Effects of Phase Transitions on Dark Matter production

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Background

- Standard Model doesn't explain Dark Matter or neutrino masses
- Neutrino masses can be explained using the 'seesaw' mechanism:

$$m_\nu = -m_D M_M^{-1} m_D^T.$$

- At keV mass, sterile neutrinos could be 'warm' Dark Matter (explaining small-scale structure formation issues with ΛCDM).
  - e.g. Missing Satellites

The Production Process

- Start with Higgs decay into an intermediate dark-sector scalar ϕ
  - These interactions do not thermalise, but self-scattering of ϕ leads to equilibrium temperature $T_\phi < T$.
- Then the ϕ can decay into the sterile neutrinos, N.
  - These may or may not thermalise to the temperature T_ϕ.

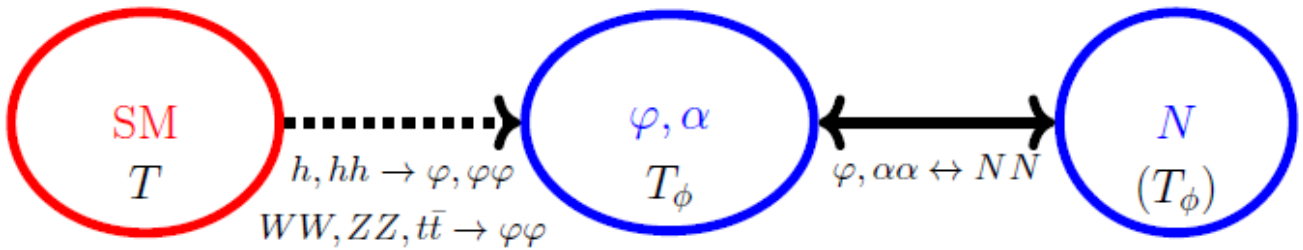

Figure: Sterile Neutrino Production Process

Thermal Corrections

- Perturbative thermal field theory on $\phi \rightarrow$ corrected mass, dependent on T.
  - First order: $m^2 \rightarrow m^2 - \frac{\lambda T^2}{12}$.
  - Alternatively, $T_c = m\sqrt{\frac{12}{\lambda}}$.
- Corrected mass affects the cross-section for both the $h - \phi$ and $\phi - N$ interactions.

Summary

- Motivation to produce sterile neutrinos
  - Neutrino mass problem
  - Warm Dark Matter
- Standard Model particle (h) produces the sterile neutrinos (N) through an intermediate dark scalar (ϕ).
- Can correct the resulting cross-sections using perturbative thermal field theory across phase transitions.