SUBCENTIMETER-SIZE PARTICLE DISTRIBUTION FUNCTIONS IN PLANETARY RINGS FROM VOYAGER RADIO AND PHOTOPOLARIMETER OCCULTATION DATA

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Analysis of measurements of the scattered and direct components of Voyager 1 radio occultation signals at 3.6- and 13-cm wavelengths yields estimates of the distribution functions of supracentimeter-size particles and thickness of relatively broad (>1000 km wide) regions in Saturn's rings (Tyler at al.,1983; Zebker et al., 1985; Zebker and Tyler, 1984). The amplitude of these signals is mostly unaffected by particles smaller than a wavelength in size, thus the distribution of these particles in the rings cannot be determined by analysis of the amplitude data alone. If, however, measurements of signal amplitude at a shorter wavelength are combined with the previously analyzed data, we can constrain the shape of the distribution functions characterizing the smaller particles. In particular, the additional measurement of amplitude at 0.26 μm wavelength from Voyager photopolarimeter occultation observations (Esposito et al., 1983) allows inference of subcentimeter-size distribution functions for a number of relatively narrow (30-100 km wide) embedded ringlets in Saturn's ring C and the Cassini division. These data are available from the January, 1986 Uranian ring occultation also, and this same technique can be used to estimate corresponding distributions for the Uranian ringlets.

If we consider size distributions of arbitrary form, many solutions are found that are consistent with the three available observations of signal amplitude. In order to limit the formal solution set to functions that are likely on a geophysical basis, we constrain the solutions to be of the power-law form with sharp lower- and upper-size cutoffs. We calculate the best-fit power law (in the least-square-error sense) to the three observations at three wavelengths for several of the embedded Saturn ringlets-- the results are tabulated in Table 1. We note that in each case but two the inferred power law index is approximately 3, which is similar to the power law that describes the distribution of supracentimeter particles in the broad ring features. Thus, it is likely that accumulations of particles in the embedded features are distributed similary to the particles in the rings as a whole, and that the forces responsible for the creation and maintenance of of the embedded features are not highly size-selective in nature.

Mie scattering theory predicts that the measured phase of the radio occultation signal is highly sensitive to particles ranging from 0.1 to 1.0 wavelengths in size, thus additional constraints on the subcentimeter-size distribution functions for both the Saturn and Uranus rings can in principle be derived from radio phase measurements. However, the observed phase and amplitude data from both sets of occultations cannot be reconciled with classical Mie theory. Discrepancies of up to a factor of three are found between predicted and measured values for nearly all physically-likely distribution functions. We have attempted to account for these differences by introducing terms in the Mie equations representing proximity effects of particles (see Zebker et al., 1985) and also for non-sphericity of the particles, however a reasonable match between theory and observation has not been found. We are beginning to investigate new models of scattering by dense particulate media in order to understand the limitations of the Mie approach, and this area of investigation remains as future work.

References:

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Table 1. Saturn Ringlet Distribution Functions

Ringlet location km from Saturn center		Power law index	Lower size cutoff, m	Upper size cutoff, m
Start	Stop			
79230	79260	3.7	0.00316	0.316
84780	84930	2.7	0.00005	0.100
85670	85695	3.6	0.00316	0.178
85930	85970	2.8	0.00032	0.100
86400	86580	2.8	0.00018	0.100
87185	87210	3.0	0.00003	0.178
87300	87325	3.2	0.00178	0.178
87500	87580	3.2	0.00002	3.162
88380	88723	3.1	0.00003	10.00
89800	89930	3.3	0.00178	0.316
90420	90600	2.9	0.00006	10.00