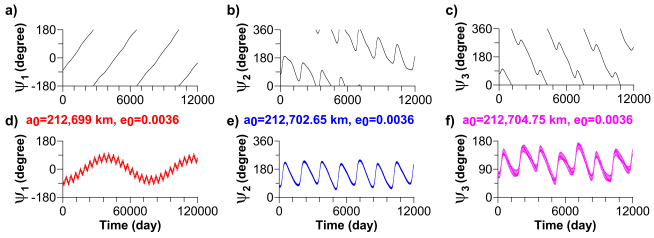

Figure 2. (a-c) **black star**: *Horizons* in the date 01/01/2016; (d) **red disk**: oscillation of ψ_1 around 0°; (e) **blue disk**: oscillation of ψ_2 around 135°; (e) **magenta disk**: oscillation of ψ_3 around 90°.

Conclusions: the current orbit of Pallene is not currently trapped into the 19:16 resonance involving Enceladus, but it is located close to its Ψ_2 multiplet which is located between Ψ_1 and Ψ_3 domains.

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