Long-lived dark matter mediators in Direct Detection experiments

IRN-Terascale meeting

Dark matter GPS session

IPPP, Durham

Outline

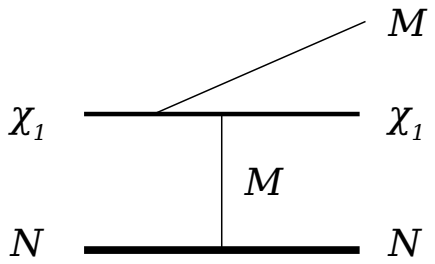
- General framework and idea
- Concrete ideas

General idea

So far, direct detection experiments are more or less blind to sub-GeV dark matter candidates.

Consider alternative processes for such cases?

· Initial idea: radiative scattering accompanied by mediator emission, incl. possibility of scattering outside the detector → only detect decay products.



e.g. photon pair

· But: kinematic limit on emitted mediator mass: $m_{med}^{max} = \frac{\mu_{\chi N} v_\chi^2}{2}$

→ for $m_\chi \sim 1$ GeV can only access ~ 1 keV mediators → too long-lived if mediator is a scalar decaying into photon pairs.

Potential ideas -1

1) Consider scattering/annihilation of dark matter particles *among themselves* to access higher mediator masses → shorter mediator lifetimes.

· Can access higher mediator masses (→ shorter lifetimes).

· Considered scattering target depends on the mediator lifetime.

Shorter lifetimes: scattering in the Earth/the Sun etc.

Potential issue: the DM number density is small

Larger lifetimes: scattering around far objects: GC etc

→ Use DD as ID?

Potential issue: DD detectors are small. But: zero background?

Potential ideas -2

2) Move to indirect detection.

· Expect ring-like photon signal around massive objects, at distances d ~ $c\tau_{med}$

· Leptonic decay constraints already studied in arXiv:1612.00845. Photons?

But then lose connection with DD

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3) Consider alternative mediators/processes.

· Example: Z' → Z* γ → $\nu\nu\gamma$ (*e.g.* in models with anomalous U(1)'s).

· (Virtual) tree-level decay → shorter lifetime.

Open issues

· Which of these ideas is the most promising? Need at least rough estimates!

And then detailed calculations

· What “external” constraints do we consider? Stellar cooling, BBN, CMB...

· How seriously do we take the relic density constraint?

· For the most, need some concrete model. Which one?

Let’s discuss!