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Mapping of CO and HCN emission in Neptune's stratosphere

A. Moullet (1), M. Gurwell (1), M. Hofstadter (2), E. Lellouch (3), R. Moreno (3) and B. Butler (4)
(1) Harvard-Smithsonian Center for Astrophysics, SMA group, 160 Concord Avenue, Cambridge MA, USA, (2) Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena CA, USA, (3) LESIA-Observatoire de Paris, 5 place J. Janssen, Meudon, France, (4) NRAO, 1003 Lopezville Rd, Socorro NM, USA (amoullet@cfa.harvard.edu / Fax: 617-496-7554)

Abstract

We present spatially resolved observations of CO and HCN mm-wave emission from Neptune's stratosphere, obtained with the Submillimeter Array. The imaged data show that CO emission is spatially uniform, while HCN exhibits decreased emission near the southern pole. Maps of the CO absorption in the upper troposphere were also obtained simultaneously. The interpretation of the mixing ratios horizontal and vertical (for CO) distribution can bring clues on the respective sources of both species.

1. Science case

The presence of minor species CO and HCN in Neptune's stratosphere has been assessed from several single-dish millimeter observations [4] [2]. However the measured abundances, $\sim$1 ppm for CO and $\sim$1 ppb for HCN, are surprisingly higher than the expected values, hence requiring a substantial replenishing source. One possible endogenic source is vigorous convection from the deep interior, where CO is stable, that could bring CO and N_2 up to the stratosphere, where the latter can be dissociated to form HCN. An additional exogenic source (satellites, rings and comets) could also explain the observed increase of CO abundance from the troposphere to the stratosphere [1]. The different sources may produce uneven spatial distributions of the minor species, in particular, recent cometary impacts could be characterized by a strong abundance increase near the impact latitude. The detection of such inhomogeneities requires the use of mm-wave interferometry to reach a sufficient spatial resolution.

2. Observations

Observations of the HCN(4-3) and CO(3-2) rotational lines were obtained on three dates in September 2010 with the Submillimeter Array (SMA), located atop Mauna Kea (Hawaii). The array, composed of 8 antennas of 6 meters diameter, was in its extended configuration (baselines up to 210 m), so the synthesized beam size at 345 GHz of $\sim$0.7", which is sufficient to resolve Neptune's 2.1" disk.
The combination of a 0.5 km/s spectral resolution and a 4 GHz-wide band allowed to detect and resolve the narrow stratospheric emission of both CO and HCN, as well as to evidence, with a good bandpass quality, the wide and shallow absorption linked to the tropospheric CO.

3. Results and objectives

Thanks to the good imaging offered by the SMA, maps of the stratospheric emission of CO and HCN could be obtained (Figure 1). While CO stratospheric emission is uniformly distributed across the disk, HCN emission appears to have a ring-like structure, that is related to the enhancement of the optically thin emission near the limbs (from the increased optical path) coupled with decreased continuum emission. The HCN map also shows a significant emission drop in a southern region located near the South pole. This feature may be related to the intense dynamics that may be present in this region, as suggested by [3]. Maps of the CO absorption from the upper troposphere and of the continuum emission at $\sim$345 GHz were also obtained, and displayed spatially uniform emission.
To quantify their spatial distribution in the stratosphere, we will present mixing ratios of both CO and HCN at different points on the disk, retrieved using a radiative transfer code and assuming reference temperature/pressure vertical profiles. The tropospheric CO content will also be presented, and compared to the stratospheric content.

The mixing ratios spatial variations will be interpreted towards new constraints on the possible sources of CO and HCN in the stratosphere.

4. Figures

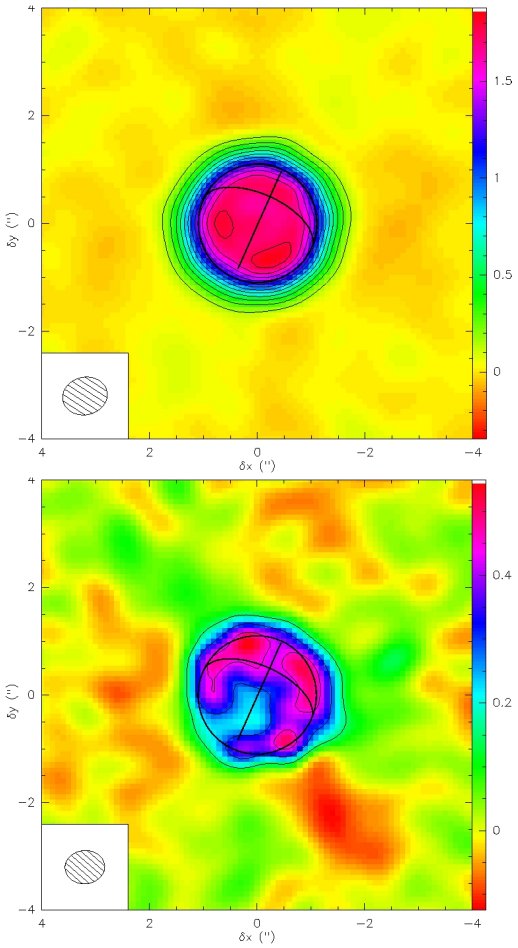

Figure 1: Maps of the integrated stratospheric emission of the CO(3-2) and HCN(4-3) lines (respectively top and bottom panels). The plotted contours correspond respectively to 150 mJy/beam (5 σ) and 90 mJy/beam (3 σ). The continuum emission was subtracted, and the data of the 3 observing dates was merged. The synthesized beam is represented in the bottom left corner. The equator and pole axis are plotted. Sub-earth latitude is of 27°.

References

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