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Multiple Cassini Radio occultations of Saturn's rings during the three years period 2005-2008 have provided a rich resource of information about the ring radial structure and its variability with longitude, as well as on physical properties of Saturn's rings.

Initial measurements of the optical depth profiles are diffraction-limited. Measurements of both the amplitude and phase of the 0.94, 3.6, and 13 cm-wavelength radio signals transmitted by Cassini through the rings and received at the ground stations of the Deep Space Network (DSN) is equivalent to sampling the microwave hologram formed behind the rings, assumed to be locally circularly symmetric and hence one-dimensional. The hologram is digitally reconstructed to remove diffraction effects, improving achievable radial resolution to a small fraction of the Fresnel-scale, determined by the wavelength and the observation geometry.

Recent efforts to refine the reconstruction resolution to its achievable limits (100 to few 100 meters) reveal interesting ring features, including detailed structure of the four gap associated ringlets in Ring C, many waves in Ring C and some in the Cassini Division, as well as two new features previously masked in the radio occultation ring profiles.

The first is a large but local ring gap centered at about 136,475 km, that is, just inside the inner edge of the Keeler gap. The gap is detectable in only one of about 24 optical depth profiles examined so far, hence is in all likelihood azimuthally discontinuous. The detection is at all three wavelengths and is consistent among multiple DSN observing stations. The resolved gap is < 1 km wide and extends azimuthally for at least 10 km (for self-consistency with the observed diffraction behavior).

An ring embedded moonlet of diameter between 250 and 300 m (material density of 0.5 to 0.9 gm/cm^3) could be responsible for opening such a large gap (a "giant propeller"). One needs to be careful, however, since the probability of detecting a giant propeller in one of only 26 radio occultation cuts is small indeed. The reality of detecting this local gap and the implied physical dimensions are unquestionable, however, irrespective of the actual physical mechanism responsible for opening it.

Also revealed in the high-resolution radio occultation profiles is Saturn's F-Ring. It is revealed in only 11 of the 24 Cassini radio occultation profiles examined. The detections are at both 0.94 and 3.6 cm (Ka- and X-band). Only 3 of the 11 are also at 13 cm (S-band). With one exception, the F-Ring profile is almost always a single strand of width about 1-2 km and peak optical depth of no more than a few tenths. Comparison with the single Voyager profile suggests likely large time variability over the past 25 years or so. The Ka-and X-band detection suggests presence of particle sizes larger than about few mm's and extending to at least several cm's within the 1-2 km wide central "core."

The "core" can't be azimuthally continuous given the negative detection in 14 out of the 25 radio cuts. In similar stellar occultations conducted at much shorter wavelengths, the F-Ring core characterization usually refers to a much broader feature few 10's of km's wide. Such feature is not detectable in the Cassini radio occultation profiles implying that particles of sizes smaller than 1 mm primarily populate this broad feature.

The radius and inertial longitude of each of the 11 Cassini radio profiles are used to constrain the parameters of an assumed freely-precessing eccentric and inclined Keplerian ellipse model, yielding close but measurably different results form those of Bosh et al. (Icarus 157, 57-75, 2002). We find it intriguing that the apparently discontinuous F-Ring radio core is still well modeled by a precessing Keplerian orbit.

Although high-resolution optical depth profiles have traditionally provided a rich resource of information for investigating ring kinematics and dynamics, radio occultations provide, in addition, information regarding physical ring properties from observations of the time-sequence of spectra (spectrograms) of the near-forward scattered radio signals. The Keplerian motion of the randomly distributed ring particles spreads the observed scattered signal in Doppler. Contribution of ring features drifting across the footprint of the Cassini high-gain antenna (HGA) can be identified in the measured spectrograms as features drifting in frequency with time at drift-rates that are determined by the observation geometry.

The drift-rate also depends on whether the particles are isotropically distributed within the HGA foorprint (the classical model) or whether they are spatially correlated formations of elongated and azimuthally canted structures (the gravitational wakes model). The latter formations scatter more like cylindrical structures, at least over an angular extent where phase coherence between the scattering particles is nearly maintained. Near-forward cylindrical scattering impacts both the scattering strength and the rate at which the contribution of a given ring feature drifts in the spectrogram. The drift rate depends on the orientation of the canted structure, hence provides a useful diagnostic tool for identification of ring regions where wake structures are present and for inference of their orientations relative to the azimuthal direction (the canting angle).

We compare and contrast results obtained form the spectrogram of over 20 ring features across spanning the full ring system. As expected, features in Ring C consistently drift at the rate implied by the classical model (or by cluster orientations of nearly zero canting angle since the drift-rates for these two cases are indistinguishable). A near-zero canting angle also characterizes the quasi-period small-scale (100-200 m) structure in Rings A and B, likely caused by gravitational overstability (Thomson et al., Geophys. Res. Lett., 34, L242032007, 2009). Multiple features in Ring B show evidence for wake structure with canting angle spread in the approximate range of 10 to 15°, smaller than the 21° usually attributed to wakes in Ring A. Definitive results for Ring A are proving more challenging to achieve because of the lack of features scattering with well identified frequency drift behavior. Remarkably for some occultations, the simultaneous contributions to the spectrogram of the gravitational wakes structure and the overstability structure of several Ring B features can be separately identified.