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Early kinetic decoupling of dark matter and the Higgs invisible decay in collider experiments

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We revisit the Higgs-to-invisible decay ratio in Higgs-portal dark matter models. The Higgs-to-invisible decay searches are powerful probes of the models with increasing sensitivity in upcoming colliders. Close to the mass threshold of a Higgs decay into a pair of DM particles, the coupling value is expected to be very small in order to be compatible with the observed value of the thermal relic abundance. This small coupling perfectly fits with the current status of Higgs-to-invisible constraints and direct detection experiments, such as the XENON1T experiment. At the same time, the small coupling implies a lower DM scattering rate with particles in the early Universe plasma. The suppression of the scattering rate makes the kinetic decoupling happens earlier. Thus, the standard assumption in many relic abundance computations, namely the local thermal equilibrium, is not justified during the freeze-out process. We reanalyze Higgs-portal DM models, such as the Scalar-Singlet and a fermion DM model, taking the new effect of early kinetic decoupling in the relic abundance computation into account. Our results show that a larger value of the DM coupling to the Higgs is allowed. Therefore, current and future Higgs-to-invisible decay searches can generically probe more of the parameter space than previously expected.

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