Ice Abundances in Comet C/2002 T7

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Abstract

Comets are celestial bodies comprised primarily of rock and ice that are remnants from the planet formation time period of the solar system. They remain frozen in the outer solar system until they are perturbed into an orbit closer to the sun suggesting their composition has remained unchanged since their formation. Consequently, they are important objects to study and provide information into the conditions in the early solar system. We analyzed the ice composition of C/2002 T7. The data were obtained from the CSHELL spectroscope located at the NASA Infrared Telescope Facility in Maunakea, Hawaii. The data were reduced to correct for pixel errors, misalignment, and the effect of Earth's atmosphere. We extracted a spectrum of emission from the comet coma (expanding atmosphere). The molecules analyzed include water, carbon monoxide, methane, methanol, and ammonia. Presented are the emission spectra and abundances relative to water for the May 7 and 8, 2004 observations; the preliminary results from T7 appear to be partially consistent with the ranges of most other comets.

Background & Motivations

The sun was formed from the gravitational collapse of a molecular cloud. Eventually, a protoplanetary disk of ice and dust formed around the sun. This orbiting matter accumulated into other planetesimals such as comets, which were then scattered by the gravity of the Jovian planets. Some of the comets escaped the solar system, although many have become a part of the Oort cloud in the outer solar system. These large-distance comets are mostly unchanged and are unobservable unless forces alter the eccentricity of their paths. As a result, comets that enter the inner solar system are important to study, since their composition yields information into the formation time period of the solar system. Furthermore, some of the molecules analyzed are essential for living organisms. Therefore, cometary research provides insight on how comets might have delivered biomolecules to planets and their role in the development of early life.

