The Sun-Jupiter Connection

Presented by Randy Gladstone at the JPL Educator’s Workshop on
Aurora in the Solar System:
Get “Charged Up” Learning about the Sun, Earth, and Jupiter
Jupiter’s Magnetosphere

- Jupiter is 11 times the diameter of Earth (1400 times the volume)
- Jupiter’s magnetic moment is 20,000 times stronger than Earth’s, and has opposite polarity
- Both Jupiter’s and Earth’s magnetospheres are tilted to their spin axis by about 10°
- Jupiter’s auroras are about 100-1000 times more powerful than Earth’s
Inner Magnetosphere

- Trapped relativistic electrons (at energies of 10s of MeV) form Jupiter’s “Van Allen belts” within a few radii of the planet
- These electrons emit synchrotron radiation at decimetric (10s of cm) radio wavelengths as they spiral around and bounce from north to south along magnetic field lines
- Jupiter is the only planet that emits synchrotron radiation, although it is often seen elsewhere in the universe
Middle Magnetosphere

- This region is powered by Jupiter’s rotation and dominated by a torus of sulfur and oxygen ions sputtered out (at more than a ton per second) from Io’s volcano-produced \( \text{SO}_2 \) atmosphere.
- Other Galilean satellites (e.g., Ganymede) have magnetic fields which carve out little magnetospheres of their own within Jupiter’s.
- The magnetic field lines connecting Io with Jupiter’s atmosphere form an electric circuit carrying several million amperes of current, with a potential drop of 400,000 volts.
Outer Magnetosphere

- Co-rotation of the magnetosphere begins to break down at 20 Jupiter radii from the planet.
- This causes a drag on Jupiter’s auroral ionosphere, leading to electric currents that produce strong upper atmosphere winds and the main auroral oval emissions.
- Near the magnetopause, the flow of the solar wind past Jupiter’s magnetosphere results in an Earth-like plasma flow, and this may result in the bright transient features observed inside the main oval on the dusk side.
Jupiter’s Auroral Emissions

- Emissions are seen at X-ray, far-ultraviolet (FUV), visible, and near-infrared (near-IR) wavelengths
- The main oval is nearly fixed on the planet in latitude and longitude
- There is usually a single arc on the morning side, but many broad arcs in the afternoon
- There is a spot of emission at the IFT footprint (with an extended tail)
- The emissions are highly variable inside the oval on the afternoon side
Jupiter’s Aurora

GALILEO SSI (Visible)
IRTFT (Near-IR)
HST STIS (UV)
ROSAT HRI (X-Ray)
The Ultraviolet Aurora

- Has been observed at higher and higher resolution with the Hubble Space Telescope (HST) through improvements in detectors
- Recent images show brightness variations on time scales of 10s of seconds
- These transient events may be connected to the flow of the solar wind past Jupiter’s outer magnetosphere
HST IMAGES OF THE JOVIAN AURORA

FOC

FOC-COSTAR

WFPC2

STIS
Pressure and Flow $Z = 0$ Plane

($\rho V^2 = 0.09$ nPa)

$B_z = -0.84$ nT, $T = 600$ hours

$300$ km/s

$X(R_j)$

$Y(R_j)$

$1 \times 10^{-12}$

$5 \times 10^{-11}$
What are the major questions left to answer?

- How does the solar wind influence jovian magnetospheric processes?
- How are plasma particles energized in the middle and outer magnetosphere of Jupiter?
- What wave processes are responsible for scattering and loss of energetic particles?
- Are the high-latitude transient auroras due to solar-wind-driven reconnection event (similar to some events on Earth)
Magnetospheric Sounds

- Earth Aurora
- Earth Lightning
- Jupiter Chorus
- Saturn Rings