Sub-GeV dark matter and high-energy neutrino production

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Quarks-2024
Pereslavl, 20 May 2024

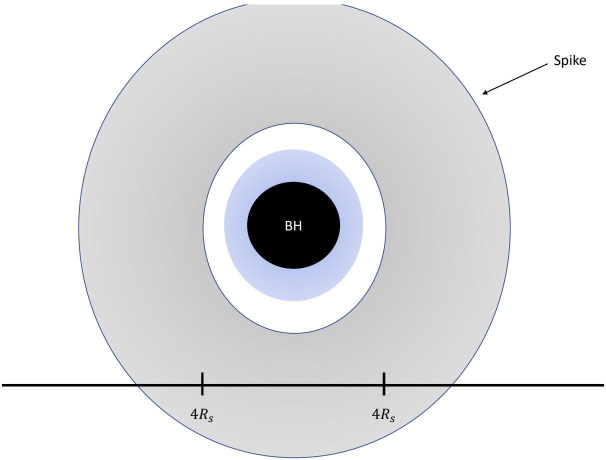
Can dark matter contribute to neutrino production?

Central part of AGN

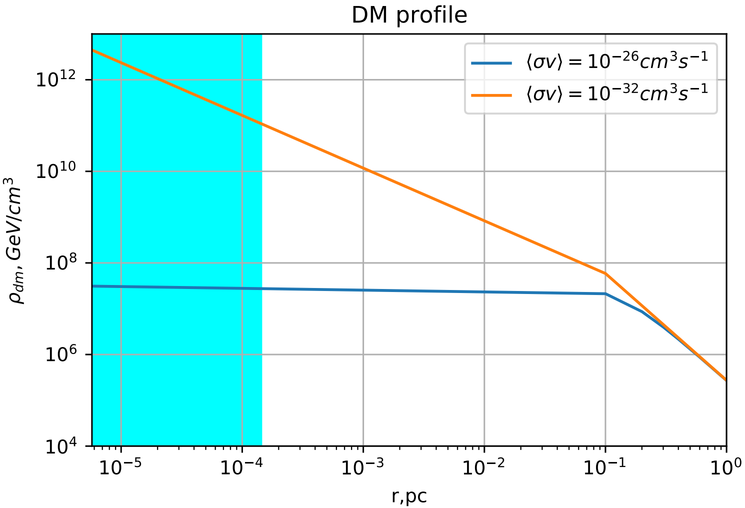
- Active galactic nuclei (AGN) are promising sources of high-energy neutrinos
- In the center of AGN supermassive black hole (SMBH) is located

Dark matter spike

If dark matter is present at the galactic center, as in current models of the dark halo, it is redistributed by the black hole into a cusp.



Dark matter spike of NGC 1068



Dark matter constrains

Constrains on DM annihilation can arise not only from astroparticle physics but also from cosmology and detection of gravitational waves.

Luque et. al. 2024

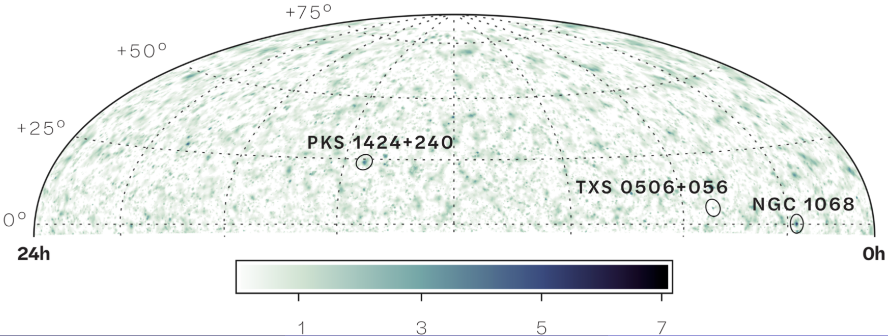
SPI data from INTEGRAL

$\langle \sigma v \rangle \approx 10^{-32} cm^3 s^{-1}$ at masses of around an MeV
$\langle \sigma v \rangle \approx 10^{-26} cm^3 s^{-1}$ at masses of over several GeV

Neutrino signal from NGC 1068

IceCube

Significance of 4.2 σ
Neutrinos in an energy range from 1.5 TeV to 15 TeV
$L_\nu = (2.9 + 1.1_{stat}) \cdot 10^{42} erg/s$
Multi-messenger data suggest that the neutrino emission radius R is smaller than $\approx$ 30 - 100 Schwartzschild radius



