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TITLE: The Effects of FUV Radiation on C-Shocks: Implications for Water and Other O-bearing Species

ABSTRACT BODY:

Abstract Body: Protostellar outflows have long been known to drive endothermic reactions that produce high abundances of oxygen-bearing species. Models of shocks in well-shielded gas made the strong prediction that essentially all of the pre-shock oxygen gets driven into water, so that the post-shock water abundances are order 10^{-4}. Herschel observations, however, including those from the key program “Water in Star Forming Regions with Herschel (WISH)” show that for most sources, the shocked gas water abundances of are far lower, 10^{-7} – 10^{-5}.
This pattern of lower-than-predicted water abundance has led us to consider that our C-shock model (Kaufman & Neufeld 1996) is incomplete. In particular, we did not previously take into account that many outflow sources have higher than average far-ultraviolet radiation fields within their outflow cavities. Strong FUV radiation has important effects on the structure of C-shocks: the ionization fraction is larger than in well-shielded gas, decreasing the coupling length between neutrals and ions, and leading to higher temperatures and a lower breakdown speeds; the pre-shock gas composition, including the presence of ice mantles and the dominant charge carriers, is strongly affected; and abundant species such as water are diminished by photodissociation in the cooled down stream gas.
In addition to the normal parameters of density, shock velocity, and magnetic field strength, we now include the external FUV field strength and the extinction between the FUV source and the shock. We use the results of a detailed PDR model to compute pre-shock chemical conditions, including the ionization fraction, the increase of which decreases the maximum velocities of C- shocks. FUV also keeps oxygen in the gas phase, making more available for H_2O formarion ; however, photodissociation beyond the temperature peak keeps the average H_2O abundance down. We present comparisons of our model results with the inferred water abundances and with observations of H_2O, CO, O and OH lines from the Herschel archive.

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