Boosting through the Darkness

collaboration with Debjyoti Bardhan, Supritha Bhowmick, Diptimoy Ghosh & Atanu Guha

presented by **Divya Sachdeva**

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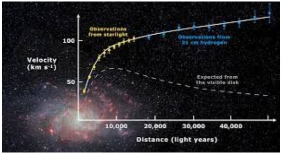
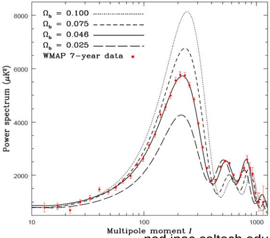


Wikipedia



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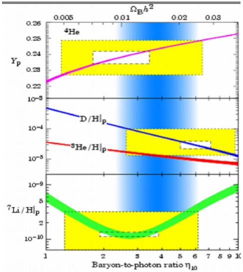
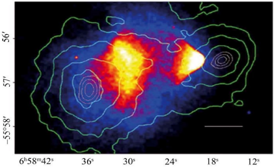


Fields & Sarkar, 2004



astrobites.org

All of these observations are indirect. Thus, it is difficult to ascertain nature of Dark Matter (DM).

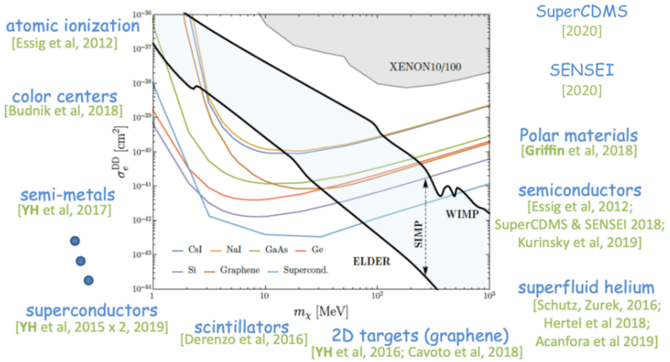
DM

WIMPs | **Axion or ALPs** | **Primordial Black Holes** | **MOND**

Sub-GeV Dark Matter and its interaction with electrons

Light DM and Direct Detection

Average velocity of DM particles in the solar neighbourhood, $v \sim 10^{-3}$, so that DD experiments lose sensitivity for DM particle below mass of ~ 5 MeV DM-electron crosssection.

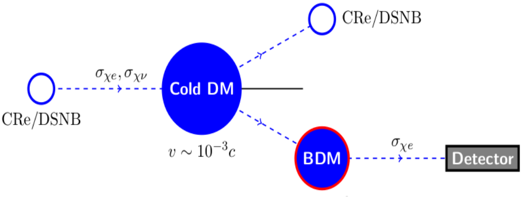


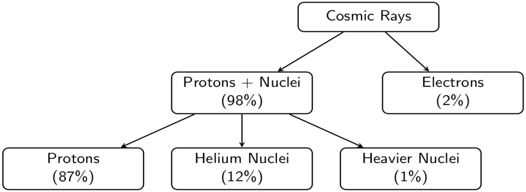
Eric Kuflik's ICHEP 2020 slides

Boosted Dark Matter and Sub-GeV DM detection

Boosted Dark Matter

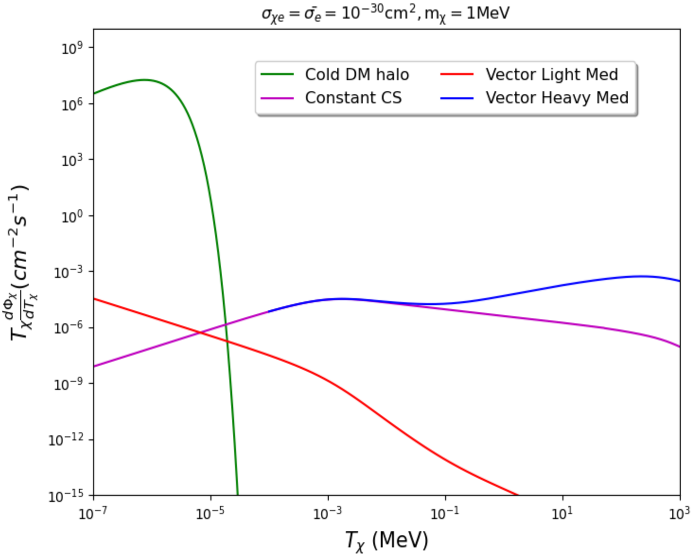
DM sub-component upscattered by cosmic-ray





