



The Curious Case of Neptune's Naiad

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Naiad is the innermost moon of Neptune, orbiting within the synchronous orbit at less than 2 Neptune radii. It was recently shown that Naiad is in a peculiar 73:69 mean motion resonance with Thalassa, Neptune's next innermost moon [1]. Combining Naiad's mass, estimated from its resonant interaction with Thalassa, combined with its size and shape estimated from Voyager 2 images [2], yield a bulk density of $\sim 0.8 \text{ g/cm}^3$, similar in density to other small icy moons.

A closer inspection of Naiad's dynamical and collisional environment leads to some contradictory conclusions. Based on its elongated shape and bulk density, we show that Naiad is likely already within the Roche limit, suggesting it must have significant cohesive strength to hold itself together. This is difficult to reconcile with the idea that Neptune's inner satellites should be weak, reaccumulated icy fragments from Neptune's original satellite system that was destroyed during the capture of Triton [3,4]. We also demonstrate that Naiad may need $\sim \text{Gyrs}$ to reach its present inclination through the current 4th-order resonance with Thalassa. Due to the bombardment of Neptune by scattered disk objects, however, Naiad and Thalassa should both have much shorter collisional lifetimes depending on their collisional strengths and the size-frequency distribution of impactors [5, 6], meaning that this pristine resonance should have been destroyed. We discuss these contradictory ideas, some possible resolutions, and their implications for the Neptune system.

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