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Plasma Environment for Thermal Nuclear Reactions in Nucleosynthesis

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We examine the effects of plasma on nucleosynthesis and propose methods to directly measure thermal nuclear reactions under astrophysical conditions, accounting for plasma effects. These effects are incorporated by solving the Boltzmann equation for photons, addressing both longitudinal and transverse components, which alter the dielectric properties and susceptibility of plasmas composed of ions and dense electrons. As a manifestation of plasma-induced dynamical screening, we derive a modified Gamow factor by revisiting the conventional assumptions used in its formulation.

Our analysis reveals that the traditional Gamow factor assumption is invalid for light nuclei, leading to penetration probabilities (PPs) that depend on the nuclear potential depth for such nuclei. By using potential depths calibrated to experimental fusion cross-section data, we show that PPs for light nuclei—such as D+D, D+T, D+3^33He, p+D, p+6^66Li, and p+7^77Li—are significantly enhanced compared to predictions from the conventional form, particularly near the Coulomb barrier. This enhancement reduces the Gamow peak energy by a maximum factor of 5.3 relative to the standard model.

These findings have important implications for determining the accessible energy range in low-energy nuclear reaction experiments based on the Gamow peak energy and for understanding electron screening effects in typical astrophysical environments.

Consent

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