Global fit of sub-GeV dark matter with GAMBIT

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arXiv:2405.17548

Abstract: Decades of experimental searches for WIMPs in the GeV - TeV mass range have produced null results so far, hence shifting focus to lower masses. Such models of sub-GeV DM with new interactions feature a rich phenomenology and thus make interesting DM candidates.

Sub-GeV Dark Matter Model

- Dirac fermion DM ψ, stable due to $U(1)'$ gauge symmetry

$$\mathcal{L}_\psi = \bar{\psi}\left(i\partial\!\!\!/ - m_{\rm DM}\right)\psi - g_{\rm DM}A'^{\mu}\bar{\psi}\gamma_\mu\psi$$

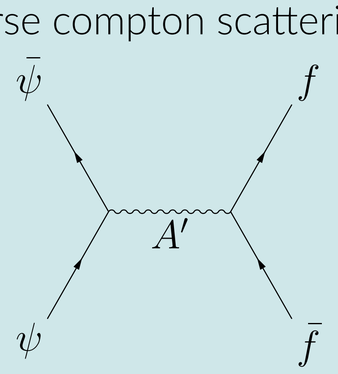
- Portal to SM through dark photon A' with kinetic mixing

$$\mathcal{L}_{\rm int} = -\frac{1}{2}m_{A'}^2 A'^{\mu}A'_{\mu} - \frac{1}{4}A'^{\mu\nu}A'_{\mu\nu} - \kappa e A'^{\mu}\sum_f q_f \bar{f}\gamma_\mu f$$

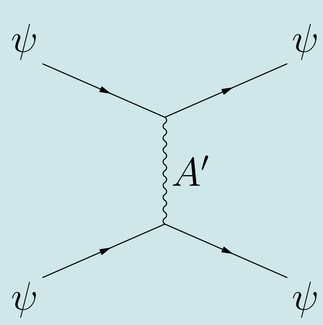
- *Freeze-out* production facilitated by annihilation to SM
- **Challenge**: annihilation cross section needed to reproduce relic abundance in tension with cosmological bounds on energy injection and indirect detection from X-rays.
- **Possible solutions**: resonant annihilation ($m_{DM} \approx m_{A'}/2$), particle-antiparticle asymmetry or multi-component DM.

Signals

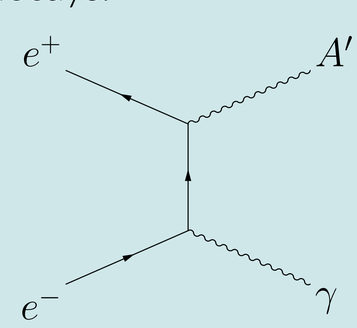
Indirect detection: DM annihilation to charged SM particles can produce X-rays from bremsstrahlung and inverse compton scattering.



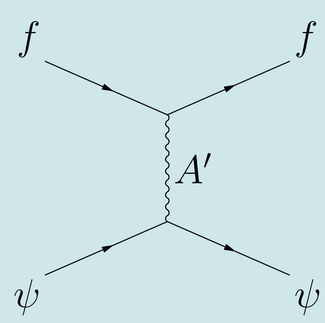
Self-interaction constraint: Self interactions affect dynamics of merger in bullet cluster through an effective *drag* force.



Accelerator searches: Missing energy from invisible decays of dark photons produced in SM annihilations or decays.



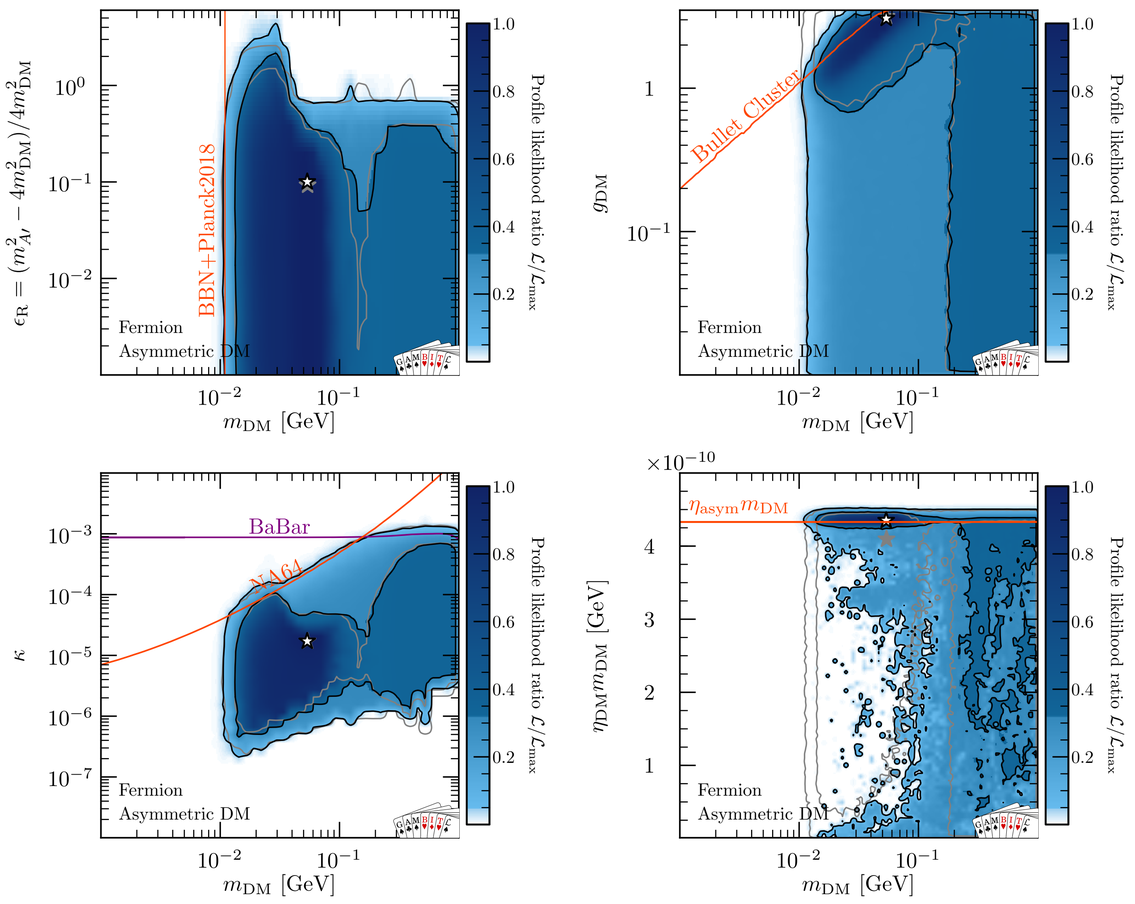
Direct detection: Searches for DM particles through nuclear and electron recoils, and Migdal effect.



