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On the Tau flavor of the cosmic neutrino flux

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Observation of high energy cosmic neutrinos by ICECUBE has ushered in a new era in exploring both cosmos and new physics beyond the Standard Model (SM). In the standard picture, although mostly ν_μ and ν_e are produced in the source, oscillation will produce ν_τ {\it en route}. Certain beyond SM scenarios, like interaction with ultralight DM can alter this picture. Thus, the flavor composition of the cosmic neutrino flux can open up the possibility of exploring certain beyond the SM scenarios that are inaccessible otherwise. We show that the τ flavor holds a special place among the neutrino flavors in elucidating new physics. Interpreting the two anomalous events observed by ANITA as ν_τ events makes the tau flavor even more intriguing. We study how the detection of the two tau events by ICECUBE constrains the interaction of the neutrinos with ultralight dark matter and discuss the implications of this interaction for even higher energy cosmic neutrinos detectable by future radio telescopes such as ARA, ARIANNA and GRAND. We also revisit the $3+1$ neutrino scheme as a solution to the two anomalous ANITA events and clarify a misconception that exists in the literature about the evolution of high energy neutrinos in matter within the $3+1$ scheme with a possibility of scattering off nuclei.
We show that the existing bounds on the flux of ν_τ with energy of EeV rules out this solution for the ANITA events. We show that the $3+1$ solution can be saved from both this bound and from the bound on the extra relativistic degrees of freedom in the early universe by turning on the interaction of neutrinos with ultralight dark matter.

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