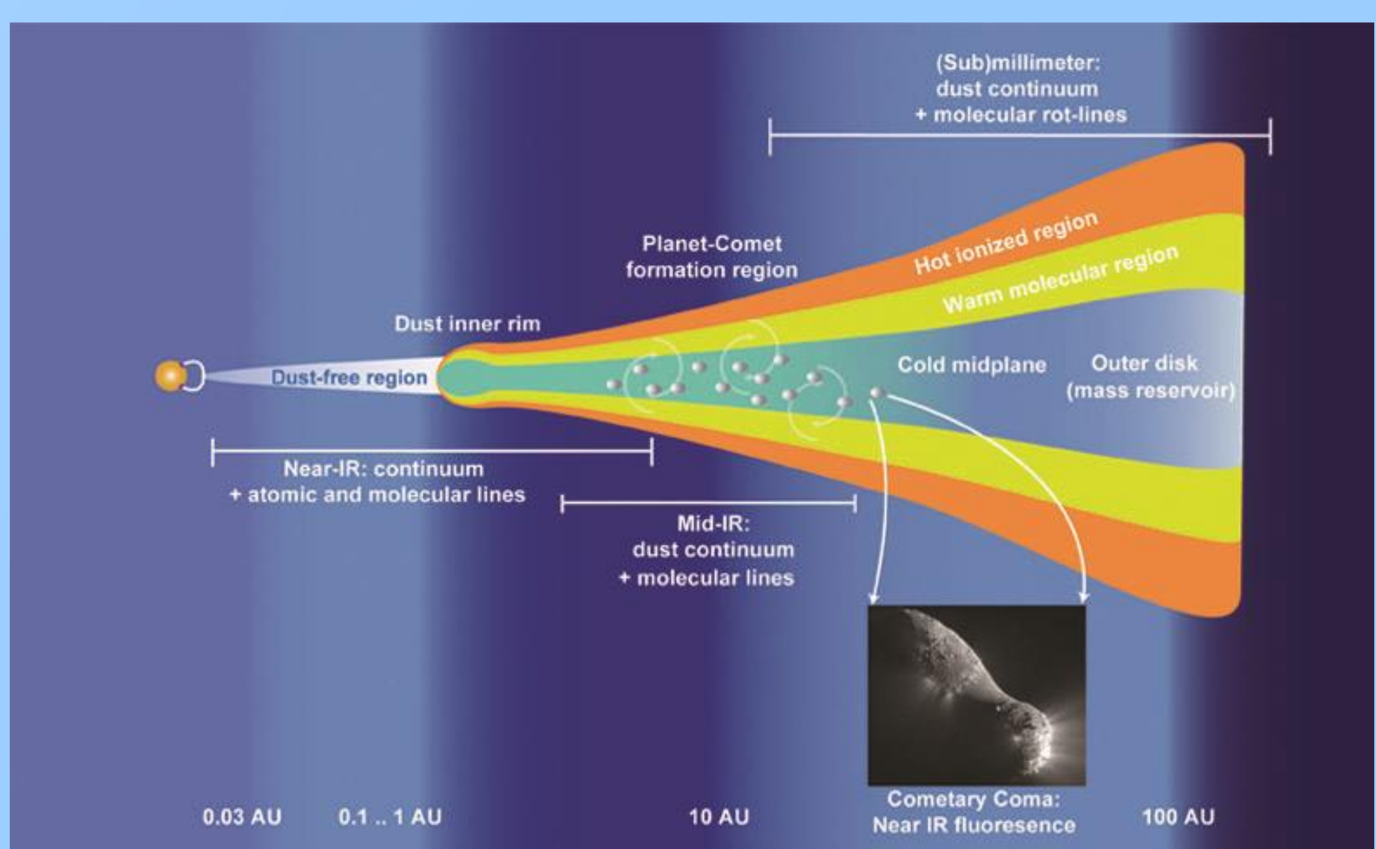

Figure 1 – Image courtesy Geronimo Villanueva, NASA Goddard Space Flight Center

We used the CSHELL spectroscope with a spectral range of approximately $2.40 \times 10^{-3} \times \lambda$ and a maximum resolving power of 30,000. The comet is observed though a slit in two positions. The A and B beams are then subtracted from one another, which leaves the comet visible but removes the sky emission. The resulting AB pairs are then stacked after data-reduction processes, which include dark and flat adjustments, "bad" pixel removals, and continuum alignment by fitting a Gaussian through the spatial direction.

References

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Villanueva et al. 2011, ApJ, 216, 227-240

