UNEARTHING URANUS'S INFRARED AURORA

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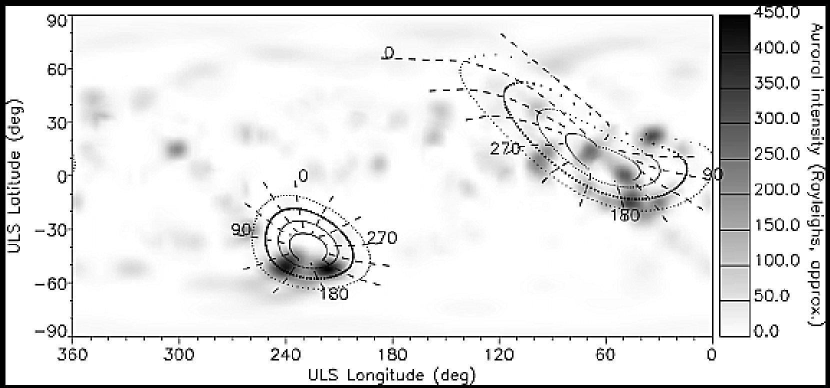
BACKGROUND

- Uranus's aurora were first observed by Voyager 2 in 1986 (Herbert, 2009 seen in Figure 1.).
- Since 1986, we have detected the aurora through UV H_2 as documented in Lamy, *et al*, 2012.
- At present we have observed a singular infrared auroral feature as discussed in Melin, *et al*, 2019.
- By observing Uranus's aurora we can determine physical properties of the planet's ionosphere.



➢ Figure 1. Uranian UV aurorae as observed by Voyager 2 with Q_3^{mp} magnetic coordinate grid in ULS coordinates (Herbert, 2009).

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INTRODUCTION

- Infrared aurora of gas giants can be observed through spectral emissions of H_3^+, a molecular ion.
- H_3^+ ions are predominately created by solar extreme-ultraviolet (EUV) radiation or through precipitating electrons within the aurora regions.

$$H_2 + H_2 = H_3^+ + H$$

- When formed H_3^+ emits infrared emissions that can be observed at Earth.
- From H_3^+ emissions, we can determine properties of the atmosphere and auroral processes.

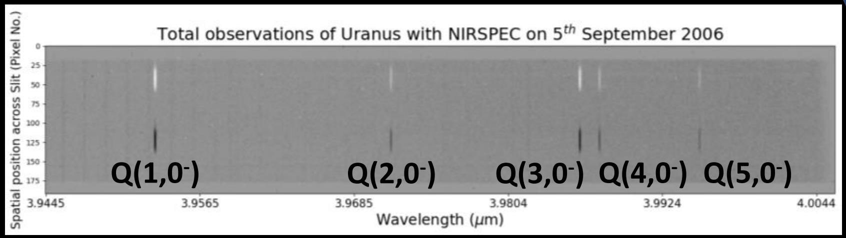


Figure 3. A spectral image containing average slit observations over 3.94μm to 4.0μm with $Q(1,0^-)$ to $Q(5,0^-)$ emission lines labelled.

OBSERVATIONS/METHOD

- We observed Uranus on the 5th September 2006 with NIRSPEC on the Keck II telescope.
- Data was taken between 3.94μm and 4.00μm, with a spectral resolution R of >20,000. The observing set up can be seen in Figure 2.
- Our observations are recorded on spectra as shown in Figure 3.
- We fitted Gaussian profiles over all 54 emission spectra sets (grouped into 13 total sets) to derive H_3^+ intensity, temperature and column density as shown in Johnson, *et al,* 2018.

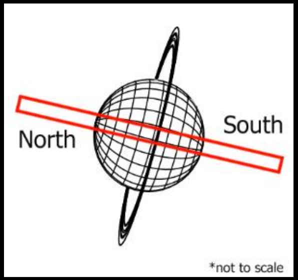
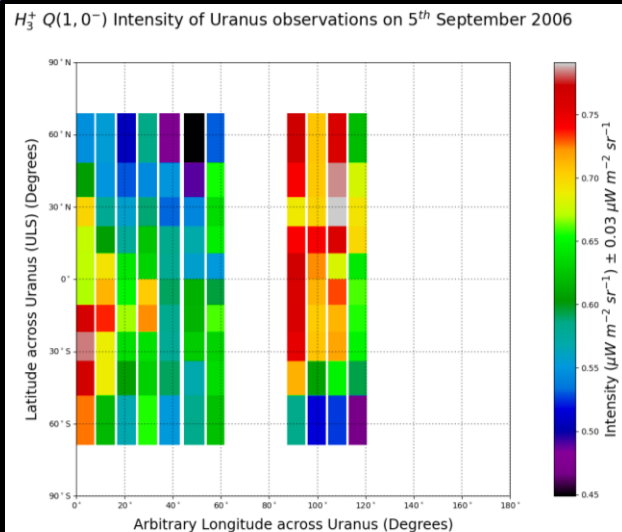


Figure 2. The observational geometry on the 5th September 2006.

