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Incorporating thermal effects into alpha decay half-life calculations for nucleosynthesis investigations

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Theoretical models aiming to accurately reproduce observed nuclear abundances require complex calculations utilizing nuclear reaction networks. These networks encompass the nature of nuclear reactions and decays, accounting for both the production and destruction of nuclei. The explosive conditions in r-process sites, where temperatures rise to the order of Giga Kelvin, may lead to nuclei existing in excited states. While the effects of nuclear thermal excitations are typically considered in processes like neutron capture and photon disintegration, a similar treatment is often overlooked in the case of alpha decay. Instead, information regarding decay modes is typically derived from measurements conducted on Earth, where nuclei predominantly reside in their ground state. However, it is crucial to account for the temperature dependence of nuclear decay rates of alpha emitters. The standard formulation is achieved by summing over the half-lives of excited states of a nucleus for a specific type of decay. To facilitate a comprehensive investigation into the role of alpha decay half-lives of thermally excited nuclei in nucleosynthesis calculations, we propose an empirical formula. This formula, derived from a model for the alpha decay half-lives of excited nuclei via fitting available data, will serve to incorporate temperature-dependent half-life calculations into nucleosynthesis models.

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