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First detection of the polarisation of H_3^+ infrared emission in Jupiter's aurora

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Abstract

Space environment studies are crucial for the understanding of the upper atmospheres mechanisms. In ionospheric and magnetospheric environments, the lack of observable is one of the main problems. We develop strong efforts to find new kind of measurements which could become new useful observables. It has recently been discovered that the emission of the terrestrial auroral oxygen red line (630nm) is linearly polarized [1]. In the jovian case, the measurement of the polarization of Jupiter's auroral emissions is thus a way to investigate new observables . We observed the H_3^+ jovian auroral region with the UKIRT during the beginning of August 2008 and we detected a linear polarization in Jupiter's auroral H_3^+ emissions around 4 μm with rates between 1% and 20 %.

Observations

We observed the emissions from the aurora of Jupiter with the UIST/IRPOL spectro-polarimeter at the United Kingdom Infrared Telescope (Hawaii) in the 3.620-4.232 μm range. This wavelength range contains bright H_3^+ fundamental Q-branch transition emissions. On August 4, 2008 we had a clear sky and observed the south auroral oval and on August 6, 2008 we had poor conditions to observe the north oval. The field of view was 0.24 $\times$ 20 arcsec with 0.12 arcsec pixel^{-1}. At the latitude of the auroral oval, a 20 arcsec slit cuts across the entire the entire auroral region. The slit was rotated to be perpendicular to Jupiter's rotational axis. We used H Bracket α filter images to position the slit across the oval. We did 16 series of exposures, each series containing 2 exposures at each of the 8 waveplate angles required for polarimetry measurements. We did not co-add the images because the planet had rotated of 6°between two series.

For calibration purposes we observed an unpolarized star, HD 188512. There is no star with known polarization in the long-L band, so

- in the lack of anything better we observed HD 150193, a star with a known polarization of 1.7 $\pm$ 0.1 in the H,J and K bands,

- we could not calibrate our results by using a standard star.

Data reduction

We divided the length of the slit into 24 boxes and summed the intensity in these boxes to obtain a spectrum for each box. We fitted the 3.953 μm line by a Gaussian profile. The fit gave us the intensity of the line. Then we calculated the polarisation rate and angle with the ratio method. (We checked the difference method give similar results. We also checked that we got similar results by adding the intensity of the individual pixels composing the line instead of fitting it by a Gaussian.)

Propagation of the variance estimates from the raw data provided uncertainty on the final results.

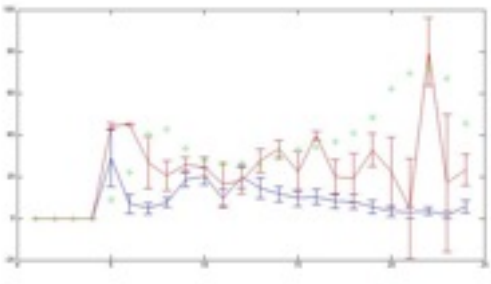

Figure 1: Intensity in green (A.U.), polarization rates in red (%) and angles in blue (degree) versus the number of the box ie the longitude

Results

The polarization rates shows variation from 1% to 20%. Considering the error bars, we showed detection of the polarization with more than 3σ confidence. If considering the variation of the polarization rates along the slit which corresponds to longitudinal variation, we can identify that the emission shows a maximal polarization close to the oval but inside of it. The opposite

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side of the oval shows the lower degrees. The polarization direction is around 20 from the north in anticlockwise direction where the polarization degree is important. For the other parts of the oval the error bars on the direction make it no significant. This discovery is of great importance for the study of the jovian upper atmosphere. It validates the polarization as an observable. In a first step, it can be interpreted as the effect of any anisotropy in the medium of emission, i.e. magnetic or electric field. However, the quantitative interpretation of the data will needed a strong effort on both modelisation and laboratory experiment. The H_3^+ is the simplest polyatomic molecule and this will constitute a challenge for molecular physicists. This result is part of a large program called SEPAGE trying to investigate the polarization of the planetary upper atmospheres emissions.

References

[1] Lilensten et al. (2008) *GRL*, 35, L0880490.