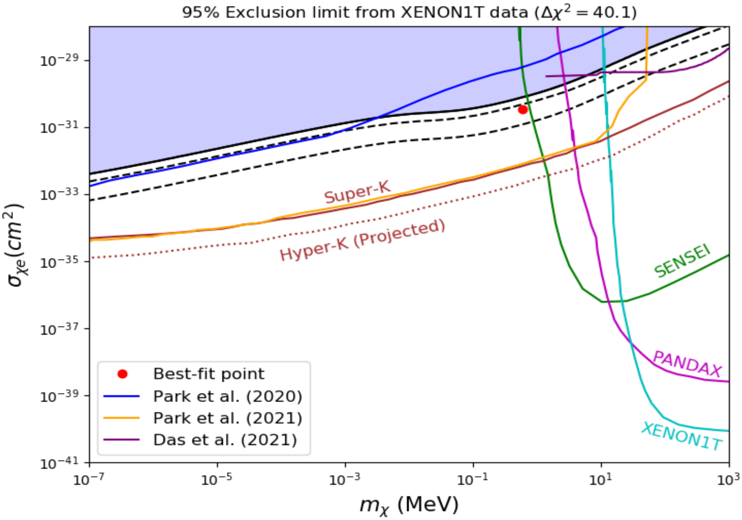
The existence of boosted DM is unavoidable as long as one assumes some DM interactions with the Standard Model (SM) particles, a pre-requisite in any Direct Detection experiment.

Boosted DM Flux



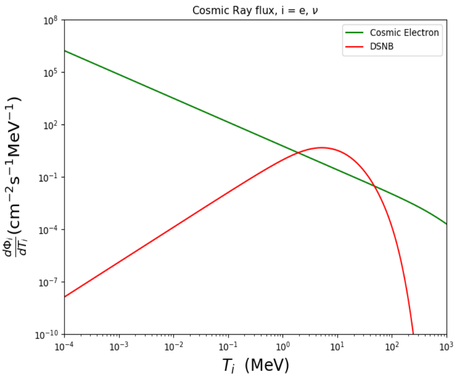
Constant Scattering cross-section

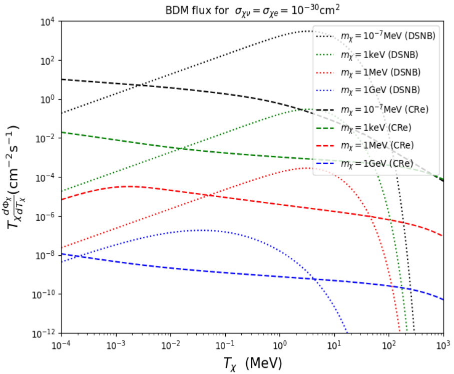
Limits on $\sigma_{\chi e}$



See Cappiello & Beacom (1906.11283) for Super K and Hyper K, Park et al. (2006.13910, 2101.11262), Das et al. (2104.00027)

