Expansion of the main auroral oval at Jupiter :

Evidence for Io's control over the Jovian magnetosphere

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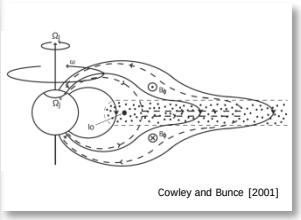
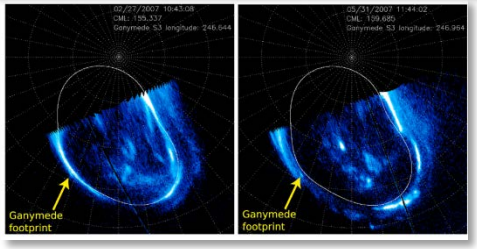
The Main Emission on Jupiter

Contrary to the case of the Earth, the main auroral oval on Jupiter is related to the breakdown of plasma corotation in the middle magnetosphere.
Even if the root causes for the main auroral emissions are Io's volcanism and Jupiter's fast rotation, changes in the aurora could be attributed either to these internal factors or to fluctuations of the solar wind.
Here we show multiple lines of evidence from the aurora for a major internally-controlled magnetospheric reconfiguration that took place in Spring 2007.

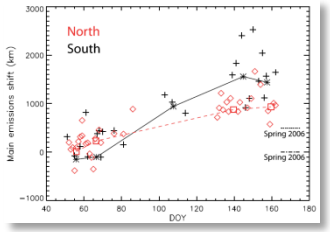


Location of the Ganymede Footprint



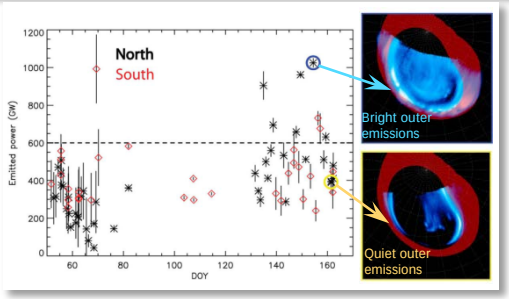
The Ganymede footprint is outside the main emission in the first image and inside it in the second case, suggesting that **the corotation breakdown boundary has moved inside the Ganymede orbit** (15 Rj). Additionally, the **Ganymede footprint location moved 0.5° equatorward** implying an increased stretching of the magnetic field lines. The white line is the reference oval from February 2007.

Motion of the Main Auroral Emissions

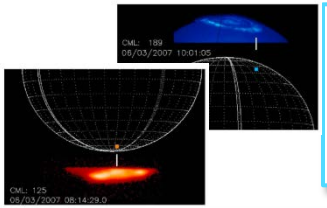


The mean distance between the main emissions and the reference oval increase with time in Spring 2007. The black stars linked by the black solid line and the red squares linked by the red dashed line represent the monthly averages in the southern and northern hemispheres. The horizontal dash-dotted and the dotted lines represent the average shifted distance for the 2005 and 2006 northern hemisphere campaigns, respectively.

Variability of Outer Emissions

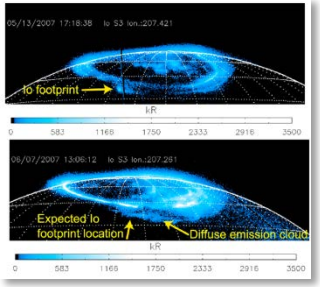


The number of observations with a total outer emissions power over 600 GW significantly increased in May–June. The power is integrated over a ribbon starting 1200 km equatorward of the monthly averaged main oval and ending at the Io footpath. The plotted values are corrected to account for the ratio between the total ribbon surface and the visible one., The top polar projection shows a case with bright patches of outer emissions while the bottom one shows a quiet case.



These two images were acquired less than 2 hours apart in the IR domain with the IRTF in the southern hemisphere and with the Hubble Space Telescope in the UV domain in the northern hemisphere. On each side, the white line underlines the large auroral blob which is tracked from one hemisphere to the other. **The bottom image is the first observation of outer emission blobs in the IR.**

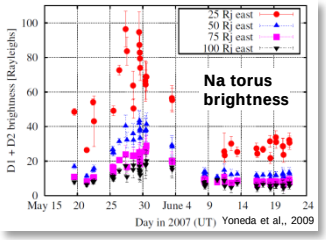
Unusual Io UV Footprint Behavior



The top image shows a typical HST ACS images of the northern hemisphere. While Io's S3 longitude is nearly the same in the bottom image, **the Io footprint has disappeared**, while it would be expected to lie at the border of the unusually equatorward patch of diffuse outer emission.
This disappearance of the Io footprint is unique within more than 10 years of high-resolution/high sensibility HST images and may be due to a disrupted interaction between Io and the depleted flux tubes connected to the patch.

Io's control over the Jovian magnetosphere

Our suggested scenario is that Io's volcanism became particularly active in February 2007, as evidenced by the spectacular Tvashtar plume seen by New-Horizons [Spencer et al., 2007]. **Strong volcanic activity is then expected to have continued at least intermittently**, as demonstrated by the tripling of the Io torus sodium nebula brightness observed by Yoneda et al. [2009] in late May. In this scenario, **the progressive ionization of volcanic material released by Io increased the density of the plasma sheet**, increasing the azimuthal current and thus moving the Ganymede footprint equatorward. **It also strengthened the mass outflow rate**, forcing the corotation breakdown to occur closer to Jupiter, which further expanded the main auroral oval.



The large amount of outward moving heavy flux tubes has to be **replaced by flux tubes sparsely filled with hot plasma**. The enhanced loading of the middle magnetosphere could then explain the highest occurrence rate of large features associated with injection signatures in May–June compared to February–March. We suggest that on 7 June, a large cloud of depleted flux tubes migrated exceptionally close to Jupiter and **disrupted the Io-Jupiter interaction**, begetting an abnormally faint Io footprint.

Take-home Message

- The main oval continuously expanded within a few months, engulfing the Ganymede footprint on its way, even if the GFP also moved equatorward. **Both the corotation breakdown boundary and the magnetic field lines stretching changed over Spring 2007.**
- Simultaneously, there was an increased occurrence rate of large equatorward isolated auroral features attributed to injection of depleted flux tubes, **a signature of intensified inward motion of empty flux tubes.**
- **We also report the first observation of an outer emission blob in the IR.**
- Furthermore, **the unique disappearance of the Io footprint** on 6 June appears to be related to the exceptional equatorward migration of such a feature.
- **The contemporary observation of the spectacular Tvashtar volcanic plume by the New-Horizons probe as well as direct measurement of increased Io plasma torus emissions suggest that these dramatic changes were triggered by Io's volcanic activity.**