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Direct detection of auroral and equatorial jets in the stratosphere of Jupiter with ALMA

Thibault Cavalié[1,2], Bilal Benmahi[1], Vincent Hue[3], Raphael Moreno[2], Emmanuel Lellouch[2], Thierry Fouchet[2], Paul Hartogh[4], Ladislav Rezac[4], Thomas Greathouse[3], Randall Gladstone[3], James Sinclair[5], Michel Dobrijevic[1], Françoise Billebaud[1], and Christopher Jarchow[4]

[1]LAB - Univ. Bordeaux - CNRS, Planetary Sciences, Pessac, France
[2]LESIA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universités, UPMC Univ. Paris 06, Univ. Paris Diderot, Sorbonne Paris Cité, Meudon, France
[3]Southwest Research Institute, San Antonio, TX 78228, United States
[4]Max-Planck-Institut fu□r Sonnensystemforschung, 37077 Göttingen, Germany
[5]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA

The upper tropospheric zonal winds have been measured since decades using cloud tracking with maximum winds speeds of □ 100 m/s in the tropical region (Ingersoll et al. 1979). Juno measurements have shown that these winds extend in the deep layers of the planet (Kaspi et al. 2018). In the ionosphere, jets have been detected in the auroral zone with velocities of 1-2 km/s (Rego et al. 1999). In-between these atmospheric regions, in the stratosphere, there are no such tracers as clouds. Even if zonal winds can in principle be indirectly derived from temperature field by assuming the thermal wind balance (e.g. Flasar et al. 2004), this technique relies on a boundary condition often taken as the cloud-top structure which is located at levels that are separated from where the stratospheric temperature field is constrained. Also, this technique breaks down at equatorial latitudes.

Using the Atacama Large Millimeter/submillimeter Array, we mapped Jupiter's stratospheric HCN emission in March 2017 to directly measure wind-induced Doppler shifts on the spectral lines. We imaged the HCN limb emission with an angular resolution of 1" and a very high spectral resolution. After subtracting the rapid rotation of the planet from the Doppler shifts measured on the spectral lines, we derived the wind speeds as a function of latitude on both limbs.

We find strong tropical jets at 1 mbar with velocities of 100-200 m/s lying atop the layers where the Quasi-Quadrennial Oscillation occurs. Most surprisingly, we find strong non-zonal winds in Jupiter's polar regions at 0.1 mbar with counter-rotation velocities of 300-400 m/s. Their position coincides with the location of the main auroral oval.

In this paper, we will present our observations and results. We will also discuss their implications on the dynamics and chemistry of Jupiter's stratosphere.