Diffused Supernova Neutrino Background

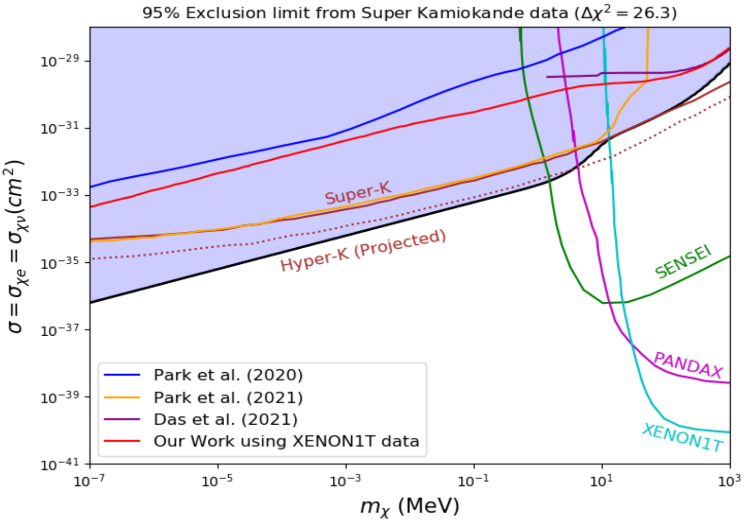




The observable effective spectra of the neutrinos emitted from supernovae, is assumed to be of Fermi-Dirac form and approximately given for each flavour as :

$$F_\nu(E_\nu) = \frac{E_\nu^{tot}}{6}\frac{120}{7\pi^4}\frac{E_\nu^2}{T_\nu^4}\frac{1}{\exp(\frac{E_\nu}{T_\nu}) + 1}$$

$\sigma_{\chi e}$ & $\sigma_{\chi\nu}$ Limits



Ghosh, Guha & Sachdeva 2021 (2110.00025)

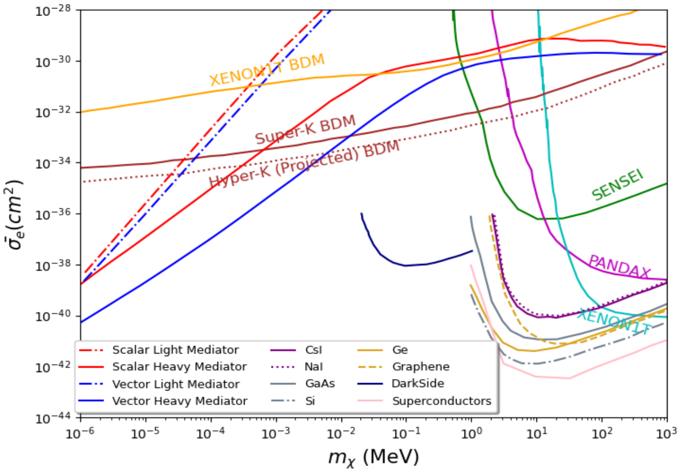
Energy dependence of scattering cross-section

It is important to include energy dependence of σ when comparing this detection technique with other ones, because they rely on different energy regimes.

We assumed DM to be SM singlet and a Dirac Fermion, χ with the following interactions:

$$\begin{aligned}
\mathcal{L}_s &= g_\chi \bar{\chi}\chi\phi + g_e \bar{e} e \phi\,, \\
\mathcal{L}_v &= g_\chi \bar{\chi}\gamma_\mu \chi B^\mu + g_e \bar{e}\gamma_\mu e B^\mu\,.
\end{aligned}$$

Limits on scalar and vector interaction case



Bardhan, Bhowmick, Ghosh, Guha & Sachdeva 2022 (progress)

Work in progress

- **We consider scalar-pseudoscalar, axial-vector model so that CMB constraints on DM annihilation can be evaded, thanks to their $p - wave$ suppressed DM annihilation.**
- **We prove that our new limits and sensitivities can test theoretically-consistent parameter space of $U(1)_{B-L}$ models.**

Conclusion

- **There exist a DM sub-component that possess a larger Kinetic Energy than DM in the viralised halo.**
- This component is unavoidable as long as DM interact with Cosmic Ray components like electron, proton, neutrinos etc.
- Such component provide an **alternate avenue to probe light DM** with existing Direct Detection experiments and with neutrino detectors.
- In this context, **we focussed on DM interactions with e^-**.
- We obtained limits on various interactions taking into account the energy dependence of the DM scattering cross-sections for different detectors such as Super-K as well as XENON1T.
- We also derived new constraints on combination of $\sigma_{\chi e}$ and $\sigma_{\chi\nu}$ if DM interacts with $\nu's$ as well as e^-'s (like Majorons).