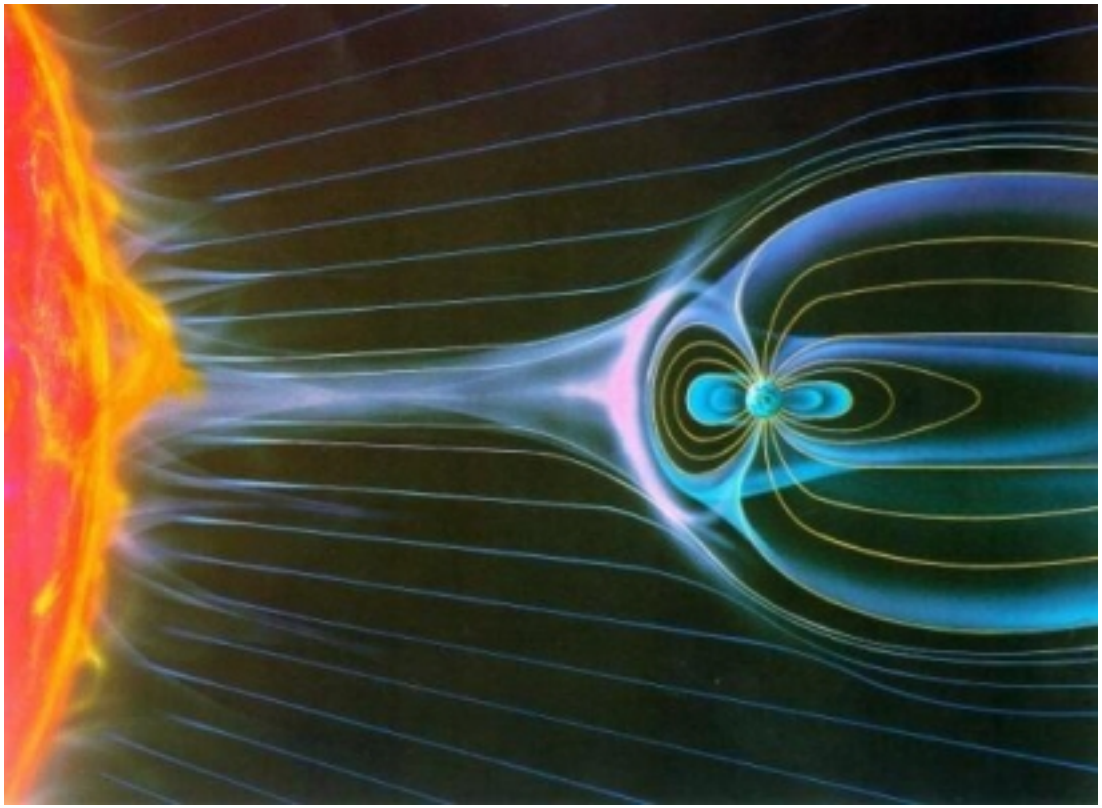
Star-Planet Interactions Discussion

Lessons from Our Star and Solar System



Paulett Liewer, Jet Propulsion Laboratory, California Institute of Technology

Planetary Magnetic Fields: Planetary Interiors and Habitability

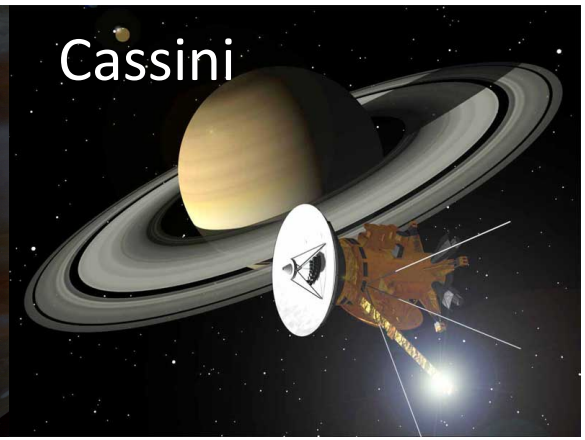
Keck Institute for Space Studies,

August 12 - 16, 2013

© 2013 California Institute of Technology. Government sponsorship acknowledged.

