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Dark pions as FIMP dark matter in $Sp(2N_c)$ gauge theory

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We study a dark $Sp(2N_c)$ gauge theory with $N_f = 2$, in which the symmetry breaking $SU(4) \to Sp(4) \simeq SO(5)$ gives rise to five dark pions: two charged under a $U(1)'$ and three neutral. The only portal to the Standard Model is kinetic mixing, ϵ, between the dark photon and the Standard Model photon. For sufficiently small ϵ, the dark pions are produced through the freeze-in mechanism and constitute feebly interacting massive particle (FIMP) dark matter. We study the parameter space $(m_{\gamma'}, \epsilon, \alpha')$ that reproduces the observed relic density while remaining consistent with existing constraints from dark photon searches.

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