Propsects and challenges for dark sectors with heavy fermions

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Based on collaboration with David Morrissey

Dark sectors with a dark photon highly motivate SM extensions with new fermions

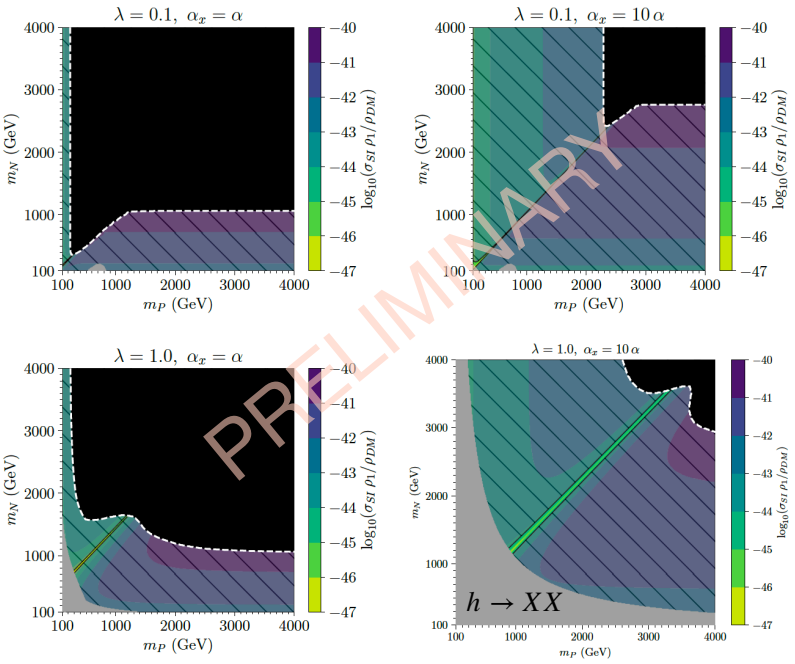
$$-\mathscr{L} \supset \frac{\epsilon}{2c_W} B_{\mu\nu} X^{\mu\nu}$$

Current bounds suggest $\epsilon \lesssim 10^{-1}$. Natural size for mixing induced by loops of fermions is $\epsilon \sim 10^{-4} - 10^{-3}$.

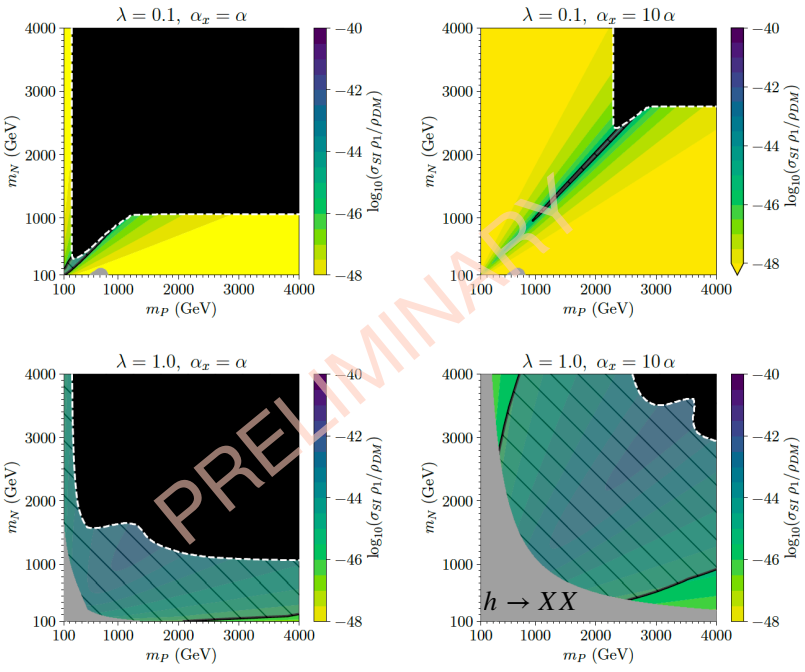
Benchmark model:

$$-\mathscr{L} \supset \left(\lambda \bar{P} \tilde{H} N + h.c.\right) + m_P \bar{P} P + m_N \bar{N} N$$

$$P = (1,2,-1/2;q_X)_{SM+U(1)_X} \quad N = (1,1,0;q_X)_{SM+U(1)_X}$$



- Strong bounds from EW precision, $h \to XX$, and LHC direct searches but can easily be avoided for large masses $m_P, m_N \gg m_Z$
- Large masses present a challenge for direct detection + relic density where barely any parameter space survives (see Fig right)



Possible solutions

1.) Higgsed theory with Majorana mass (see Fig left) via scalar singlet, Φ. Suppresses Z-, W-mediated nuclear cross section.

$$-\mathscr{L} \supset \frac{1}{2} y_N \Phi \bar{N}^c N + h.c.$$

2.) Higgsed theory with lepton mixing via new scalar doublet, ϕ (details to appear soon!). Depletes relic density by allowing decays to SM particles

$$-\mathscr{L} \supset \lambda_a \phi \bar{P}_R L_{La} + h.c.$$

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