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Results

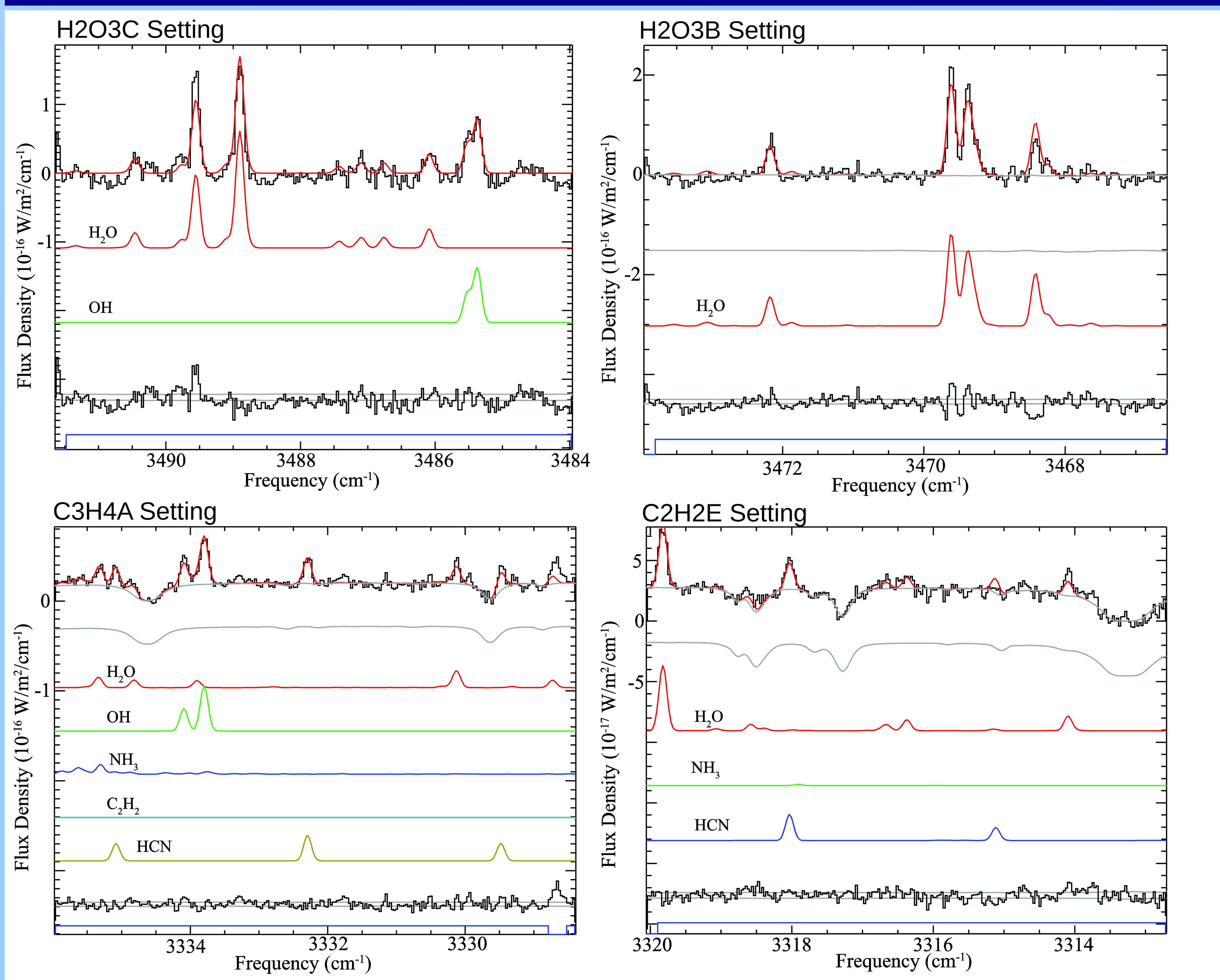

Figure 2 – Emission spectra for settings H2O3B, H2O3C, C3H4A, and C2H2E.

Setting	Molecule	Production Rate (10^{27} molecules $\cdot s^{-1}$)	Relative Abundance (%)
May 7			
H2O3B	H_2O	407.81 ± 25.21	90.54 ± 5.66
H2O3C	OH	1159.61 ± 37.29	257.46 ± 8.60
	H_2O	327.08 ± 28.65	72.62 ± 6.39
May 8			
C2H2E	H_2O	429.80 ± 79.77	95.43 ± 17.73
	NH_3	10.23 ± 0.74	2.27 ± 0.17
	HCN	0.35 ± 0.17	0.08 ± 0.04
C3H4A	H_2O	427.78 ± 67.29	94.98 ± 14.96
	OH	483.77 ± 12.63	107.41 ± 2.97
	NH_3	2.51 ± 0.28	0.56 ± 0.06
	HCN	0.52 ± 0.07	0.12 ± 0.01
	C_2H_2	3.03 ± 0.99	0.67 ± 0.22

Figure 3 – Table of production rates and abundances relative to water of various molecules

Discussions

The results suggest that T7 falls within the "normal" ranges of composition for some molecules. For the May 8 observations, the average relative abundance of NH_3 is 1.42%, compared to 1.5%, or the mean of previously-observed comets (Mumma & Charnley 2011). Other molecules such as H_2O and OH have production rates and relative abundances that mimic previous results. However, several percentages do not fit the "normal" trend, organics enriched, or organics depleted classifications. HCN is lower than 0.25% and C_2H_2 has an abundance of 0.67%, which is significantly higher than its weighted mean of 0.25% (Villanueva et al. 2011). Consequently, further studies are needed to identify the cause of this irregularity. We plan to verify these values with ones from other settings, and then compare the finalized results with other comets again.

Figure 4 – A composite image of T7 over 3-4 days starting April 21, 2004. Credit: Svend and Carl Freytag/Adam Block/NOAO/AURA/NSF