Laboratory Studies of Primordial Chemistry and Implications for First Star Formation

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Abstract.

During the epoch of protogalaxy and first star formation, H_2 was the dominant coolant for collapsing primordial clouds at temperatures below 8,000 K. Hence, a reliable model of H_2 formation and abundance is critical for our understanding of structure formation in the early Universe. The dominant H_2 formation mechanism during this epoch is initially the associative detachment (AD) reaction $H^- + H \rightarrow H_2 + e^-$. There are a number of reactions, however, which limit the H^- abundance available to form H_2. One of the most important of these is the mutual neutralization (MN) reaction $H^- + H^+ \rightarrow H + H$. As a cloud continues to collapse and the density increases, the cloud converts to fully molecular, largely through the three body association (TBA) process $H + H + H \rightarrow H_2 + H$. The energy released by TBA formation of H_2 heats the cloud and can delay collapse of the cloud. Uncertainties in the rate coefficients for all three of these reactions have limited our understanding of structure formation in the early Universe. Here we will report recent measurements which largely remove the uncertainties for the AD and MN reactions. We will also discuss the experimental challenges of attempting to measure the TBA reaction. This work is supported in part by the NSF Division of Astronomical Sciences Astronomy and Astrophysics Grants program.