Possibilities with dark matter: Some minimum bias conclusions

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A. Kar, S. Mitra, BM, T. Roy Choudhury, Phys. Rev. D101, 023015 (2020)

K. Dutta, A. Ghosh, A. Kar, BM, JCAP 09, 005 (2022)

K. Dutta, A. Ghosh, A. Kar. BM, arXiv: 2212.09795 [hep-ph]

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- *In practice:*
  Possibilities can be more divergent than we think.....

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- *Observation of γ-ray signals, excess positrons, excess in galactic antiproton/proton ratio....*

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- *For indirect signals, values of the relevant astrophysical parameters are in 'standard' ranges*

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- *Some inkling on the theoretical framework*

  $+$

  Astronomical observations
  $\Rightarrow$ *Indications about astrophysical parameters*

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- *For $m_\chi \gtrsim$3-4 TeV, annihilation rate can be insufficient to ensure relic density limits*
- *Spectra with, for example, co-annihilation provision can still allow WIMP with mass 10 TeV or more*

- *DM annihilation in some galaxies/clusters*
  $\Rightarrow$ *electron-positron pairs*
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- *Potential sources: dwarf spheroidal galaxies (dSph)*

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Indirect signals in radio astronomy...

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- *Signals for* $m_{DM} \simeq 5 - 8$ *TeV can be seen with 100 hours of observation in SKA - 1* $(100MHz - 4GHz)$
  $\Rightarrow$ *Regions the* $m_{DM} - \langle \sigma v \rangle$ *space can be probed, using constraints from gamma-ray + cosmic-ray data*

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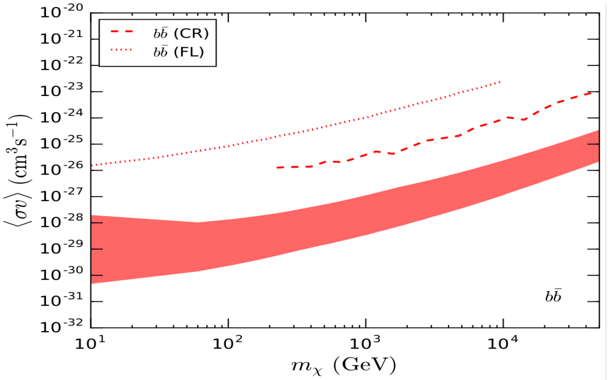
100 hours on Draco: from A. Kar *et al.* (2019)



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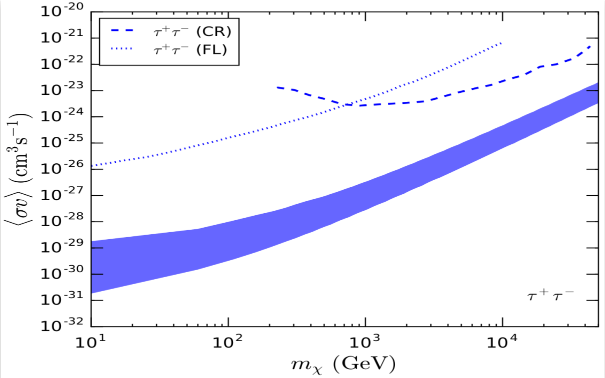

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  also brings more high-energy $e^\pm$ *down to the required range*

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- *But actually it is much more unrestricted, with anything* $\gtrsim$ *10 MeV allowed*
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- *AMS-02 positron search limits (best in 1 - 100 GeV, with enough lepton-pairs produced)*

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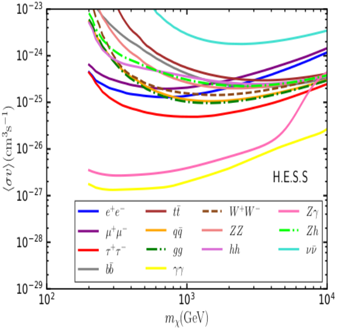

FIG. 1. 95% C.L. upper limits on $\langle\sigma v\rangle$, obtained from the GC gamma-ray observation by H.E.S.S, assuming 100% BR for each individual SM final state.

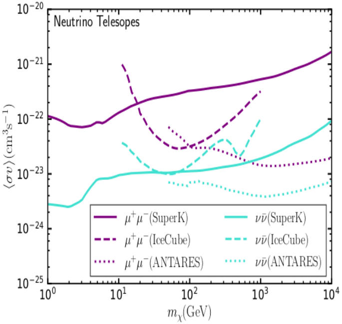

FIG. 2. 95% C.L. upper limits on $\langle\sigma v\rangle$ for $\nu\bar{\nu}$ (cyan) and $\mu^+\mu^-$ (purple), obtained using the data of Super-Kamiokande (solid lines), IceCube (dashed lines) and ANTARES (dotted lines) telescopes, assuming 100% BR for each channel.

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- *The area between these two curves is always allowed.*

After everything...

