Observations of Interstellar Ices

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The icy grain mantles in dense interstellar and circumstellar environments are formed by a complex interplay of chemical and physical processes. Key questions on the formation and evolution of the ices must be answered by the combination of observations, chemical modeling, and laboratory experiments. Recent infrared (2-30 micron) spectroscopic surveys of large samples of Young Stellar Objects (YSOs) [1] and background stars tracing quiescent cloud material [2] have shown that the ice abundances and absorption band profiles vary considerably as a function of environment. Using laboratory spectra in the identification process (Figure 1), it is clear that a rather complex mixture of simple species (CH3OH, CO2, H2O, NH3, CO) exists even in the quiescent cloud phase. In particular, our discovery of frozen CH3OH in some isolated dense cores, and its absence in others, show that local physical conditions (CO freeze out) and time scales (CH3OH formation) are key factors in the chemistry before star formation occurs. Sublimation and thermal processing of the ices are dominant processes during the YSOs evolution. The identification of several ice absorption features is still disputed. I will outline laboratory work needed to further constrain the ice band identification as well as the thermal and chemical history of the carriers. Such experiments will also be essential to interpret future high spectral resolution SOFIA and JWST observations.

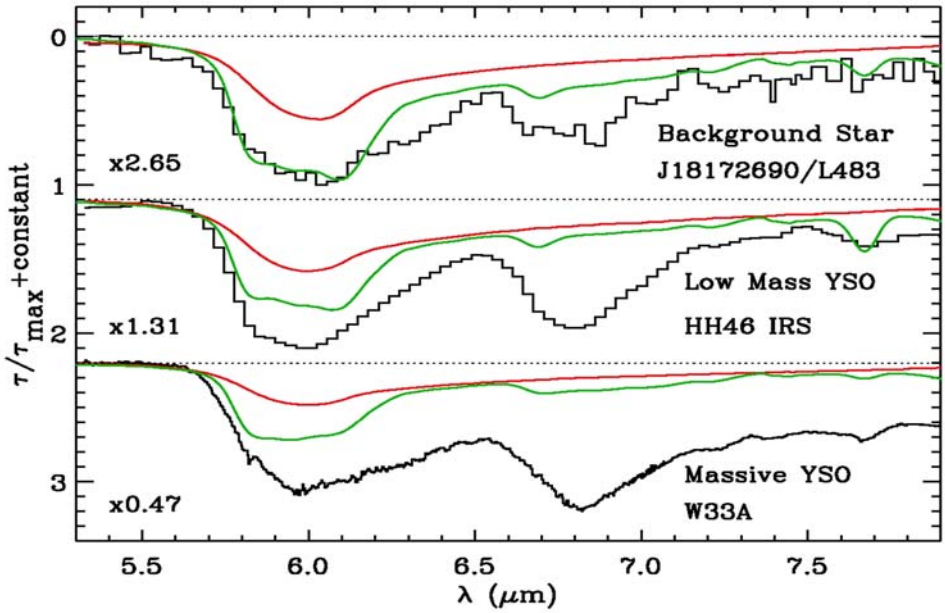

Figure 1: Mid-infrared spectra of a star tracing quiescent cloud material (top), a low mass YSO (middle) and a massive YSO. For each source, the smooth red line is a laboratory spectrum of pure amorphous H2O ice at 10 K. The green line below that includes laboratory spectra of frozen H2O, CH3OH, CH4, CO2, NH3, HCOOH, and H2CO. Clearly, a significant fraction of the absorption remains unexplained.

References

[1] A. Boogert, et al., 2008, ApJ 678, 985.

[2] A. Boogert, et al., 2011, ApJ 729, 92.