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Accurate estimate of the relic density and the kinetic decoupling in non-thermal dark matter models

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Non-thermal dark matter generation is an appealing alternative to the standard paradigm of thermal WIMP dark matter. We reconsider non-thermal production mechanisms in a systematic way, and develop a numerical code for accurate computations of the dark matter relic density. We discuss in particular scenarios with long-lived massive states decaying into dark matter particles, appearing naturally in several beyond the standard model theories, such as supergravity and superstring frameworks. Since non-thermal production favors dark matter candidates with large pair annihilation rates, we analyze the possible connection with the anomalies detected in the lepton cosmic-ray flux by Pamela and Fermi. Concentrating on supersymmetric models, we consider the effect of these non-standard cosmologies in selecting a preferred mass scale for the lightest supersymmetric particle as dark matter candidate, and the consequent impact on the interpretation of new physics discovered or excluded at the LHC. Finally, we examine a rather predictive model, the G2-MSSM, investigating some of the standard assumptions usually implemented in the solution of the Boltzmann equation for the dark matter component, including coannihilations. We question the hypothesis that kinetic equilibrium holds along the whole phase of dark matter generation, and the validity of the factorization usually implemented to rewrite the system of coupled Boltzmann equations for each coannihilating species as a single equation for the sum of all the number densities which also allows to compute the kinetic decoupling temperature in case of coannihilating particles. This formalism can be applied also to other particle physics frameworks, and also to standard thermal relics within a standard cosmology.

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