# Stabilization and Formation of Primordial Hydrogen in Non-Perturbative $QED_2$

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While hydrogen formation is usually described through effective recombination kinetics, the real-time emergence and stabilization of a neutral atomic bound state from the quantum vacuum is fundamentally a non-perturbative phenomenon. In this work, we investigate the stabilization and formation of primordial hydrogen within a non-perturbative formulation of $QED_2$. Rather than modeling cosmological recombination directly, we consider a quantum quench in which a localized structureless charge +e, representing the sudden appearance of a proton-like source, is introduced into the vacuum. We then follow the ensuing non-equilibrium dynamics of the coupled fermion-gauge system and analyze the emergence of screening through the Schwinger process, stabilization and bound-state formation through radiative damping. While derived in a 1+1-dimensional setting of quantum electrodynamics, the results provide a first-principles, non-perturbative picture of how a hydrogen-like atomic configuration emerges dynamically around a localized charge source, and offer fresh insight into the dynamical origin and interpretation of the atomic ground state.