Mapping Jupiter's Infrared Aurora

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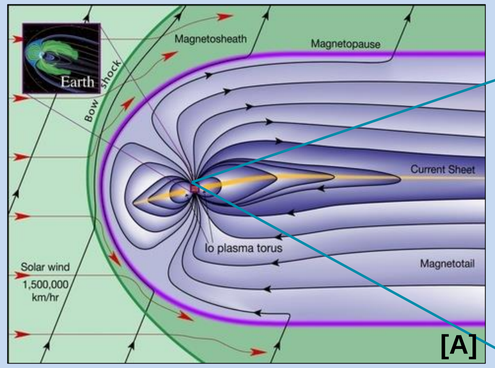
Why is Jupiter's aurora important?

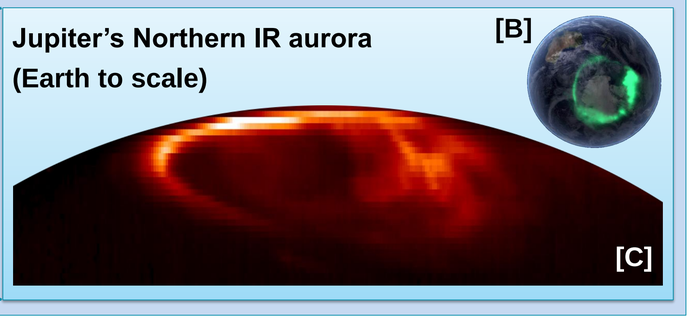
Particles are constantly flowing away from the Sun, dragging with them the Sun's magnetic field, and together they are known as the *solar wind.* Conditions in the solar wind often change and this variability is known as *space weather.*

With the progression into the space age, a good understanding of space weather and its influence on the Earth and other planets is paramount. Studying Jupiter's aurora and the effect of space weather can not only be applied to the Earth-Sun system, but it also prepares us for future space exploration and the potential industrialisation or colonisation of Jupiter's moons.

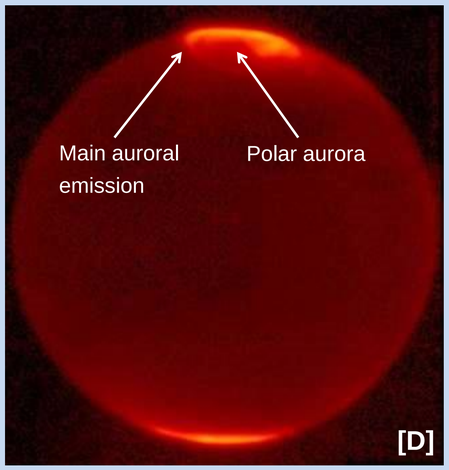
1. Jupiter's Magnetosphere

Jupiter's magnetic field is 10 times stronger than the Earth's and expands into a bubble surrounding Jupiter, known as a magnetosphere.





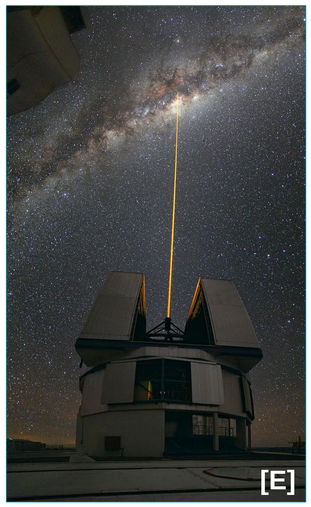
2. Jupiter's Infrared Aurora



Jupiter's magnetosphere (Figures A and H) rotates quickly and is filled with charged molecules from the volcanic moon Io.

The cause of the main auroral emission is known but the cause of the highly variable polar aurora remains a controversial topic.

The polar aurora may be solely caused by Io or the solar wind or a combination of the two.



