Abstract

WIMPs have not yet been seen via direct detection, indirect detection, or in collider searches. Perhaps now is a good time to consider alternate mechanisms for DM production.

We investigate a new production mechanism for dark matter that consists of both a non-thermal freeze-in component as well as a hidden sector freeze-out.

Spoiler Alert!

Enhancement of the final yield can occur due to the relative importance of the (UV) freeze-in operator at LATE TIMES!

Model

Fermionic Higgs Portal

\[-\mathcal{L} \supset \frac{1}{M} |H|^2 \bar{\psi} \psi\]

- Non-renormalizable operator
- Produces DM via freeze-in at the earliest (UV) temperatures
- Typically assumed to become inefficient as DM cools off.

Hidden Vector Boson Interaction

\[-\mathcal{L} \supset \bar{\psi}(iD_\mu \gamma_\mu)\psi\]

- Introduces a secondary interaction mechanism for DM
- Depletes DM via hidden freeze-in.
- Can UV transfer re-populate the hidden sector while this occurs?

Boltzmann Equation

The relative strengths of various terms in this equation determine how effective late time UV freeze-in will be.

\[\dot{n} = -3Hn + \langle \sigma v \rangle_{ann} \left( n_{EQ}(T_x)^2 - n^2 \right) + N_{\psi} \langle \sigma v \rangle_{tr} \left( n_{EQ}(T)^2 - n^2 \right)\]

- Universe is always expanding.
- Typical freeze-out interaction:
  - Entirely set by hidden sector dynamics.
- UV freeze-in interaction:
  - Entirely set by visible sector dynamics.

\[\frac{\Omega_x h^2}{T} < 1\]