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Exotic proton decays and the GUT Models

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In the first part we discuss exotic proton decay processes within grand unification that are characterized by non-minimal embeddings of the Standard Model matter fields within the irreducible representations of the grand unified group. We take $SU(7)$ as the grand unified group and allow for different options for the dominant proton decay processes, depending on the details of the $SU(7)$ symmetry breaking and the embedding of the quarks and leptons in $SU(7)$ multiplets.

Proton decay scenarios include: two-body processes via $B + L$ or $B - L$ conserving channels, three-body processes, or the proton can be made exactly stable.

All nonzero proton decay processes appear at one or higher loop orders, with exotic states in the loops that are odd with respect to an emergent Z_2 symmetry, similar to scotogenic scenarios for neutrino masses. The approach also allows for several possible dark matter candidates and a variety of possible scenarios for the neutrino sector.

In the second part , we explore scenarios within grand unification in which proton decay can be suppressed and possibly eliminated due to novel embeddings of the Standard Model matter fields into irreducible representations of the grand unified group and residual symmetries.

The scenarios are based on an $SU(7)$ gauge group, in which the matter fields are embedded within an anomaly-free set of fields that can be realized as a natural subgroup of the fundamental spinor representation of an $SO(14)$ gauge symmetry.

Depending on the embedding, proton decay can either be forbidden at tree level and generated via one-loop diagrams, or the proton can be made stable by forcing it to decay channels that must have an even number of leptons, independently of the bosonic content of the theory. We describe the theoretical and phenomenological implications of such scenarios, including their implications for dark matter and neutrino masses.

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