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Molecular hydrogen formation in the early universe: new implications from laboratory measurements

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Molecular hydrogen plays a central role in the cooling of primordial gas and the formation of the first stars and galaxies. The creation of molecular hydrogen in the early universe during the epoch of first star formation proceeds predominantly through the associative detachment (AD) reaction $H^- + H \rightarrow H_2 + e^-$. Despite being the most fundamental anion-neutral reaction in physics and chemistry, no agreement has yet been reached between theory and experiment for this process. The uncertainty in the H_2 creation rate severely limits our understanding of the formation of the first stars and protogalaxies. To address this issue we have developed a new merged beams apparatus to measure the H_2 AD rate coefficient as a function of the collision energy. Kinematical compression for fast velocity-matched beams allows us to achieve collision energies from 4meV to 1eV. We will describe the experimental approach and present the first energy-resolved measurement of the H_2 associative detachment reaction which we use to derive an experimentally confirmed thermal rate coefficient. We will also present the results of new cosmological models, demonstrating the implications of our measurements for the evolution of primordial gas in an initially ionized protogalactic halo.