Cassini Imaging Observations of the Jovian Ring

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See also Throop et al 2004, Icarus 172, 59-77

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Cassini ISS Imaging Summary

- 1200 images of main ring
  - No halo or gossamer observations
- Mostly short exposures, < 5s
  - Frames co-added for highest SNR
- Closest approach = 136 R_J at ring plane crossing
- $\lambda = 450 – 950$ nm
- Phase angle 0.5 – 120 deg over 40-day encounter
- Radial profiles in forward-, back-scatter
- Phase, wavelength coverage fills holes in existing observations
- Stray light from Jupiter was significant
Ring Movie

- Movie shows 500 inbound frames, $\alpha=0.5 - 2.5$ deg, $t=2$ sec, clear
- Metis (large) and Adrastea (small)
Azimuthal Asymmetry

- We searched for both near-far and left-right asymmetries
- Maximum asymmetry seen: 20% (1σ) near-far arm during 75 degree sequence
- <5% right-left ansa asymmetry seen during ring plane crossing
- No conclusive evidence for any systematic asymmetry
Azimuthal Features

- We performed comprehensive ‘keplerian deprojection’ to co-add frames and search for clumps in 600 inbound frames.
- No clumps identified of width >10 deg and brightness > 2x average.
- Galileo ‘checkerboard’ features of Ockert-Bell not seen due to lower Cassini resolution.
- Possible azimuthal clumps identified in visual search (at right)
  - Motion is roughly keplerian
  - Detection is marginal
Ring Plane Crossing

- Observed for 30 minutes at lat = -0.02 deg, $\alpha=63$ deg
- Deepest and closest obs of encounter
  - 32 sec, 137 $R_J$
- Ring thickness $z/2 \leq 40$ km at sidescatter
  - Galileo $z/2 \leq 100$ km
- There is at most a 5% intrinsic brightness difference between left and right ansae
Radial Profiles

- Backscatter: Large bodies
- Forwardscatter: Dust
- Ring has substantial, radially-uniform large-body population
- Dust distribution drops off rapidly inward of Metis: loss process?
Cassini observations fill in large holes in phase angle coverage
Main-ring observations 1979-2001 have measured ~1300 data points of I/F (λ,θ)
Photometry: Method of Fitting Observations

- Total I/F from ring is sum of two components
  - **Dust grains**
    - Optical depth $\tau_D$
    - $n = 1.5 + 0.001i$
    - $r = 0.01 - 100 \ \mu m$
    - Non-spherical grains (Mishchenko & Travis 1998)
    - Various size distributions $n(r)$
  - **Large bodies**
    - Optical depth $\tau_p$
    - Spectrum of Amalthea; phase function of Callisto
  - Free parameters $\tau_D$, $\tau_p$, $n(r)$
    - We iterate to find best fit solutions for the free parameters given the suite of all I/F observations.
  - Our model for determining size distribution considers all 1300 data points simultaneously -- e.g., spectrum and phase curve are fit together, not separately
We fit data with two-component model of large bodies + dust

Best fit:
- Large bodies: $\tau \sim 1 \times 10^{-6}$
  - Must be very red (albedo linear with wavelength)
- Dust: $\tau \sim 4 \times 10^{-6}$
  - $\text{n}(r) \, dr \sim r^{-2.5} \, dr$
  - $r^2 \text{n}(r)$ peaked around 10-15 $\mu$m
  - Non-spherical particles ($\epsilon = 1.5$ spheroids, Mishchenko & Travis) provide much better fit than spherical grains
  - Spherical grains are too bright near backscatter (`glory'): no opposition surge seen

Ring Phase Curve and Size Distribution

Visible Phase Curve
Size distribution most strongly constrained by NIMS data.

Brooks (2003) provides possible mechanism for selection of 15 µm grains: size is preferentially absorbed as they cross Metis' orbit due to drag-orbital resonance.
Conclusions

● Cassini ISS observations
  – No strong detections of any asymmetry
    ● Sketchy detection for keplerian-moving clumps
  – Improved upper-limit ring thickness (z/2 <= 40 km)
  – Improved radial profile measurements at three phase angles separate large, small bodies
  – Fills in major holes in wavelength, phase-angle space.

● Photometry with Cassini + all previous observations
  – 1300 data points from Cassini ISS & VIMS, Galileo SSI & NIMS, NICMOS, Keck, Palomar, HST
  – I/F for all data sets can be fit nearly self-consistently, if ring is modeled with two distinct components. Single-component models do not fit.
    ● Large bodies: \( \tau \sim 1.3 \times 10^{-6} \)
      – Very red
    ● Dust: \( \tau \sim 4.7 \times 10^{-6} \)
      – \( r^2 \) \( n(r) \) peaked around 10-15 \( \mu m \)
      – Best fit size dist: \( n(r) \) \( dr \sim r^{-2.5} \), for \( r = 0.4 \), but most sensitive to peak size
      – Spherical grains do not fit, esp. near 0 deg