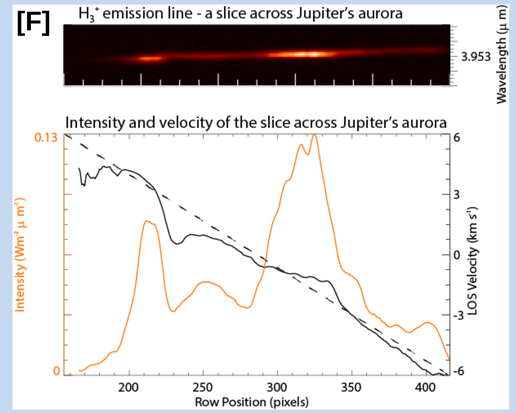
3. The Very Large Telescope (VLT)

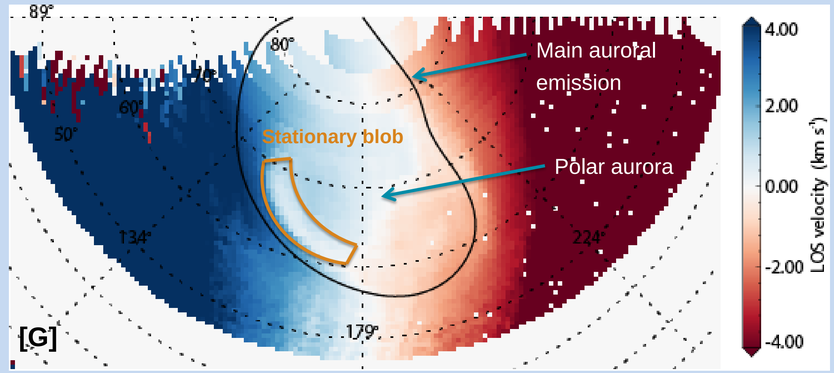
To study Jupiter's aurora I use data from the Very Large Telescope (VLT) situated in Chile. Using a long-slit echelle spectrometer (CRIRES), an instrument which can separate the wavelengths of light, the infrared auroral emissions of H_3^+ ions can be measured. The H_3^+ ions are charged molecules created in Jupiter's upper atmosphere through a chain reaction, beginning with collisions with energetic electrons from Jupiter's magnetosphere.

4. CRIRES Data

A Gaussian is fitted to every spatial position along the emission line:

- The height of the Gaussian provides intensity
- The position of Gaussian provides a Doppler shift
  - The Doppler shift is the change in wavelength of emitted light from the ions and is caused by the motion of these ions in Jupiter's upper atmosphere. From this, we can calculate the velocity of the ions which create the aurora.





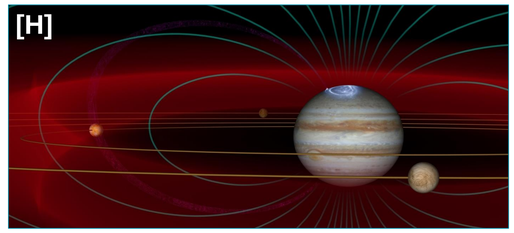
5. Polar Projection

By using the CRIRES instrument to scan the Northern aurora, velocities can be mapped onto a polar projection.

Here, blue represents velocities moving towards the observer (blue shift) and red represents velocities moving away from the observer (red shift).

6. Is Jupiter effected by space weather?

- The polar projections of the velocities reveal the dynamics of Jupiter's upper atmosphere and magnetosphere, as charged particles are strongly intertwined with magnetic field lines.
- A key result of this research is the stationary blob of ions observed in a dark region of Jupiter's polar aurora. This blob is highlighted by an orange box in the Figure G. The ions here are stationary compared to the rest of the ions which are moving around in Jupiter's upper atmosphere.
- The reason that the ions are stationary in the blob is that the magnetic field lines in this region are connected to the solar wind. **This means that Jupiter's polar aurora is effected by space weather.**



7. Conclusions

- Through observations of Jupiter's infrared aurora, we have found that a region of Jupiter's dark polar aurora is connected to the solar wind.
- Exactly how Jupiter's upper atmosphere and the solar wind are connected to the solar wind remains to be discovered…

[A] F. Bagenal & S. Bartlett, University of Colorado ; [B] Image Spacecraft Pictures, NASA; [C] J. Connerney, NASA Goddard; [D] Y. Beletsky, ESO;
[E] J. Spencer, University of Colorado; [C,F,G] R Johnson*

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