Hot water molecule around Orion Source I

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We report ALMA observations of submillimeter H_2O lines at bands 6, 7, 8 and 9 toward a massive protostar candidate Source I in the Orion KL region. We detect in total seven H_2O lines including vibrationally ground and excited (ν_2=1) transitions at the highest upper state energy of ~3500 K. Their maps show compact structures associated with a close vicinity to Source I (<200 au). The 321 GHz ($10_{2,9}$-$9_{3,6}$) and 658 GHz (ν_2=1, $1_{1,0}$-$1_{0,1}$) lines show elongated structure along the northeast-southwest bipolar outflow[1,2]. On the other hand, higher excitation transitions such as 336 GHz (ν_2=1, $5_{2,3}$-$6_{1,6}$) and 232 GHz (ν_2=1, $5_{5,0}$-$6_{4,3}$) lines show more compact structures[1], as shown in Figure 1.

All the H_2O line maps show velocity gradients perpendicular to the bipolar outflow indicating rotation motions about the outflow axis. We interpret that the 321 GHz and 658 GHz lines trace the base of the bipolar outflow similar to the vibrationally excited SiO masers[3]. According to their brightness, the 321 GHz and 658 GHz lines are thought to be maser emissions. In contrast, some of the other H_2O lines could be explained via thermal excitation emitted from a midplane of the edge-on hot (~3000 K) molecular gas disk rotating around Source I. Based on the spectral profiles and intensity maps of the detected lines, we will discuss physical and dynamical properties of the hot molecular gas disk around Source I.

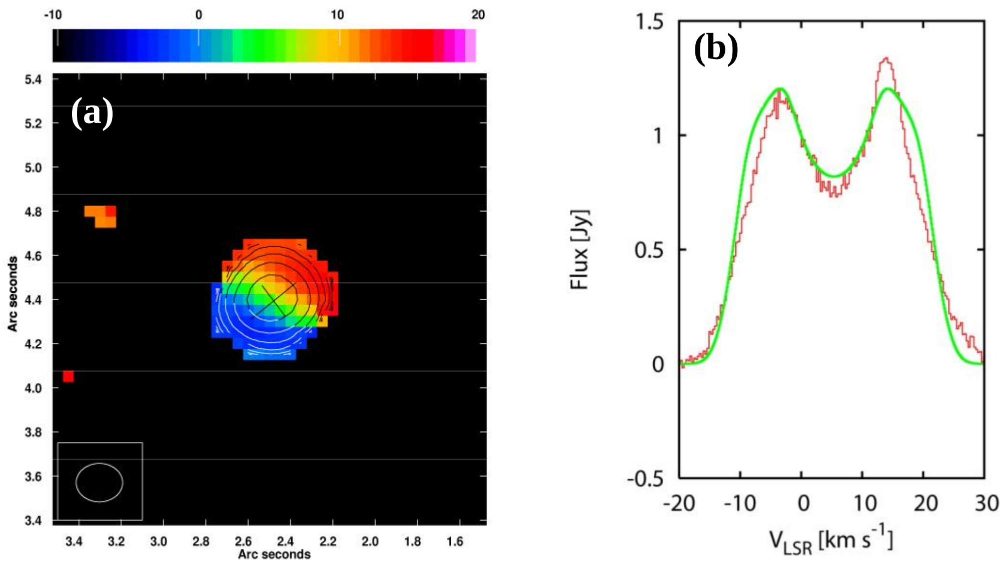

Figure 1: (a) Moment 0 (contour, integrated intensity) and 1 (color scale, peak velocity) maps of the 232 GHz H_2O line. A cross indicates the position of Source I determined from the continuum emission peak.
(b) Observed (red) and model (green) spectra of the 232 GHz H_2O line.

References

[1] T. Hirota, M. K. Kim, Kurono, Y. & M. Honma 2014, ApJL, 782, L28.
[2] T. Hirota, M. K. Kim, & M. Honma 2016, ApJ, 817, 168.
[3] M. K. Kim, T. Hirota, M. Honma, et al. 2008, PASJ, 60, 991.