Hot water molecule around Orion Source I

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We report ALMA observations of submillimeter H$_2$O 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$_2$O lines including vibrationally ground and excited ($v_2$=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 ($v_2$=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 ($v_2$=1, $5_{2,3}$-$6_{1,6}$) and 232 GHz ($v_2$=1, $5_{5,0}$-$6_{4,3}$) lines show more compact structures[1], as shown in Figure 1.

All the H$_2$O 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$_2$O 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$_2$O 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$_2$O line.

References