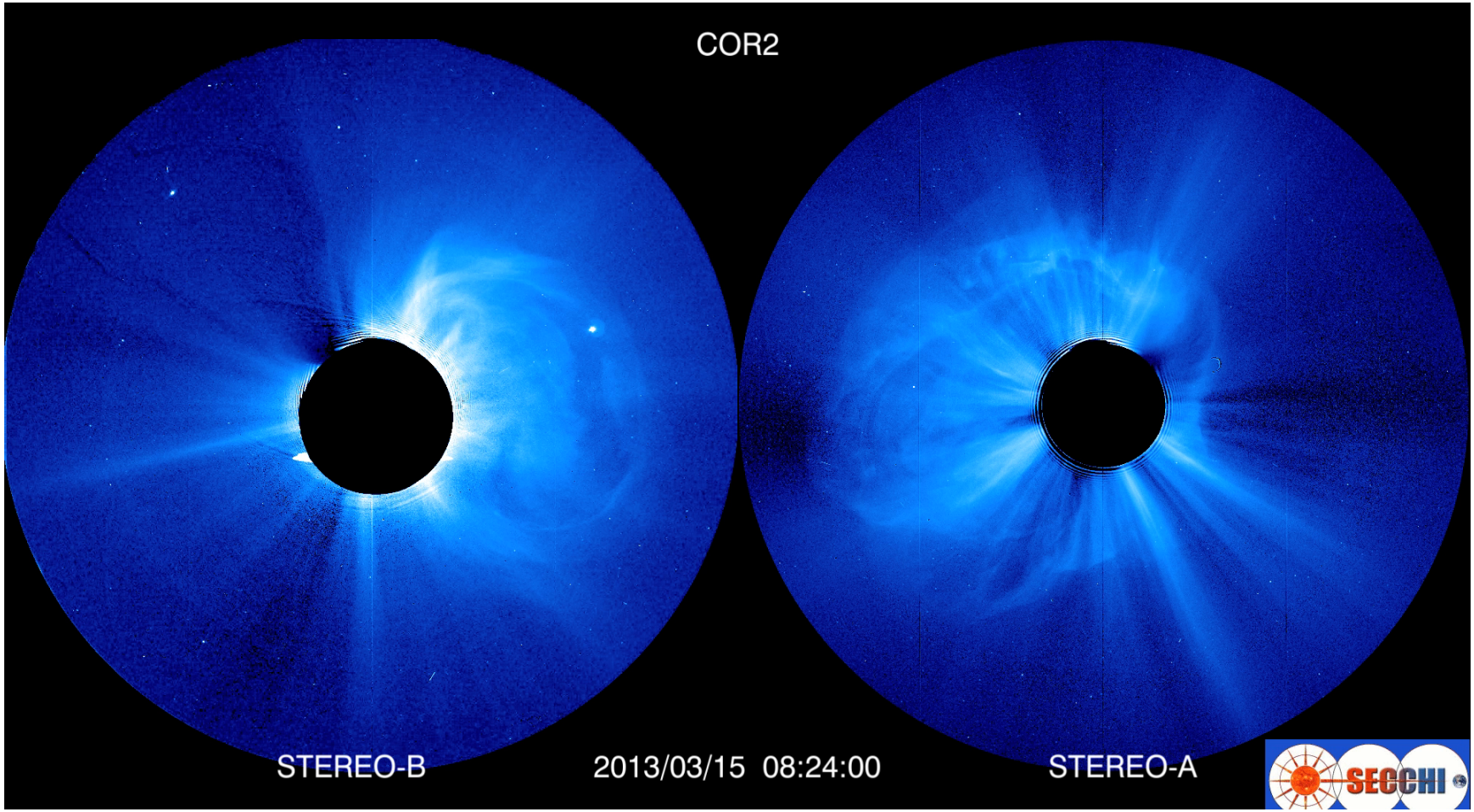
ANTENNAS IN SPACE!

- Star-planet emission contrast in our solar system most favorable in radio[~1 for Jovian decameter]
- Jupiter's emission seen from Earth
- Voyager detected kilometric radiation from poles of Saturn, Uranus and Neptune



STEREO views of Solar Corona

(add movie later)



Solar Wind – Magnetosphere Interactions

Unmagnetized flow impinging on magnetized obstacle

- Radio and UV emissions from planets with magnetospheres increase with increased solar wind (SW)kinetic energy flux
  - Seen at Jupiter (Zarka&Genova 1983; Gurnett+ 2002; Hess+ 2012) & Saturn (Prange+2004)
- Process
  - SW energy dissipated in **magnetic reconnection** which **accelerates electrons**, leading to coherent **electron cyclotron maser emission** near and auroral ultraviolet emission in polar regions
  - Radiometric Bode's Law introduced in 1984 (Desch & Kaiser)

Moon – Magnetosphere Interactions

Magnetized flow impinging on an obstacle

- Interaction of moons with planetary magnetospheres also causes strong radio and UV emissions
  - Seen at Jupiter & Saturn (*what about Neptune & Uranus?*)
- Magnetized obstacle (Jupiter-Ganymede; "dipolar")
  - Continuous reconnection between 2 magnetospheres accelerates electrons causing CMI in auroral regions
  - *Analogy to Star-planet reconnection?*
- Unmagnetized obstacle (Jupiter- Ion; "unipolar")
  - Relative motion of moon and magnetopshere causes electron acceleration via electric field (waves or induced) causing electron cyclotron maser emission
  - *Analogy to unmagnetized hot Jupiters or planets around white dwarfs ?*

