Ground-based observations of the aurora, ionosphere and upper atmosphere of Uranus.
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Introduction: Our understanding of the upper atmosphere and ionosphere of Uranus comes from a combination of Voyager measurements, as well as a continuing programme of ground-based observations over the past three decades. These post-Voyager observations follow the detection of the molecular ion H3+ at Uranus[1], which is formed via the ionisation of molecular hydrogen. In the upper atmosphere of Uranus, the ionisation energy is provided by both solar radiation and particle precipitation of magnetospheric origin. Whilst the solar contribution is expected to create a uniformly glowing ionosphere, the particle precipitation is centred on the magnetic poles, which rotate in and out of view, creating a modulation in H3+ brightness as the planet spins on its axis. Here, we present a combination of both short and long-term studies of the H3+ emission from Uranus, combining observations of Uranus using Keck, VLT, Gemini and the NASA IRTF.

Short Term variability: The short term studies, which includes AO corrected data taken by VLT-CRIRES in 2013 (Figure 1) and Keck-NIRSpec data from 2006 (Figure 2), show significant modulation in the H3+ emission intensity, with dusk brightening and spots of emission, as well as ion wind flows that appear to indicate broad-scale currents flowing within the ionosphere, most likely driven by the ionosphere-magnetosphere interaction that drives any aurora.

Long Term variability: Our long-term study reveals significant thermal cooling over an extended period, which appear to act on a seasonal timescale, but with cooling that extends beyond the equinox (Figure 3). These are not understood, but perhaps indicate a magnetospheric source of heating. Long-term changes in H3+ density do not follow changes in the EUV have also indirectly indicated the presence of strong aurorae.

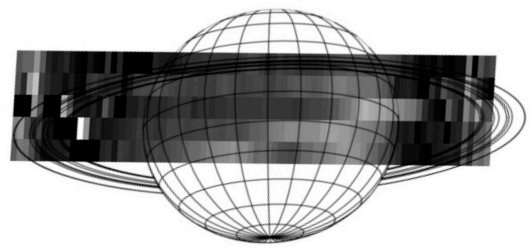

Figure 1: H3+ emission intensity from a slit scan across the disk of Uranus from VLT-CRIRES, showing a clear dusk brightening in the AO corrected data

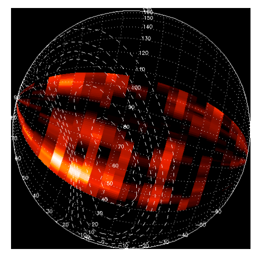

Figure 2: H3+ emission above a threshold background level, measured by Keck-NIRSpec, with the slit aligned along the rotational pole of the planet, measuring the intensity as the planet rotates under the slit. A clear emission feature is seen in the North, compared with a possible magnetic pole location.

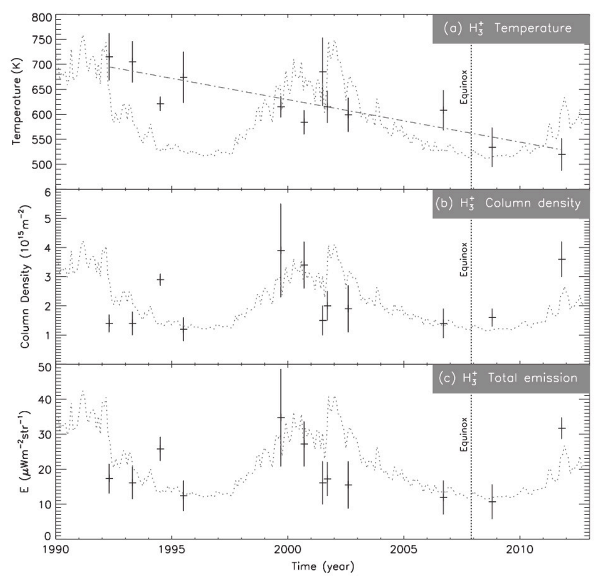

Figure 3: The long term H3+ temperature, density and total emission between 1993 ansd 2013, showing a clear decrease in temperature, and spikes in H3+ density (Taken from [4])

References:

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[4] Melin, H., Stallard, T., Miller, S., Geballe, T.R., Trafton, L.M., Encrenaz, T., 2013. Seasonal variability in the ionosphere of Uranus. Icarus 223, 741-748