Progress Towards Laboratory Measurements of H_2 Formation for Early Universe Chemistry

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We are developing a novel apparatus at the Columbia Astrophysics Laboratory to study anionneutral reactions. Our initial measurements with this apparatus will be of the associative detachment (AD) reaction $H^- + H \rightarrow H_2^- \rightarrow H_2 + e^-$.

During the epoch of first star and protogalaxy formation, this is the dominant formation mechanism of the important primordial cloud coolant H_2. Published values for this AD process differ by nearly an order of magnitude. This introduces uncertainties into cosmological models of structure formation. For example, recent modeling studies have shown that the effect is particularly large for protogalaxies forming in previously ionized regions, affecting predictions of whether or not a given protogalaxy can cool and condense within a Hubble time, and altering the strength of the ultraviolet background that is required to prevent collapse (Glover, Savin, & Jappsen 2006, ApJ, 640, 553).

To study this reaction in the laboratory, we begin with an anion beam and will use photodetachment to generate a self-merged, anion-neutral beams arrangement. Laboratory beam energies are in the keV range. Because the beams are co-propagating, center-of-mass energies from the meV to keV range will be achievable. We will observe the AD reaction by detecting fast H_2^+ ions formed through ionizing collisions of the AD-generated H_2 with the background gas in the vacuum chamber. Here we present the current status of the project and discuss our future plans.