

The Effects of Neighbouring Planets on the Formation of Circumsolar Resonant Dust Rings in the Inner Solar System

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The presence of a circumsolar ring of dust near the orbit of Venus has first been indicated by photometry data of the Venus-orbit crossing Helios probe. Since then, imagery data from STEREO, as well as in situ dust measurements made by the IKAROS mission have further supported the existence of a circumsolar ring associated with Venus. It has been theorized that the ring is an analogue of the resonant ring of Earth, arising from dust particles being trapped in the planet's external mean-motion resonances (MMRs). Attempts to model this phenomenon as a result of trapping of migrating dust have so far been unable to produce a meaningful density enhancement due to an overall low trapping efficiency of Venus's external MMRs. Recently, Pokorny et al. (2019) have found that only dust stemming from a hypothetical population of Venus co-orbital asteroids can produce enough signal to adequately match the observations. This might indicate a fundamental difference between Earth's resonant ring – dust migrating from the asteroid belt being trapped in external MMRs – and Venus's resonant ring – dust being released directly into a co-orbital resonance. However, the underlying cause for the low trapping probability of Venus's external MMRs remains unclear.

In this work we present an approach to model resonant features associated with the inner planets and specifically look into the dependency of these dust structures on the multi-planet configuration. We conduct a series of simulations for dust of different particle sizes, migrating through the inner solar system. We confirm previous results suggesting that the observed dust enhancement at Venus orbit cannot be caused by trapping in external MMRs. Furthermore, we try to isolate the effects of neighbouring planets on the formation of resonant features by removing individual planets from the simulation. We find that the single most important reason for the absence of Venus's external MMR ring is the perturbing influence of Earth, destabilizing resonating particles or preventing entry into a resonance altogether. The closer distance to the Sun is of minor importance as under the absence of Earth, Venus is able to produce an external MMR ring comparable in strength to the nominal ring of Earth. In the same manner, Venus affects the internal MMRs of Earth, diminishing their displacing effect. On the other hand, we find that Mars is neither capable of trapping significant amounts of dust, nor does it affect the trapping efficiency of Earth due to its low mass. Likewise, Mercury is unable to produce a meaningful enhancement of migrating dust – with or without its neighbour Venus. Finally, we see a minor facilitating effect for specific resonances under the gravitational interaction of Earth and Venus.