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Neutrinos and gamma rays from long-lived mediator decays in the Sun

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We investigate a scenario where dark matter (DM) particles can be captured and accumulate in the Sun, and subsequently annihilate into a pair of long-lived mediators. These mediators can decay further out in the Sun or outside of the Sun. Compared to the standard scenario where DM particles annihilate directly into Standard Model particles close to the solar core, here we also obtain fluxes of gamma rays and charged cosmic rays. We simulate this scenario using a full three-dimensional model of the Sun, and include interactions and neutrino oscillations. In particular, we perform a model-independent study of the complementarity between neutrino and gamma ray fluxes by comparing the recent searches from IceCube, Super-Kamiokande, Fermi-LAT, ARGO and HAWC.

We find that the resulting neutrino fluxes are significantly higher at high energy when the mediators decay further out in the Sun. We also find that gamma ray searches place stronger constraints than neutrino searches on these models even in cases where the mediators decay mainly inside the Sun, except in the approximately inner 10% of the Sun where neutrino searches are more powerful. We present our results in a model-independent manner and release a new version of the WimpSim code that can be used to simulate this scenario for arbitrary mediator models.

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