Space Burp: Magnetic Explosion at Saturn

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“Frozen-in” condition
What controls the shape and size of a magnetosphere?
Magnetic reconnection
The role of fast rotation in plasma loss

Hill et al. (2008)
Enceladus: A source of internal plasma

~100 kg of Water group ions per second
Saturn’s Refresh Rate

Rymer et al. (2013)
The conditions at Saturn

<table>
<thead>
<tr>
<th>Plasma Source</th>
<th>Plasma Loss</th>
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<tbody>
<tr>
<td>Dayside (Dungey) reconnection</td>
<td>Nightside (Dungey) reconnection</td>
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<tr>
<td>Moon</td>
<td>Nightside (Vasyliunas) reconnection</td>
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</tbody>
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Credit: Bagenal and Bartlett
Mass loading vs loss

- Enceladus deposits +100 kg/s of plasmas
- This is continuous

- A plasmoid has a typical volume of 10 cubic Saturn radii
- Each plasmoid ejects $-62 \times 10^3$ kg
- This amounts to $\sim 200$ plasmoids/day (every $\sim 7$ minutes) required to eject all of Enceladus’ plasmas

- It was thought nightside reconnection is not frequent enough to sufficiently shed all the loaded mass.
- Other magnetospheric mechanism proposed to contribute to the mass loss
Microphysics of reconnection:  
First detection of the diffusion region at Saturn

- Mass of proton = ~ 1800 mass of electron
- Protons become demagnetized first then electrons
- The consequence → Hall fields

Arridge et al. (2016)
Long duration magnetic reconnection

- Reconnection lasted for 19h (approx. two rotations of Saturn)
- The estimated mass loss from this was $3 \times 10^7$ kg
- This is 3 orders of magnitude (~1000 times) more than previously estimated
- An event as such every 4-40 days is required to shed all of Enceladus’ plasma instead of every 7 minutes
- Hence magnetotail reconnection can act as a very significant loss mechanism in a fast rotating planet
Over 300 hot Jupiter-like planets discovered
We not have a better understanding of how these systems behave

Much wider implications
Summary

• Nightside reconnection can be explosive at Saturn

• The ejected plasma has been estimated to be enormous and can provide the required mass loss to balance Enceladus’ continuous outgassing

• A new and important result for fast-rotating magnetospheres as well as reconnection physics