Dark Matter - Neutrino Scattering at the Galactic Center

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Motivation for DM- ν interactions

From cosmology, there's strong motivation for DM annihilation (WIMP Miracle) and thus we should expect DM- ν scattering.





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Dark Matter - Neutrino Incoherent Scattering

Isotropic neutrino flux

Results in an anisotropy on the neutrino flux X

Attenuated neutrino flux



DM- ν Incoherent Scattering Models*

* Not an exhaustive list

OLIVARES - DEL CAMPO, A., ET AL., PHYS.REV.D 97 (2018) 7, 075039





SCALAR DM Scalar Mediator

Low $E_{\nu}: \sigma \to \text{const}$ High $E_{\nu}: \sigma \propto E_{\nu}^{-2}$ FERMION DM Scalar Mediator



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FERMION DM VECTOR MEDIATOR



SF Ø χ

SCALAR DM Fermion Mediator









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DATASET: 3D EVENT PARAMETER SPACE IN ENERGY, RA, DEC

	DNN-C
Number of astrophysical events	~2840
Total number of events	23144
Energy Range	1 TeV - 10 ⁵ TeV
Source Direction	All Sky

Optimized HE cascade (DNN) reconstruction

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Combined Events





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Binned Likelihood Method

Neutrino Sources

Astrophysical Flux Atmospheric Flux Atmospheric Muon Flux



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Binned Likelihood - Signal Subtraction Approach

$$\mathscr{L} = \sum_{i}^{i} \log \operatorname{Pois}(\overrightarrow{x_{i}}, \mu_{i}(\overrightarrow{\theta}, \overrightarrow{\eta}))$$

$$TS = -2\Delta LLH$$

EXTRAGALACTIC ASTROPHYSICAL NEUTRINOS Follows a power law spectrum $\phi(\vec{x}, \vec{\theta}; \vec{\eta}) = n_{astro} E^{-\gamma} \cdot \theta_{att} \propto \sum c_i$ Profile LLH over nuisance parameters

$$\vec{x} = \langle E, \delta, \alpha \rangle \quad \vec{\theta} = \langle g, m_{\phi}, m_{\chi} \rangle$$
$$\vec{\eta} = \langle n_{\text{astro}}, \gamma_{\text{astro}} \rangle$$
$$\mu(\vec{\theta}, \vec{\eta}) = \mu_{\text{astro}\nu}^{\text{signal}}(\vec{\theta}, \vec{\eta}) + \mu^{\text{bkg}}$$

BACKGROUND: ATMOSPHERIC NEUTRINOS AND MUONS

 $\mu^{bkg} = \mu_{atm_{\nu}} + \mu_{muon}$ Scrambling MC over right ascension, α

$$u^{\text{bkg}} = \tilde{\mu}_{\text{data}} - \tilde{\mu}_{\text{astro}\nu}^{\text{signal}}(\vec{\theta}, \vec{\eta})$$

$$i\hat{\phi}_i e^{\lambda_i \tau}$$





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Fermion χ - Scalar ϕ : $m_{\phi} = 1e-02$ GeV





Goal: Reject SM from BSM Models $TS = -2\Delta LLH = -2\log\left(\frac{\mathscr{L}_{DM}}{\mathscr{L}_{SM}}\right)$

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14

ASIMOV SENSITIVITIES* SCALAR DM - FERMION MEDIATOR



Goal: Reject SM from BSM Models $TS = -2\Delta LLH = -2\log\left(\frac{\mathscr{L}_{DM}}{\mathscr{L}_{SM}}\right)$

OCTOBER 24,2023





15

Conclusions

- DM-Neutrino scattering is motivated by scotogenic models. • We are searching for a DM-neutrino interactions at the Galactic
- Center (not exhaustive).
- Sensitivities with RA-scrambled background have been established for a variety of dark matter parameters.



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Evidence for the existence of dark matter strongly motivates the efforts to study its unknown properties. Additionally, the origin of high-energy astrophysical neutrinos detected by IceCube Abstract remains uncertain. If dark matter and neutrinos couple to each other, we can search for a non-zero elastic scattering cross section. The interaction between an isotropic extragalactic neutrino flux and dark matter would be concentrated in the Galactic Center, where the dark matter column density is largest. The flux of high-energy neutrinos would be attenuated by this scattering, and the resulting signal, with correlated energy and arrival direction, can be observed in IceCube. Using the seven years of IceCube data, we perform an unbinned likelihood analysis, searching for several potential DM-neutrino interaction scenarios.

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Related Argüelles, et al., Rev. Mod. Phys. 93 035007 work Argüelles, **DD**, et al., arXiv:2210.01303

OTHER INFORMATION

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