Models of dark matter

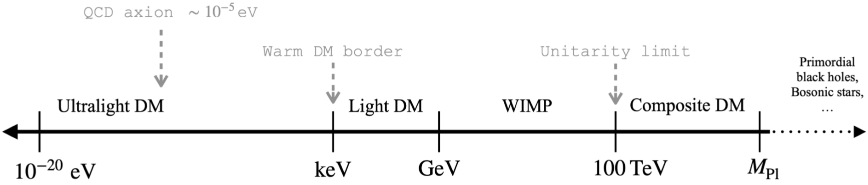
Any dark matter model may be deconstructed into three sectors: the SM, the DM, and the fields that mediate the DM's interactions with the SM.

$$L = L_{SM} + L_{DM} + L_{mediator} \quad (1)$$

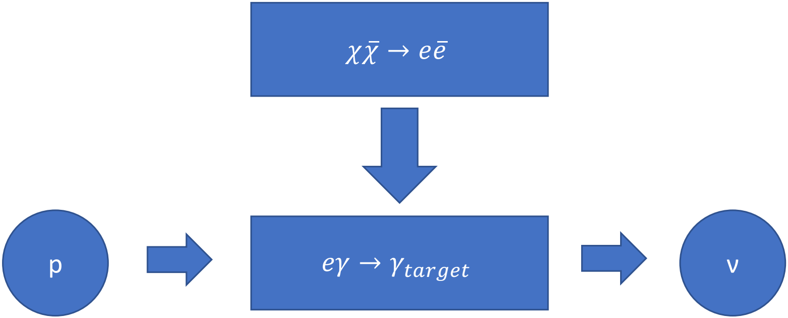
1. Kinetic mixing portal
2. Higgs portal

Exotic mass of dark matter

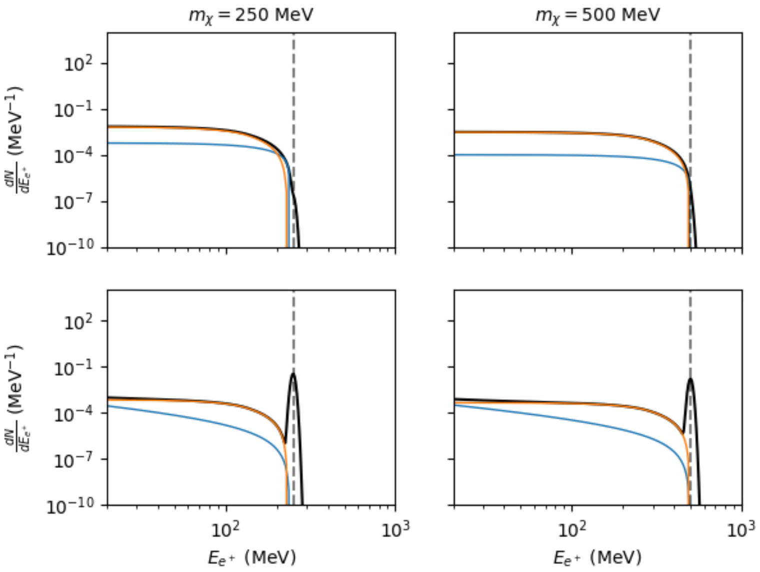
Sub-Gev dark matter in this work - 20 MeV - 1 GeV



Neutrino production



Dark matter annihilation



Electron spectra

To get number dencity of electrons and positrons we need to solve the standart diffusion-loss differential equation

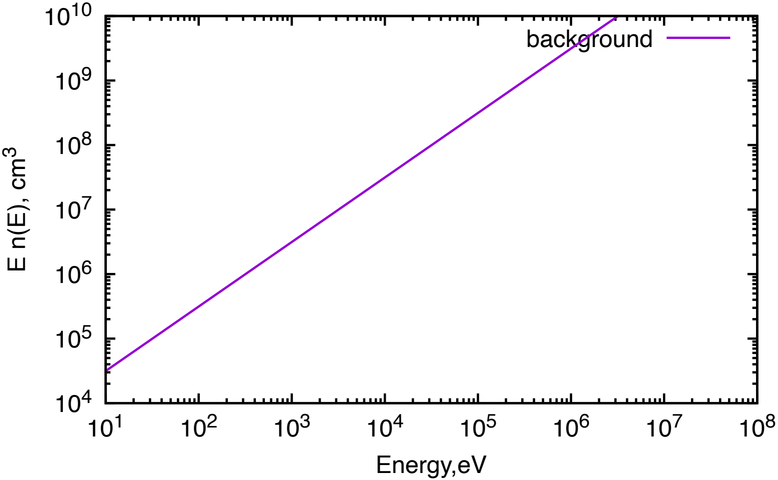
$$\frac{\partial f}{\partial t} - \nabla(K(E,r)\nabla f) - \frac{\partial}{\partial E}(b(E,r)f) = Q(E,r) \tag{2}$$

where $f = \frac{n_e}{4\pi p^2}$ and for DM annihilation

$$Q_e = \frac{1}{2}(\frac{\rho}{M_{DM}})^2\langle\sigma v\rangle\frac{dN_e}{dE} \tag{3}$$

