Saturn Approach: Cassini
Radio and Plasma Wave Science

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Titan: From Discovery to Encounter
ESTEC, 13 – 17 April 2004
Outline

• Titan Objectives
• Approach Science
  – Trajectory
  – Saturn kilometric radiation fine structure
  – Saturn kilometric radiation periodicity
  – Solar wind – SKR correlations
  – Saturn electrostatic discharges
  – Upstream waves
  – Escaping continuum radiation
• Conclusions
Cassini RPWS Titan Objectives

- Establish the spectrum and types of plasma waves associated with gaseous emissions from Titan.
- Determine the role of plasma waves in the interaction of Saturn’s magnetospheric plasma (and the solar wind) with the ionosphere of Titan.
- Determine the spatial and temporal distribution of the electron density and temperature in Titan’s ionosphere.
- Characterize the escape of thermal plasma from Titan’s ionosphere in the downstream wake region.
- Carry out a definitive search for lightning in Titan’s atmosphere during the numerous close flybys of Titan.
Trajectory
Cassini
Saturn Approach Trajectory

Saturn Orbit Insertion
1 Jul. 2004

Initial SKR Detection

Sun

30-Day tics

22 Dec. 2003

27 Dec. 2002

1 Jan. 2002
Saturn Kilometric Radiation
Fine Structure
Saturn Kilometric Radiation Periodicity
Ulysses analysis update + Cassini

![Graph showing changes in SKR period over years from 1993 to 2003. The x-axis represents years from 1993 to 2003, and the y-axis represents SKR period in units of SLS period, with values ranging from 0.99 to 1.03.]
Cassini: $10.76 \pm 0.015 \text{ Hours}$

Voyager: $10.66 \pm 0.0018 \text{ Hours}$
Solar Wind – SKR Correlations
High Density Plasma Detected at Cassini
Irfe Lfdr ExEw, Mfdr ExEw, Mfr 13ExEw, Hfr ABC12EuEvEx

2003-11-10 (314) 00:00:00  SCET  2003-11-18 (322) 00:00:00

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Saturn Kilometric Radiation
Integrated Power
(Scaled to 100 $R_S$)

40 - 300 kHz
Saturn Electrostatic Discharges
First SED Detection?

2003-07-22 (203) 19:00:00  SCET  2003-07-22 (203) 21:00:00

2.5
2.0
1.5
1.0
0.5

dB above background

SCET  19:00  19:15  19:30  19:45  20:00  20:15  20:30  20:45  21:00
R_s  2672.09 2672.01 2671.93 2671.86 2671.78 2671.70 2671.62 2671.54 2671.47
Lon  315.80  324.25  332.69  341.14  349.58  358.03  6.48  14.92  23.37
SED Power Spectrum

Day 200 - 210

10 hr 05 mn - 10 hr 10 mn
VGR: 10:05
Upstream Waves
Cassini RPWS
March 22, Day 082, 2004

![Graph showing frequency vs. time with labels for Langmuir Waves and Ion Acoustic Waves.](image)

- Frequency (kHz)
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7

- Spectral Density (V/m² Hz)
  - $10^{-17}$
  - $10^{-16}$
  - $10^{-15}$
  - $10^{-14}$
  - $10^{-13}$

- Time (SCET)
  - 21:40:00
  - 21:40:10
  - 21:40:20
  - 21:40:30
  - 21:40:40
  - 21:40:50

- Distance from Saturn ($R_s$)
  - 825.18
Conclusions

- RPWS has a number of exciting Titan objectives involving the ionospheric electron density and temperature, the role of plasma waves in the Titan-magnetosphere interaction, the loss of Titan’s atmosphere to Saturn’s magnetosphere, and a much improved search for atmospheric lightning.
- The Approach Science phase has been ongoing for RPWS
  - Beginning with the first observations Cassini has provided unprecedented detail of the fine structure of Saturn kilometric radiation
  - Saturn kilometric radiation displays a periodicity which varies by order 1%. This may mask the true rotation period of Saturn and presents an interesting problem.
  - Voyager demonstrated correlations between the solar wind and SKR intensity; we hope to refine these to use as a proxy for solar wind input during the tour.
  - Despite a very early detection of Saturn electrostatic discharges (lightning), none have been observed until just recently. This suggests temporally variable storm intensity.
  - Upstream waves in the form of Langmuir waves and ion acoustic waves have been seen at distances of more than 800 Rs, indicating that Cassini will spend a long, fruitful time in Saturn’s foreshock region.
  - The lowest frequency radio emission from Saturn, escaping continuum radiation, has just recently been observed.