Morphology of Jupiter’s Polar Auroral Bright Spot Emissions via Juno-UVS Observations

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Outlines

• Planetary magnetic field
• Magnetosphere
• Jupiter’s auroras
• Juno-UVS observations
• Results: Location and power variation of bright spot emissions
• Summary
Planetary Magnetic Fields

- **Planetary Magnetic Fields**: generated by an internal dynamo, process which converts mechanical energy to electromagnetic energy through induction.
- The simplest structure is dipole model.
- Charged particles travel along magnetic field line by gyromotion.

Figure 1. Tilts of planetary magnetic fields with respect to their rotation axes. (Credit: Fran Bagenal & Steve Bartlett)
**Planetary Magnetosphere**: the region around the planet which the dynamics is predominated by the planetary magnetic field

**Bow shock**: the region of first impact between the solar wind and the planet’s magnetic field

**Magnetosheath**: the region where shocked solar wind flows around the magnetosphere

**Magnetopause**: the boundary current sheet which separates the solar wind plasma and the magnetosphere plasma

**Cusp**: open field line region that shocked solar wind plasma can penetrate to magnetosphere

Figure 2. A schematic of Jupiter’s magnetosphere. The dayside is located on the left in direction toward the Sun and the nightside is on the right. (Credit: Bagenal & Bartlett)
Jupiter’s auroras

- The light emission produced by the interactions between precipitating high energy particles and the atmospheric particles
- Complex morphology
- Main components: the main emissions, the equatorward emissions, the polar emissions, and the satellites’ footprints

Figure 3. HST FTIS FUV image of Jupiter’s northern aurora with three main regions, taken in 1998. (Credit: Clarke et al., 2004)
The bright spot features

- The emissions in Jupiter’s polar auroras
- Compact shape
- Very dynamic and very bright in UV aurora
- Located closed to magnetic noon local time and related to magnetospheric cusp (Pallier and Prange, 2001)

Figure 4. Jupiter’s auroras acquired by Juno-UVS contain the bright spot feature in (left) the northern hemisphere and (right) the southern hemisphere.
The bright spot features

Main study

- Positions and local times
- Power emissions
- Behaviors

Figure 4. Jupiter’s auroras acquired by Juno-UVS contain the bright spot feature in (left) the northern hemisphere and (right) the southern hemisphere.
Observations

- Ultraviolet Spectrograph (UVS) instrument on board the Juno spacecraft
- 68-210 nm wavelength range with dog bone-shaped slit
- Acquired a Jupiter’s aurora image every ~30 seconds as Juno’s spin period
- The first 25 orbits: Aug 27, 2016 to May 29, 2019
- Polar projection: altitude 400 km above 1 bar level

Figure 5.
(a) Photon-count image obtained from Juno-UVS
(b) Polar projection of Jupiter’s northern aurora of the data from one spin taken at 27 March 2017, 08:09:15
(c) Full view of Jupiter’s aurora created by integration data taken between 08:09:15 to 08:26:47.
Observations

• Orbit ~53-day period
• Perijove (PJ): trajectory when spacecraft orbit close to the planet center
Jupiter’s bright spot emissions

**PJ1:** Three bright spot emissions within 30 min time range, appeared nearly the same system III position

**PJ3:** Two distinct bright spot emissions appeared at different SIII longitudes

**PJ6:** Large bright spot emissions

**PJ8:** A spot at position different from others

**PJ13:** Two bright spot emissions during 25 min time interval

*Figure 6. Bright spot emissions found in Northern hemisphere.*
Jupiter’s bright spot emissions

PJ4: Six bright spot appearances during ~4-h observation time, quasiperiodic behavior
PJ8: Fainter emission compare to others but appear many times
PJ9: Bright spot emissions with clear evolution to change in SIII longitude
PJ12: Two bright spot emissions appeared at different SIII longitudes
PJ14: Many emissions within 30 min of selected time window
PJ15: Fainter emission compare to others
PJ16: Seven bright spot emissions with quasiperiodic behavior

Figure 7. Bright spot emissions found in Southern hemisphere.
Jupiter’s bright spot emissions

PJ20: Four bright spot emissions during 1-hour of selected time interval
PJ21: Bright spot emissions at different SIII positions
PJ22: Large bright spot emissions
PJ23: Two bright spot emissions appeared at different SIII longitudes
PJ24: Bright spot emissions with clear evolution to change in SIII longitude
Locations and local times

- 60°-70° latitude, 160°-190° SIII longitude
- Analogous to X-ray hot spot region
- Approximate local time: Midnight – Noon
- Vogt’s mapping model:
  - >110 R_J in magnetosphere, dawn time
  - Unmapped for > 90% of spot data

Figure 9. Polar projections shows the positions of bright spots observed in northern hemisphere with the statistical locations of the main emission (dash contours) (Bonfond et al., 2012). The color presents the approximated magnetic local time of bright spot.
Locations

Figure 10. Bright spot position in SIII longitude and latitude map (plus symbol & bluish tone for northern spots and cross symbol & green to red tone for southern spots). The line connecting each data presents the motion of bright spot with observing time order starting from a dot in each plot.
The power variations: PJ4

- time interval between peak: ~ 30 min
- evidence of quasiperiodic behaviors (period ~28 min)
Summary

• Occurrence from both N&S hemispheres
• The emitted power is tens GWs, some bright spot emissions can reach up to a hundred GWs.
• Reappearance of bright spot emissions within a Juno perijove in the same system III position, indicative of quasiperiodic pulsations
• The time interval between two consecutive brightening: ~3-47 minutes
• The system III positions of bright spots:
  • **Northern hemisphere:** region around 175° system III longitude and 65° latitude.
  • **Southern hemisphere:** scattered around the polar region
• Bright spot emissions can be seen at any local times, contrast from previous studies
• More data and in situ observations are currently under investigation
In-situ observations

- Events: PJ3, PJ15, PJ33
- Instruments: UVS, JEDI, JADE, Waves, MAG

Figure 12. Jupiter’s auroras observed by Juno-UVS during PJ3, PJ15, and PJ33