Target-photons

Electrons interect with CMB photons

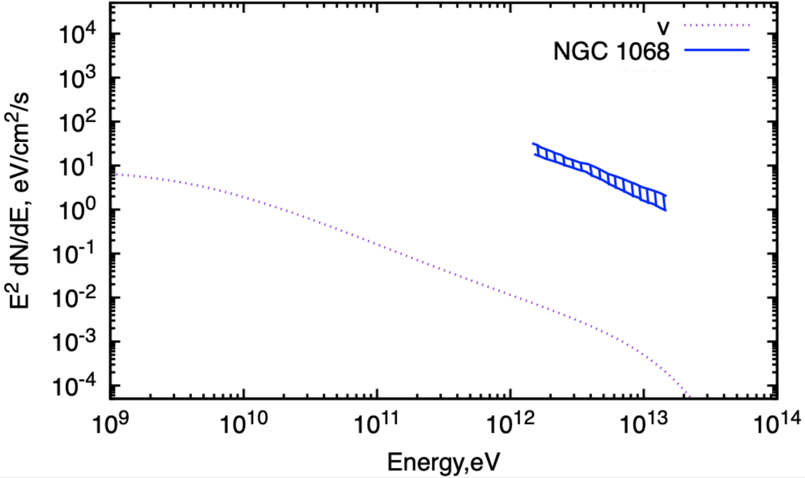


Protons

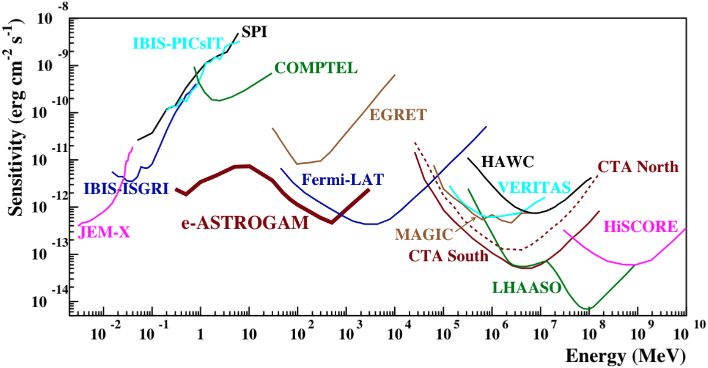
We do not know proton luminosity of the source. To check the model we take values of

- $L_{Edd} \approx 10^{45} erg \cdot s^{-1}$
- $100 L_{Edd}$
- $500 L_{Edd}$

Numerical calculation of neutrino flux



Future



- AMEGO, expected in 2026-2028
- COSI, expected in 2027
- e-ASTROGRAM, expected in 2029

Conclusions

- Dark matter can contribute to the flux of astrophysical neutrinos.
- Future work examining the spectra of neutrinos from dark matter annihilation may help identify a dark matter-related feature in the spectra from galactic nuclei

Thank you!

This work is supported in the framework of the State project "Science" by the Ministry of Science and Higher Education of the Russian Federation under the contract 075-15-2024-541.

Appendix: kinnetik mixing

$$\mathcal{L}_{\mathrm{Int}(S)} = -S\left(g_{S\chi} + g_{Sf}\sum_f \frac{y_f}{\sqrt{2}}\bar{f}f\right) + \frac{S}{\Lambda}\left(g_{SG}\frac{\alpha_{\mathrm{EM}}}{4\pi}F_{\mu\nu}F^{\mu\nu} + g_{SF}\frac{\alpha_s}{4\pi}G^a_{\mu\nu}G^{a\mu\nu}\right) \quad (4)$$

Appendix: higgs portal

$$\mathcal{L}_{\text{Int}(V)} = V_\mu \left(g_{V\chi} \bar{\chi} \gamma^\mu \chi + \sum_f g_{Vf} \bar{f} \gamma^\mu f \right) - \frac{\epsilon}{2} V^{\mu\nu} F_{\mu\nu}. \tag{5}$$

Numerical calculation of electron spectra