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Cupid is Still Doomed: Overlapping Power Laws and the Stability of the Inner Uranian Satellites

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Abstract: We have continued our exploration of the stability of the inner Uranian satellites (French & Showalter 2011, DDA abstract) using simulations based on recent observational data. We find that the moon subsets Cressida/Desdemona/Juliet and Cupid/Belinda/Perdita are unstable in isolation, crossing orbits in 10^6 - 10^7 years. The presence of the other inner moons reduces this time to 10^4 - 10^6 years. The stability of the inner moons is not changed by the presence of the five classical satellites but Perdita, a very small moon, has a surprisingly large effect on the stability of Cupid and Belinda. We extend the power law previously discovered by Duncan & Lissauer (1997, Icarus, 125, 1-12), in which the crossing time of a pair of moons can be predicted using multiple simulations with higher moon masses, to the case of two unstable moon pairs. We use this new formalism to predict the lifetimes of Cupid/Belinda and Cressida/Desdemona using a conservative density assumption, $\rho=0.5 \text{ g/cm}^3$. The inner satellites continue to exhibit instability with crossing times of 10^5 - 10^7 years in this case. Such short crossing times imply the continuing, rapid evolution of the Uranian satellites.

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