HYDROGEN MOLECULES AND THE RADIATIVE COOLING OF PREGALACTIC SHOCKS

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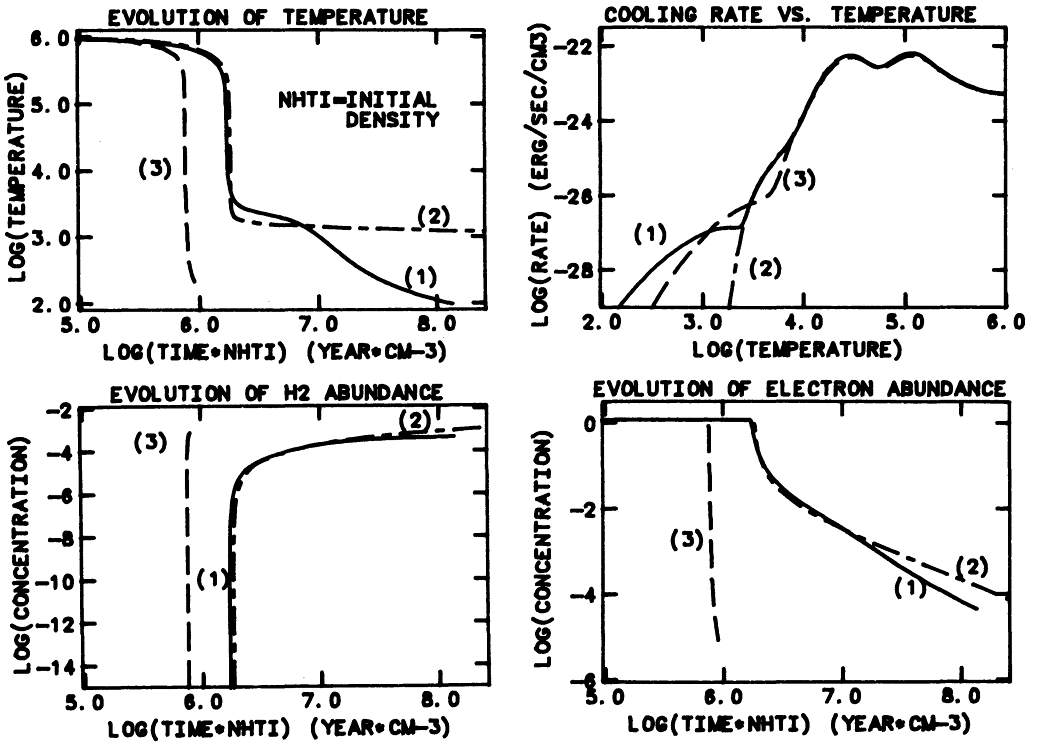
When a pregalactic gas of H and He is heated and reionized, as by a shock wave occurring in the nonlinear collapse of density fluctuations or in the case of explosions in the IGM, the gas cools radiatively and recombines out of equilibrium. The temperature drops faster than the ions can recombine. When the temperature falls below 10^4K, the residual electron concentration is large enough, as a result, to form H^- ions which form H_2 molecules, via $(H + e \rightarrow H^- + h\nu)$ and $(H + H^- \rightarrow H_2 + e)$. Molecules also form via $(H^+ + H \rightarrow H_2^+ + h\nu)$ and $(H_2^+ + H \rightarrow H_2 + H^+)$. As a consequence, H_2 can form with a sufficient concentration ($\sim 10^{-3}$) to cool the gas further, by rot-vibrational line excitation and the formation process itself, to $\sim 10^2$K. This has an important effect on the Jeans mass and fragmentation. We show some illustrative results below for the time-dependent cooling and non-equilibrium recombination and molecule formation. The three cases are as follows: (1) isochoric cooling at hydrogen number density 1 cm^{-3}; (2) isochoric cooling at 3×10^7 cm^{-3}; (3) isobaric cooling starting at initial density 1 cm^{-3}. At high densities, molecular cooling is suppressed.



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