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An absolute radius scale for Saturn's rings from Cassini RSS, VIMS, and UVIS occultations

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Abstract

The Cassini mission continues to transform our understanding of the dynamics and structure of Saturn's rings, thanks to a rich set of complementary observations from multiple instruments at a variety of wavelengths and over a wide range of viewing geometries [1], [2]. Many of the discoveries have come from the highest resolution Cassini observations of the rings, provided by over a hundred stellar occultation profiles obtained at ultraviolet (UVIS) and near-IR (VIMS) wavelengths and dozens of earth occultations at radio wavelengths by the RSS instrument. By studying these ring features in quantitative detail, we can learn a great deal about their surface mass density and detect a wide variety of weak dynamical effects that shape the rings and their detailed internal structure. Ultimately, we will be able to characterize the internal mass distribution of Saturn itself, since this governs the precession rate of Saturn's rotational axis as well as the apsidal and nodal precession rates of the narrow ringlets, both of which can be determined from precise occultation measurements of the rings. All such investigations require the precise measurement of the locations of ring edges and gaps, their registration onto an accurate absolute radius scale for the rings, and a robust orbit-fitting code to determine the orbital properties of the rings, using individual measurements of ring features in hundreds of occultation profiles. To these ends, we have developed a least-squares fitting code to solve simultaneously for the orbital elements of ring features, corrections to the Cassini spacecraft trajectory, and Saturn's pole direction. We have also determined by least squares profile fitting the precise radial locations of $\sim$100 ring features in each of $\sim$150 Cassini RSS, VIMS, and UVIS occultation profiles, for a total of over 10,000 measurements in all. (For sharp-edged features, the typical measurement uncertainty is less than 100 meters in ring plane radius.) With these results in hand, we have determined an absolute radius scale for the rings, with an estimated accuracy of $\sim$250 m, using an iterative approach in which we identify a set of over 50 or so putative circular, equatorial features, solve for along-track spacecraft trajectory errors for each occultation, and use this best-fitting orbital solution to establish the reference system to register each occultation on an absolute radius scale. We compare these results to the ring radius scale [3] derived from Voyager 1 and 2 occultations and observations of the 28 Sgr stellar occultation in 1989. We also calculate the sensitivity of the radius scale to the assumed pole direction and precession rate.

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