RESULTS



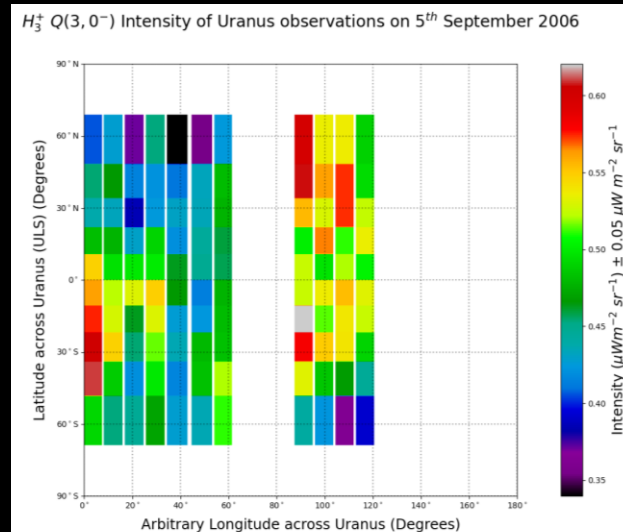


Figure 4 and 5. H_3^+ $Q(1,0^-)$ and $Q(3,0^-)$ Intensity profiles across Uranus between 07:36 and 13:01 UTC on the 5th September 2006.

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Watch the full observation run of September 2006 for yourself!

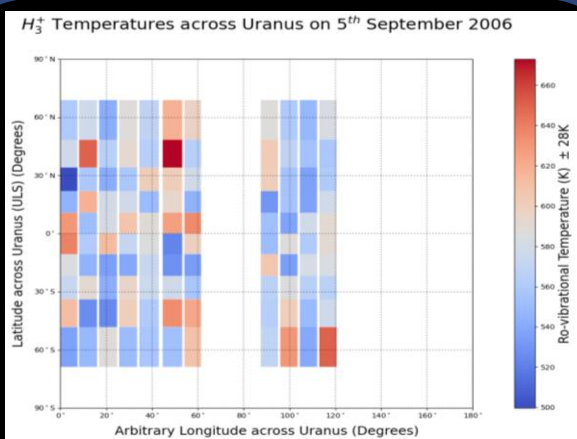

Figure 6. H_3^+ Rotational Temperatures across Uranus between 07:36 and 13:01 UTC.

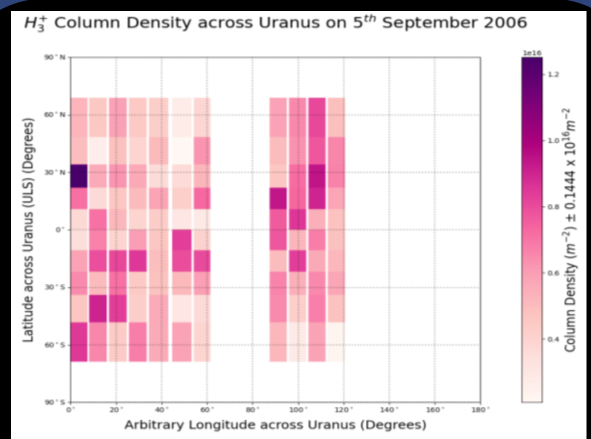

Figure 7. H_3^+ Column Densities across Uranus between 07:36 and 13:01 UTC.

RESULTS

- Between 0º and 70ºS latitude starting at 0º longitude we observe an area of peak H_3^+ intensities (0.78 to 0.49 μW m^{-2} sr^{-1} or 15% above average).
- Between 70ºN and 30ºS latitude starting from 85º to 112º longitude we observe a larger area of peak H_3^+ intensities (0.77 to 0.50 μW m^{-2} sr^{-1} or 14% above average).
- Temperatures at these regions are 581K and 563K respectively, hence these emissions cannot be produced by thermal processes.
- Column densities at these regions show peaks 65% to 59% more than the mean of this dataset.

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REFERENCES

- Background Image, Polar lights on Uranus, [https://bit.ly/2Q7yjq4]. Accessed on [8/03/20].
- Herbert, F., 2009. '*Aurora and magnetic field of Uranus*', JGR: Space Physics, 114(A11).
- Lamy, L., (2012), *'Earth-based detection of Uranus' aurorae'*, GRL, 29(7).
- Melin, H., et al (2019), *'The H_3^+ ionosphere of Uranus decades-long cooling and local-time morphology'*, PToRASA, 377(2154).
- Johnson, R.E., et al (2018), *'Mapping H_3^+ Temperatures in Jupiter's Northern Auroral Ionosphere Using VLT-CRIRES*', JGR: Space Physics 123(7).

CONCLUSIONS

- We observe two ares of H_3^+ intensity peaks, one smaller in the southern hemisphere and a larger set in the northern hemisphere.
- These are not due to thermal processes, and instead arise from column density peaks specific to these regions, **proving that we have uncovered the infrared aurora at Uranus for the first time**.
- We can confidently present the first infrared auroral mapping of Uranus.
- We aim to have our full results published in Thomas, E.M., *et al,* 2020, *in write up*.
- Future work will use iSHELL observations since 2016 to produce more maps across Uranus.