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FIMP Dark Matter from Flavon Portals

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We investigate the phenomenology of a non-thermal dark matter (DM) candidate in the context of flavor models that explain the hierarchy in the masses and mixings of quarks and leptons via the Froggatt-Nielsen (FN) mechanism. A flavor-dependent $U(1)_{FN}$ symmetry explains the fermion mass and mixing hierarchy, and also provides a mechanism for suppressed interactions of the DM, assumed to be a Majorana fermion, with the Standard Model (SM) particles, resulting in its FIMP (feebly interacting massive particle) character. Such feeble interactions are mediated by a flavon field through higher dimensional operators governed by the $U(1)_{FN}$ charges. We point out a natural stabilizing mechanism for the DM within this framework with the choice of half-integer $U(1)_{FN}$ charge n for the DM fermion, along with integer charges for the SM fermions and the flavon field. In this flavon portal scenario, the DM is non-thermally produced from the decay of the flavon in the early universe which becomes a relic through the freeze-in mechanism. We explore the allowed parameter space for this DM candidate from relic abundance by solving the relevant Boltzmann equations. We find that reproducing the correct relic density requires the DM mass to be in the range (100–300) keV for n = 7.5 and (3–10) MeV for n = 8.5 where n is the $U(1)_{FN}$ charge of the DM fermion.

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