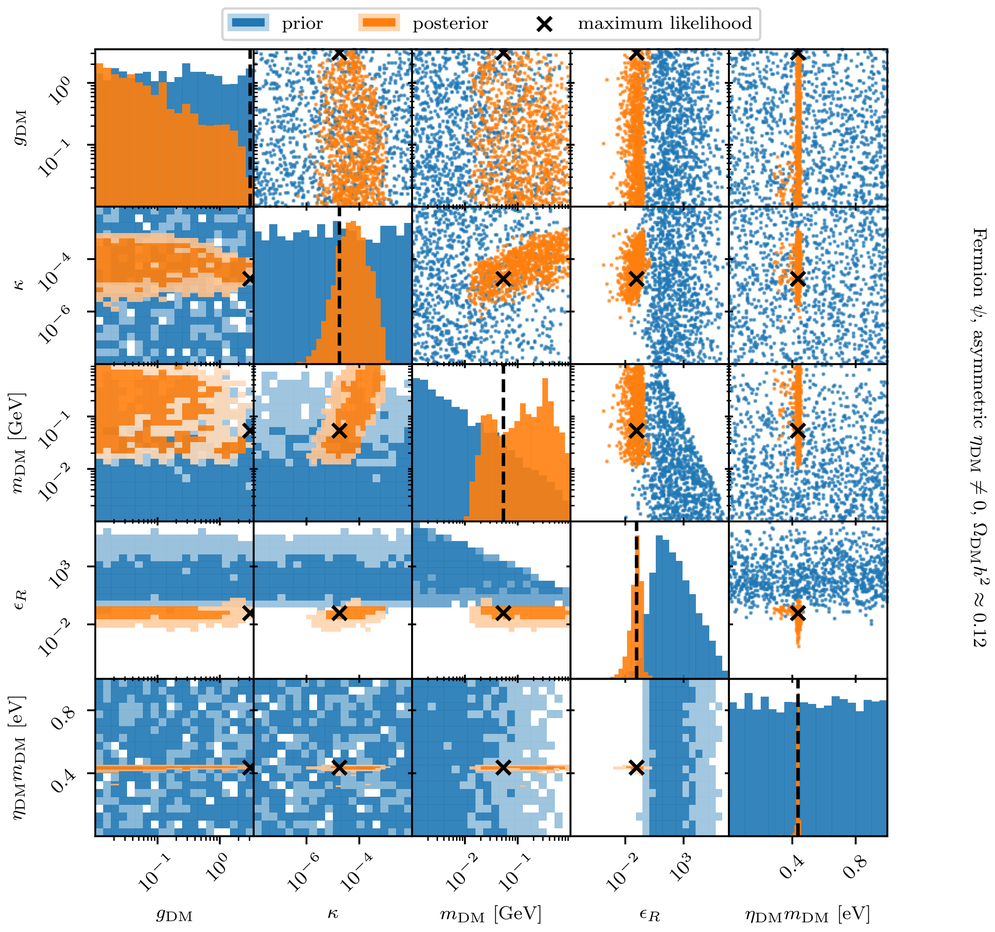
Results from Global Fits

Interplay between resonant annihilations, asymmetry and sub-dominant DM studied through bayesian and frequentist global fits using the GAMBIT global fitting framework. For efficient exploration of parameter space close to resonance, we define $\epsilon_R = m_{A'}^2/4m_{DM}^2 - 1$.

Frequentist



Bayesian



Conclusion

Inclusion of asymmetry or multi-component DM is successful in evading cosmological and indirect detection constraints, rendering large parts of parameter space close to resonance viable. Furthermore, for the case where our DM candidate saturates the relic abundance, Bayesian analyses shows a strong preference for asymmetry (Bayes factor ~ 15).

Acknowledgements: S.B. acknowledges the support by the Doctoral School - *Karlsruhe School of Elementary and Astroparticle Physics: Science and Technology*

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