Dark Matter and Cosmic-Rays scattering indirect detection

High-Energy Astrophysics in the multi-messenger era

Igor Reis, Aion Viana, Emmanuel Moulin

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- In 2021 I started my PhD under supervision of Aion Viana at the Universidade de São Paulo, with cotutelle from Emmanuel Moulin at Université Paris-Saclay



UNIVERSITE PARIS-SACLAY

Things I have done

 Since 2021 I am participating, with some friends, in a research project at LNCC (the National Laboratory of Scientific Computation)



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H.E.S.S. collaboration: https://arxiv.org/abs/1607.08142

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- Usually this is done searching for a gamma-ray signal in the final state of annihilating or decaying dark matter particles
- Different experiments, such as H.E.S.S. and CTA have already published results on its sensitivity for these cases (usually WIMPs)
- However, direct detection experiments have already heavily constrained WIMPs



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We will focus on a region from ~100eV to a few MeV



$$\frac{d\Phi_{\gamma}(E_{\gamma})}{dE_{\gamma}} = 2\int_{E_{min}}^{\infty} \frac{\sigma_{\chi p}^{in}(E_p)}{m_{\rm DM}} \frac{d\phi_p(E_p)}{dE_p} dE_p \times \int d\Omega \int_{l.o.s.} \rho[r(s)] ds$$

$$dE_p \times \int d\Omega \int_{l.o.s.} \rho[r(s)] ds$$

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$$CR \text{ flux: power law}$$
with index 2.3

Ing between cosmic rays and DM

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$$(CR flux: power law) with index 2.3$$

$$(CR flux: power law) profile$$





$$\int_{0}^{x} \int_{0}^{x} \int_{0$$

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- Indirect and direct detection results comparison: $\sigma_{\chi p}^{in} \rightarrow \alpha_2 \sigma_{\chi p}^{el}$
- This makes any cross section constraint obtained from this method directly comparable to direct detection

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- This is a problem all in itself, as there are lots of uncertainties regarding the correct parametrization of the density in this region
- As usual in the literature, we will focus on the Einasto and NFW profiles at first



- We perform an ON-OFF analysis in the inner 3° (H.E.S.S. and CTA) and 10° (SWGO) regions
- □ We exclude the central ±0.3° region
- 2D binned likelihood in different ROIs (spatial bins)



PRELIMINARY results



□ We also did this for LHAASO

- We also did this for LHAASO
- We extracted the data required to do this from "Constraints on Heavy Decaying Dark Matter from 570 Days of LHAASO Observations" (https://arxiv.org/abs/2210.15989)



Now going back to the beginning



Now going back to the beginning





Now going back to the beginning







Thank you!

Extra slides

Following something similar to what is done in the Aharonian paper for proton-proton scattering

$$q_{\pi}(E_{\pi}) = \int \delta(E_{\pi} - f_{\pi}E_{\rm kin})\sigma_{\rm pp}(E) J_{\rm p}(E) dE$$

- □ In our case, I changed the energy transfer fraction from 10% to 100%
- As an example, we can see the curves for CTA shown here.



Extra slides



Extra slides

Signal for CTA, H.E.S.S. and SWGO

