Jonas Schräpler (Georg-August-Universität Göttingen)

A Two-Scalar Model for WIMP Dark Matter

By conducting observations over all cosmological scales, evidence has been accumulating, suggesting that dark matter (DM) is a main component of our cosmos, contributing large parts of the energy density. This project aims to study a possible model for the evolution of DM. For new models, it is often best to start with minimal extensions to well established ones. The common approach in cosmology is to extend the standard model (SM) of particle physics, describing the fundamental particles and their interaction, by adding one or more particles. These particles are chosen to have certain properties to be in accordance with what we expect DM particles to look like. The properties are commonly a small interaction with the SM-sector (this ensures they are “dark” w.r.t our detectors), a low velocity (i.e. non-relativistic, or cold), and sufficiently heavy to make up much of the energy content. DM obeying this particular set of properties is called WIMP-Dark-Matter (Weakly Interacting Massive Particle). After one particle extensions were strongly constrained by direct and indirect detection endeavours, we consider in this project a two particle extension, following the WIMP framework. Typically, in this framework, the DM populations during early cosmological times are kept in thermal equilibrium through collisions. They are forced out of equilibrium, however, due to expansion diluting the number of particles per volume, reducing the probability of collisions. This process is called freeze-out. After freeze-out, we observe a relic density of dark matter, to which we compare our results. The relic density dictates how much a particle population contributes to the total energy density; its evolution over time is described by the model's Boltzmann equations. We probe the relic density of a Two Real Scalar WIMP Model in the assisted freeze-out framework (i.e. only one Particle interacts with the SM) by conducting a numerical analysis of the coupled Boltzmann equations and the associated parameter space; using a simple Runge-Kutta 2 adaptive step integrator. We want to further probe promising parts of the parameter space, where the two-scalar model was shown to evade direct detection constraints, by providing more degrees of freedom. We want to show that the model produces viable dark matter (DM) candidates for a range of parameters and compare our results to previous calculations. Then we want to allow for new interaction channels, by allowing co-annihilation.