Azimuthal Brightness Asymmetry in Saturn's A and B Rings

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From a long series of Hubble Space Telescope WFPC2 observations of Saturn's rings from 1996-2004, we have obtained precise UBVRI measurements of the reflectivity of the rings (I/F) at high spatial resolution ($\sim$300 km), over the full range of solar phase angles and ring opening angles visible from the Earth. A distinctive feature of these measurements is a pronounced quadrupole brightness variation with ring azimuth, reaching +/- 20% in the central part of the A ring, for moderate ring opening angles. The asymmetry appears to be due to the spontaneous formation of transient gravitational wakes. The amplitude, phase, and shape of the asymmetry vary with illumination and viewing geometry, and from comparisons of the observations with Monte Carlo radiative transfer models of light scattering from N-body simulations of gravitational instabilities, we are able to set strong constraints on the spatial distribution of ring particles within the wake structures. We have used models based on both a monodispersion and a power-law particle-size distribution. Broad particle size distributions tend to suppress the amplitude of the asymmetry. As part of our results, we also estimate the opposition effect associated with ring particle shadowing. Although the asymmetry is strongest in the A ring, where tidal disruption is weakest, there are clear signatures of brightness variations in the B ring as well, away from the densest regions. Finally, the nature of the asymmetry changes at ring radial locations near to strong satellite resonances, probably due to the stirring effects associated with the resonances.