



Contribution ID: 196

Type: **Presentation**

FIMP realization of the scotogenic model

Friday 27 June 2014 17:00 (15 minutes)

The scotogenic model is one of the simplest scenarios for physics beyond the Standard Model that can account for neutrino masses and dark matter at the TeV scale. It contains another scalar doublet and three additional singlet fermions (N_i), all odd under a Z_2 symmetry. We examine the possibility that the dark matter candidate, N_1 , does not reach thermal equilibrium in the early Universe so that it behaves as a Feebly Interacting Massive Particle (FIMP). In that case, it is found that the freeze-in production of dark matter is entirely dominated by the decays of the odd scalars. We compute the resulting dark matter abundance and study its dependence with the parameters of the model. The freeze-in mechanism is shown to be able to account for the observed relic density over a wide range of dark matter masses, from the keV to the TeV scale. In addition to freeze-in, the N_1 relic density receives a further contribution from the late decay of the next-to-lightest odd particle, which we also analyze. Finally, we consider the possibility that the dark matter particle is a WIMP but receives an extra contribution to its relic density from the decay of the FIMP (N_1). In this case, important signals at direct and indirect detection experiments are generally expected.

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Session Classification: Particle Physics

Track Classification: Particle Physics