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Collider and early-Universe interactions of dark matter in Higgs-portal models

(abstract)

This dissertation is devoted to interactions of Higgs-portal dark matter in the early Universe and at particle colliders. After recalling the most relevant cosmological concepts, including the Boltzmann equation and the freeze-out mechanism, we provide a short review of dark matter physics: evidence and candidates (chapter 3), and experimental searches (chapter 4).

Chapters 5 and 6 contain original results. The former discusses the issue of *t*-channel singularity: a phenomenon affecting processes with a massive, stable *t*-channel mediator on its mass shell.. An occurrence of that issue leads to singularity of the matrix element describing the process, which results in an infinite value of the corresponding cross section. After determining the strict condition for the singularity to occur in a given $2 \to 2$ process, we propose a regularization mechanism, which is based on interactions between the would-be singular mediator and the surrounding gas of particles. Those interactions limit the lifetime of the mediator, allowing to introduce an effective decay width, which regularizes the would-be-singular cross section. Chapter 6 presents a study of production of dark particles at the future e+e- colliders, operating at energies maximizing the cross section of the Higgs-strahlung process (around 240–250 GeV).. We take into account the present limits, constraining the parameter space of the DM models employed, and estimate the maximal possible production cross section. The conclusion is that although the models of DM are severely constrained by the null-results of the present and past experimental searches, the dark particles could be efficiently produced and detected at the future colliders if the values of the parameters are close to the optimal ones. Moreover, in that chapter, we investigate the influence of the spin of the dark particle on production rate: although all three analysed models of dark matter provide a similar maximal production cross section (at the level of 60 fb), the shape of the allowed parameter space differs depending on the spin, which, in principle, could enable to disentangle the cases of dark particles of different spins from each other.

The models of dark matter employed in this dissertation are fully consistent, renormalizable Higgs-portal models. Along with some details of calculations performed throughout the thesis, they are described in the appendices.