Queen Mary University of London

The Dawn of FIMP Dark Matter

Tommi Tenkanen
in collaboration with
N. Bernal, M. Heikinheimo, K. Tuominen, and V. Vaskonen

Queen Mary University of London

Talk based on arXiv: 1706.07442
(+ 1506.04048, 1601.07733, 1604.02401, 1607.01379, 1704.05359, 1711.07344, 1801.03089, 1803.08064, 1806.11122...)

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E-mail: t.tenkanen@qmul.ac.uk

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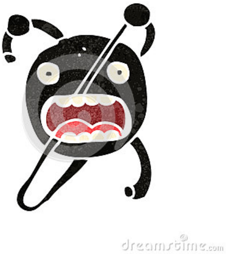
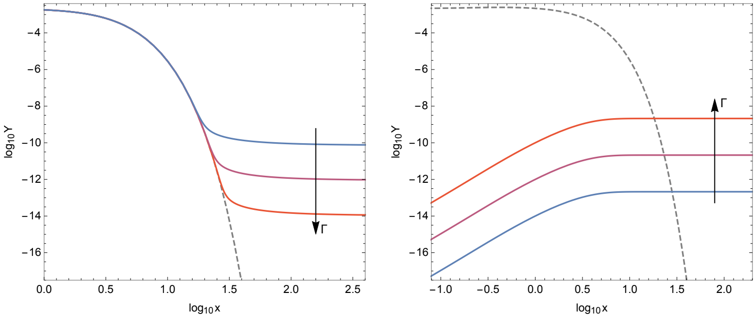


- Are they WIMPs, FIMPs, SIMPs, GIMPs, PIDMs, WISPs, ALPs, Wimpzillas, or sterile neutrinos?

Dark Matter production mechanisms

- There are basically two mechanisms for dark matter production: freeze-out and freeze-in



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- May lead to a WIMP miracle: thermal relic with a weak scale cross-section and a mass $m \sim \mathcal{O}(10^2)$ GeV gives the correct relic abundance.
- Starts to be very constrained by experiments

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- In the simplest case almost impossible to test by colliders and direct detection experiments (exceptions exist; see e.g. 1506.07532 and 1807.05022)
- However, can be tested especially by cosmological and astrophysical observations, including indirect detection

  (see e.g. 1801.03089)

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- One can introduce a sterile neutrino, or introduce a "dark Higgs" which is a complex doublet of some hidden (gauge) symmetry, and so on
- Other models include supersymmetric particles, (pseudo-)Goldstone bosons, massive gravitons, ...

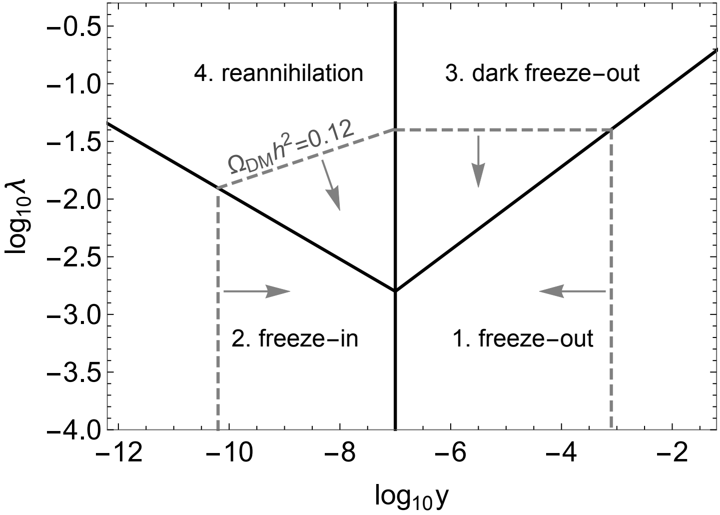
Review of freeze-in scenarios

- See arXiv: 1706.07442

The Dawn of FIMP Dark Matter: A Review of Models and Constraints

Nicolás Bernal,[a,b] Matti Heikinheimo,[c] Tommi Tenkanen,[d] Kimmo Tuominen[c] and Ville Vaskonen[e]

Thermal History of Dark Matter: a phase diagram



Thermal history of the Hidden Sector: a simple example

- An initial population of DM is produced through Higgs decays $h \to SS$ at $T \sim m_{\rm h}$. In the standard freeze-in scenario, this is also the final abundance.

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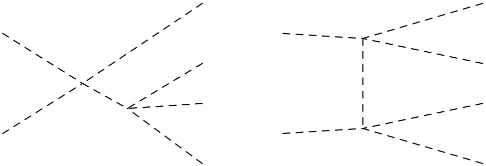
- This reduces temperature of DM particles and increases their number density until thermal equilibrium is reached

Dark Freeze-out

- The $SS \leftrightarrow SSSS$ interactions maintain thermal equilibrium until the $SSSS \rightarrow SS$ interaction rate drops below the Hubble rate and the number density freezes out



Examples of number-changing interactions.

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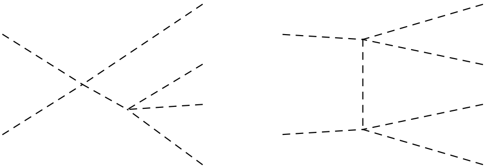
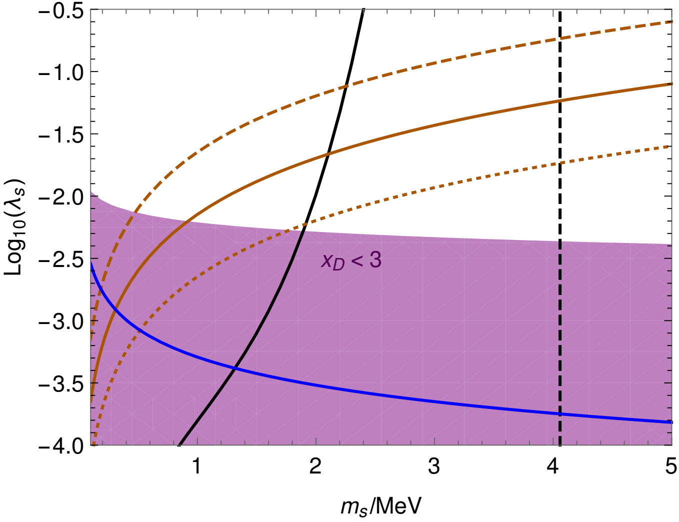


Examples of number-changing interactions.

- This mechanism is referred to as dark freeze-out

Effect on abundance



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- The FIMP framework provides for a compelling alternative to the standard WIMP paradigm
- Freeze-in models have a rich phenomenology (dark freeze-out, reannihilation...)
- Especially cosmological and astrophysical observations provide a valuable resource on testing different DM models