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Time modulation of nuclear decays deep-underground as a probe of axion dark matter

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We investigate the time modulation of alpha and weak nuclear decays as a method to probe axion dark matter. To this end, we develop a theoretical framework to compute the θ-dependence of alpha and weak nuclear decays, including electron capture and β decay, which enables us to predict the time variation of alpha and weak radioactivity in response to an oscillating axion dark matter background. As an application, we recast old data sets, from the weak nuclear decays of ^{40}K and
$ce^{137}Cs$ taken at the underground Gran Sasso Laboratory, in order to set constraints on the axion decay constant, specifically in the axion mass range from few 10^{-23} eV up to 10^{-19} eV. We finally propose a set of new measurements at the Gran Sasso Laboratory, based on the weak nuclear decay of ^{40}K via electron capture and on the alpha decay of ^{241}Am, in order to explore even shorter timescales, thus reaching sensitivities to axion masses up to 10^{-9} eV.

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