Magnetic (and Other) Observations of Saturn from the Cassini Mission

Cassini Magnetometer Team, Imperial College

Science / Operations: Dr. Nicholas Achilleos
Principal Investigator: Professor Michele K. Dougherty
Operations team Leader: Steve Kellock
Operations / Data Processing: Dr. Peter Slootweg, Tim Seears
Science: Dr. Cesar Bertucci, Christopher Arridge
plus co-investigators at Leicester University, NASA JPL, UCLA,
University of Cologne, CESR Toulouse, University of Braunschweig

• The Cassini mission – the journey to Saturn
• Images on approach to Saturn (Imaging Science Subsystem)
• Magnetic field measurements from Cassini first orbits
• Images from Huygens probe mission (25 Dec 2004 – 14 Jan 2005) to Titan
Galileo 1610 ‘Saturn has ears’

Giovanni Cassini 1625-1712
Moons ‘Cassini Division’

Christiaan Huygens 1629-1695
Rings and Titan
Rings are made of ice and ‘dirt’ (tholin)
Cassini Division is due to ‘orbital resonance’ with Mimas

Courtesy Cassini Imaging Science team

Cassini Magnetometer Observations (Nick Achilleos, 20 September, 2005)
F Ring features due to Prometheus pulling on ring material
**Planetary Magnetic Fields**

Bar magnet – iron filings line up along ‘lines of force’. Two poles, N and S – *magnetic dipole*.

Earth’s magnetic field (and other planets) – looks like giant ‘bar magnet’ near planet centre. At large distances, field looks like dipole. Dipole or magnetic axis usually displaced from planet’s rotation axis (‘dipole tilt’).
**Magnetism and Rotation**

<table>
<thead>
<tr>
<th>Planet</th>
<th>Mass</th>
<th>Radius</th>
<th>Rotation</th>
<th>Moment ( (B_{eq} R^3) )</th>
<th>Tilt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth</td>
<td>1</td>
<td>1 (6400km)</td>
<td>1 day</td>
<td>( 1 ) ( (B_{eq} = 32000\text{nT}) )</td>
<td>10.6 deg</td>
</tr>
<tr>
<td>Jupiter</td>
<td>318</td>
<td>11</td>
<td>0.414</td>
<td>18000</td>
<td>9.4</td>
</tr>
<tr>
<td>Saturn</td>
<td>95</td>
<td>9.5</td>
<td>0.426</td>
<td>550</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>

- Giant planets are rapid rotators *for their size*, and thought to have liquid metallic hydrogen above core → excellent conductor → strong magnetic field from dynamo action (planet rotation plus convection in interior)
Metallic hydrogen → perfect electrical conductor → strong planetary magnetic field
Cassini Magnetometer: Saturn Arrival Science

- Flux-gate Magnetometer (FGM)
- Vector/Scalar Helium Magnetometer (V/SHM)
Cassini First Orbit, MAG VHM Data (KSM Cylindrical, 1 min avg)

From Dougherty et al, recent issue of Science journal
Plasma blobs on the same field line **stay** on that field line → ‘Frozen-in’ flow
Cassini Magnetometer Observations (Nick Achilleos, 20 September, 2005)
Material in Saturn’s magnetosphere flows around Titan (up out of page)

Titan

Magnetic Data from Cassini Titan Flyby A (2004 October 26)

300T14:30:00
300T15:00:00
300T15:30:00
300T16:00:00

to Saturn

Cassini Magnetometer Observations (Nick Achilleos, 20 September, 2005)
Magnetometer Overview on TA flyby

Cassini Magnetometer Observations (Nick Achilleos, 20 September, 2005)
Discovered by Huygens 1655
2575 km radius (2nd largest moon in Solar System)
Cassini INMS

Voyager UVS
(Verfack et al, 2004)

Courtesy R. Yelle
(Cassini INMS team)
‘Channels’ fed by liquid methane ‘rain’ on Titan

Courtesy Huygens imaging team
Radar penetrates ‘haze’ of Titan.
Large crater 440 km wide – not seen before on Titan (surface ‘reshaping’).

Courtesy Cassini RADAR team
Preliminary results from 17\textsuperscript{th} February and 9\textsuperscript{th} March flybys, confirmed more recently by July 14 flyby (Khurana et al) → Interaction seems similar to Io

Saturn magnetic field is being bent around the moon. Enceladus is adding plasma/mass to the E ring and plasma torus. Tenuous atmosphere / higher production of ions than expected?
Exploration of Saturn – ongoing and a long-term activity!!