ALMA Band 7 Observations of Water Lines in the Protoplanetary Disk of V883 Ori

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The FU Orionis star V883 Ori provides a unique opportunity to probe the water snowline in a protoplanetary disk. During an accretion burst, the enhanced stellar luminosity heats the disk, sublimating ices and bringing volatile species into the gas-phase[1],[2],[3],[4]. The water snowline, located at ∼80 au in the midplane[3], represents a key boundary for dust growth and volatile delivery to forming planets.

We present Atacama Large Millimeter/submillimeter Array Band 7 observations of V883 Ori (PI: S. Notsu) that detect two targeted water isotopologue transitions: para-$H_2{}^{18}O$ $5_{1,5}$–$4_{2,2}$ at 322 GHz and HDO $3_{3,1}$–$4_{2,2}$ at 335 GHz. After correcting for Keplerian rotation, we detect HDO and $H_2{}^{18}O$ at 23.6σ and 9.3σ, respectively.

Rotational-diagram analysis using a Markov Chain Monte Carlo approach yields T_{rot} = 116.89 ± 12.81 K and N = (4.90 ± 1.69) × 10^{15} cm^{-2} for $H_2{}^{18}O$, and T_{rot} = 87.46 ± 4.95 K and N = (4.47 ± 0.62) × 10^{15} cm^{-2} for HDO. These results imply water vapor abundances of N_{H2O}/N_{H2} ∼ 3 × 10^{-7}–5 × 10^{-6} and an HDO/H_2O ratio of (0.4–2.0) × 10^{-3} near the snowline, broadly consistent with inheritance from protostellar envelopes.

The HDO line in Band 7 is significantly weaker than predicted from Band 6 extrapolation, showing only ∼26% of the expected strength. This attenuation can be explained by a more compact, hotter emitting region with an effective radius of ∼53 au and/or frequency-dependent dust absorption that enlarges the apparent inner cavity at higher frequency. Our results highlight both the diagnostic power of water isotopologue lines and the need for higher angular-resolution observations to resolve the snowline and test these scenarios.

References

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