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The Rings of Uranus: Shepherded, or Not?

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Abstract

I investigate the hypothesis that small, unseen moons are "shepherding" the main rings of Uranus. The ring edges are expected to be confined at the discrete locations of Lindblad resonances, where the moon's influence produces a wavy edge. For a narrow, optically thick ring, this interaction manifests itself as a periodic variation in the ring's brightness. Under many circumstances, the induced pattern in the ring should be far more detectable than the moon itself. I will re-analyze images from Voyager and the Hubble Space Telescope to seek these patterns, and thereby place new constraints on the population of Uranian shepherd moons.

1. Introduction

The rings of Uranus are widely suspected to be confined by the shepherding effects of small moons. Four resonances have been identified: Ring ε falls between Cordelia's 24:25 outer Lindblad resonance (OLR) and Ophelia's 14:13 inner Lindblad resonance (ILR). Cordelia's 23:22 ILR falls atop ring δ and its 6:5 ILR atop ring γ [1]. Other ring edges are unexplained. In addition, painstaking analysis of occultation data has revealed radial modes operating in two rings: a two-cycle oscillation (m = 2) in ring δ and a "breathing" mode (m = 0) in ring γ [2]. Finally, ring λ comprises a co-rotating pattern of five uniformly-spaced arcs [3]. These patterns remain unexplained.

2. Initial Results

If an optically thick ring varies in width due to a resonant or non-resonant mode, then its radially-integrated reflectivity should show periodic variations travelling at the moon's mean motion. The expected resonant patterns in ring ε, with m = 24 and m = 14, were first noted in Hubble images of the Uranian rings in 2006. In a quick re-analysis of six wide-angle Voyager images, these two patterns are stunningly obvious, and the other known patterns are also easily detected. The initial analysis already suggests the presence of a previously unidentified m = 4 pattern in ring γ, which is superimposed upon the m = 6 pattern driven by Cordelia. This may explain the unusually large residuals always found in orbital fits to the γ ring.

3. Work in Progress

The fine sensitivity raises the possibility that any additional patterns with m-values up to a few hundred should be detectable in the each ring. I will report on the results of a comprehensive analysis of the finest-resolution Voyager images. If shepherding plays a role in the other Uranian rings, then it should be possible to identify the associated resonant patterns, even if the moons themselves are too tiny to have been revealed by Voyager's cameras.

Acknowledgements

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References

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