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Spatial distribution of gaseous hydrogen cyanide on Neptune's stratosphere revealed by ALMA

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Abstract

We report the spatially resolved spectroscopic observation result of Neptune's stratospheric hydrogen cyanide (J=4–3) rotational transition at 354 GHz observed with Atacama Large Millimeter/submillimeter Array (ALMA) in April 2016. Spatial resolution and Neptune's angular diameter were 0.4 and 2.24 arcseconds, respectively. The molecular emission was clearly obtained over the Neptune's disk. Latitudinal variation of the integrated intensity that has the strongest peak at the equator was detected. Radiative transfer analysis indicates that the equatorial region has 50% higher column density value than that of 60 S region.

1. Introduction and imaging result

The presence of gaseous hydrogen cyanide (HCN) characterizes Neptune's stratospheric composition.

We analyzed an ALMA archived data of project ID 2015.1.01471.S(PI: R. Moreno), the same project as that of used in [1]. The data includes the HCN (J=4–3) rotational transition at 354.505 GHz. The observation was performed on 11:09 – 11:48, 30 April 2016(UTC) using 41 12–m antennae.

The total bandwidth of the spectral window and the channel spacing were 1875 and 0.977 MHz, respectively. The total observing time of Neptune was 808.1 seconds. The apparent angular diameter of Neptune was 2.24 arcseconds.

The integrated-intensity map and the intensity plot measured at the same emission angle along the 0.95 arcseconds circular arc, which can exhibit the latitudinal intensity variation without the effect of different emission angles, are shown in Figure 1. Eastern and western hemisphere is plotted separately. An interesting feature was found for both hemispheres that the greatest intensity peak is locating at the equator. The lowest intensity values of both hemispheres locate at 70 S – 60 S.

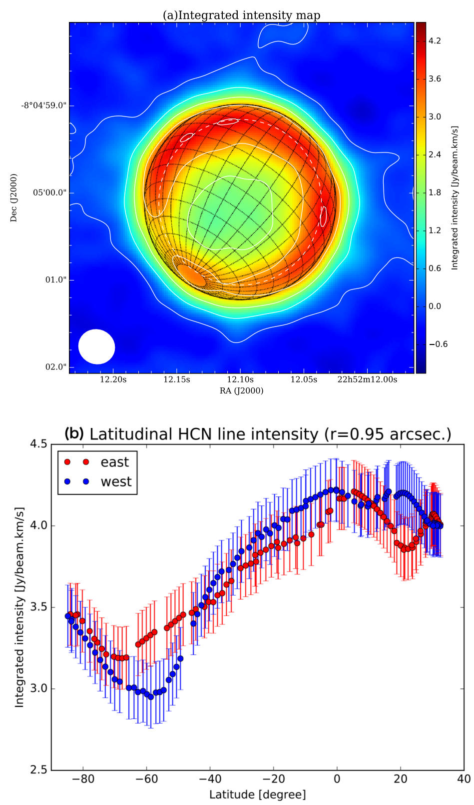

Figure 1: (top) An integrated intensity map of HCN (J=4–3) locates at 354.5 GHz obtained by ALMA. (bottom)Latitudinal variation of HCN integrated intensity for eastern and western hemispheres.

2. Radiative transfer analysis result

The HCN abundance was estimated by searching the best-fit spectrum through radiative transfer calculations. A modeled spatial resolution was 0.175 arcseconds. Figure 2 presents an HCN column density map and a graph summarizing the latitudinal variation. The intensity distribution indicates increased levels of HCN over the equator, such that the equatorial HCN column density is $\sim$50% higher than that in the 60 S region. The calculated disk-averaged column density, mixing ratio and p_0 values were $3.6 \pm 0.6 \times 10^{14}$ molecules cm^{-1}, $0.75^{+0.12}_{-0.13}$ ppb and $1.7\ ^{+0.3}_{-0.4}$ mbar, respectively.

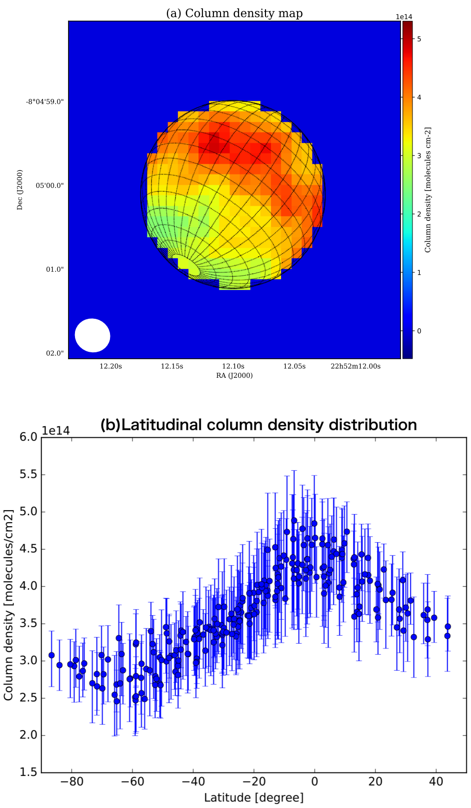

Figure 2: Spatial(top) and latitudinal(bottom) distribution of HCN column density.

3. Summary and Implications

We derived that Neptune's HCN shows non-uniform distribution in the stratosphere. A newly discovered HCN spatial distribution peak shows coincidence with where the downward motion was suggested by mid-IR and cm observations [2]. This coincidence could support a hypothesis that HCN is produced in the stratosphere and transported downwardly on the equator. In addition, a temporal decrease of the stratospheric temperature possibly decreases the HCN abundance.

Acknowledgements

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References

[1] Moreno, R., et al., (2017), Detection of CS in Neptune's atmosphere from ALMA observations. A&A, 608, L5. [2] de Pater, I., et al., (2014). Neptune's global circulation deduced from multi-wavelength observations. Icarus, 237, 211–238.