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Relaxing Cosmological Neutrino Mass Bounds with Unstable Neutrinos

At present, cosmological observations set the most stringent bound on the neutrino mass scale. Within the standard cosmological model (ΛCDM), the Planck collaboration reports $\sum m_\nu < 0.12\,\mathrm{eV}$ at 95 % CL. This bound, taken at face value, excludes many neutrino mass models. However, unstable neutrinos, with lifetimes shorter than the age of the universe $\tau_\nu \leq \tau_U$, represent a particle physics avenue to relax this constraint. Motivated by this fact, we present a taxonomy of neutrino decay modes, categorizing them in terms of particle content and final decay products. Taking into account the relevant phenomenological bounds, our analysis shows that 2-body decaying neutrinos into BSM particles are a promising option to relax cosmological neutrino mass bounds. We then build a simple extension of the type I seesaw scenario by adding one sterile state ν_4 and a Goldstone boson φ, in which $\nu_i \to \nu_4 \varphi$ decays can loosen the neutrino mass bounds up to $\sum m_\nu \sim 1\,\mathrm{eV}$, without spoiling the light neutrino mass generation mechanism. Remarkably, this is possible for a large range of the right-handed neutrino masses, from the electroweak up to the GUT scale. We successfully implement this idea in the context of minimal neutrino mass models based on a $U(1)_{\mu-\tau}$ flavor symmetry, which are otherwise in tension with the current bound on $\sum m_\nu$.

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