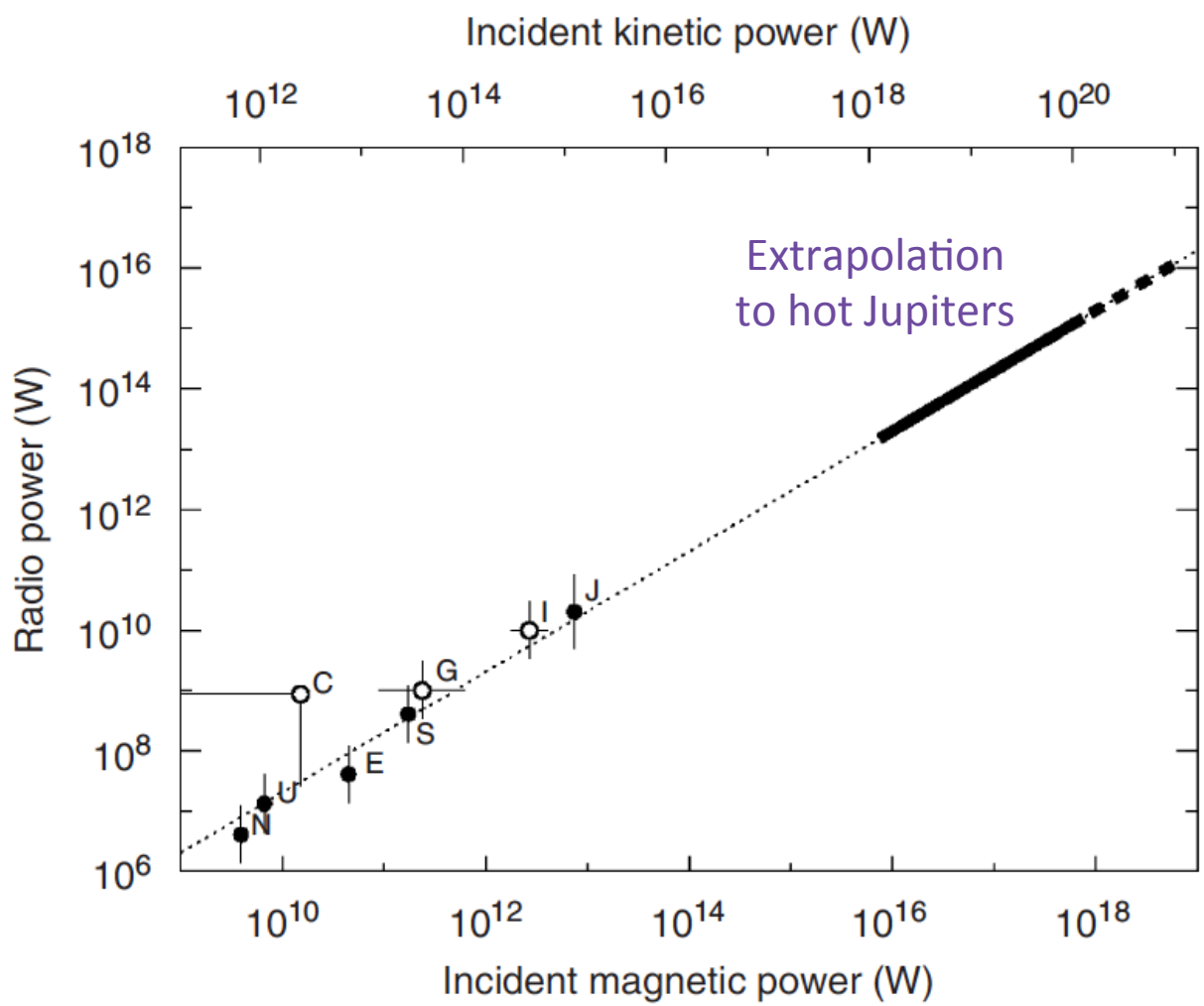
Generalized Radio Bode's Law - *Zarka (2007)*

Radio power vs. incident kinetic power or Poynting Flux

- *Captures both types of interactions*
- *Kinetic-to-radio efficiency is 10^{-5}, magnetic-to-radio efficiency is 2×10^{-3}*

- E, J, S, U, N: 5 radio planets

○ Io, Ganymede, Callisto (upper limit)



Extrapolating to Extra-solar systems

- Various other extrapolations from our solar system appear in the literature
  - Refs Farrell+ (1999); Lazio+ (2004), Hess & Zarka (2011)
  - How good are the extrapolations?
- What if a star has superflares?
  - Largest known Earth event: Carrington event ~10^{32} ergs
  - Interplanetary shocks lead to big enhancements in radio emission
  - Superflares (10^{33}-10^{36} ergs) in Kepler data analyzed (Maehara +, Nature 2012 & Notsu+ Ap, 2013)
    - Found 365 superflares (>10^{33} ergs on 148 solar-type star)
    - Statistics not consistent with hot Jupiter as cause
    - Stars appear to have larger starspots than our Sun