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Scale-invariant scalar field dark matter through the Higgs portal

We discuss the dynamics and phenomenology of an oscillating scalar field coupled to the Higgs boson that accounts for the dark matter in the Universe. The model assumes an underlying scale invariance such that the scalar field only acquires mass after the electroweak phase transition, behaving as dark radiation before the latter takes place. While for a positive coupling to the Higgs field the dark scalar is stable, for a negative coupling it acquires a vacuum expectation value after the electroweak phase transition and may decay into photon pairs, albeit with a mean lifetime much larger than the age of the Universe. We explore possible astrophysical and laboratory signatures of such a dark matter candidate in both cases, including annihilation and decay into photons, Higgs decay, photon-dark scalar oscillations and induced oscillations of fundamental constants. We find that dark matter within this scenario will be generically difficult to detect in the near future, except for the promising case of a 7 keV dark scalar decaying into photons, which naturally explains the observed galactic and extra-galactic 3.5 keV X-ray line.

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