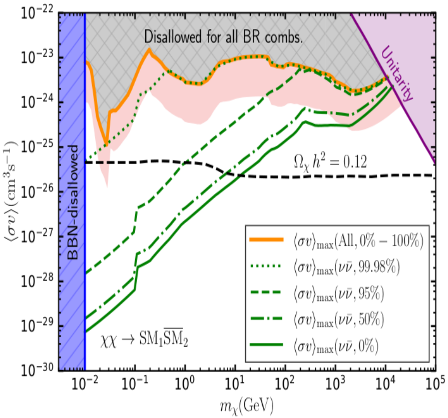

FIG. 4. For a single-component thermal WIMP, constituting all the observed DM, the orange line represents the BR-independent upper limit on total $\langle\sigma v\rangle$ (at 95% C.L.) and the light red band shows its variation with the astrophysical uncertainties, in the m_χ range 10 MeV - 100 TeV. The gray region is ruled out for all possible BR combinations, while, the blue region is disallowed by BBN [25, 26]. The purple and the black lines are the same as in Fig. 3. Variation of the maximum allowed total $\langle\sigma v\rangle$ with the BR attributed to $\nu\bar{\nu}$ are shown by the green lines. See the text for details.

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- *Constraints are even less stringent if co-annihilation has a role in the relic density*

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- *Again, a completely unbiased survey of* $\Sigma_i \Gamma_i (BR)_i$ *opens up many avenues*

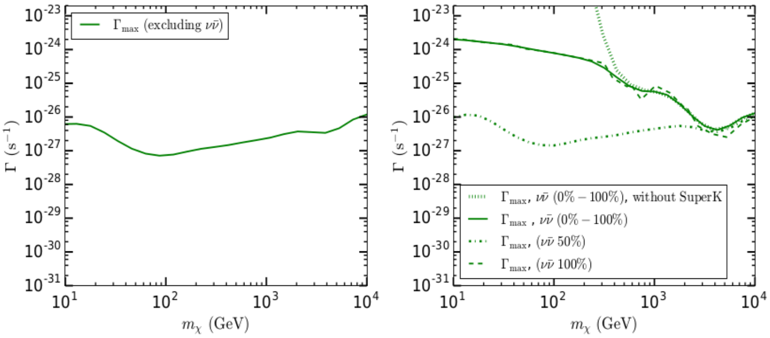

Figure 7. *Left:* Varying the branching ratios of all SM final states (excluding $\nu\bar{\nu}$) in the range 0%–100% and combining the data of Planck CMB, Fermi-LAT IGRB and AMS-02 positron observations the maximum allowed value of the total DM decay width, i.e., Γ_{max}, is obtained for m_χ in the range 10 GeV – 10 TeV. For any $\Gamma > \Gamma_{max}$ there exists no branching ratio combination which is allowed by all the aforementioned observations. *Right:* The branching ratio of $\nu\bar{\nu}$ final state is also varied in the range 0% – 100% and the data of the above-mentioned observations are used along with the data of Super-Kamiokande neutrino flux measurement to obtain the Γ_{max} shown by the green solid line. The green dotted line is obtained without including the Super-Kamiokande data. Combining all four observations the green dashed dotted and the green dashed lines are derived which represent the Γ_{max} for DM decays to $\nu\bar{\nu}$ with precisely 50% and 100% branching ratios, respectively. See the text for details.

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- *Detectable radio signal predicted in 100 hours at SKA, for decaying DM mass upto $\approx$ 10 TeV*

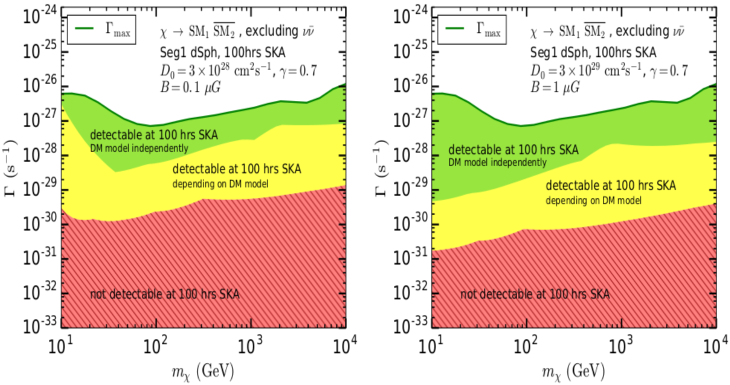

Figure 10: Regions in the $m_\chi - \Gamma$ plane those are detectable in the 100 hours of observation of the Seg 1 dSph at the SKA are determined for Case 1, i.e., excluding DM decays to $\nu\bar{\nu}$ and varying the branching ratios of the remaining SM final states arbitrarily. $\Gamma_{\rm max}$ (the green solid line) is the upper limit on total Γ, obtained by combining the data of Planck CMB, Fermi-LAT IGRB and AMS-02 positron flux measurements. Here we have considered $D_0 = 3 \times 10^{28}\text{cm}^2\text{s}^{-1}$, $B = 0.1\mu$G (left) and $D_0 = 3 \times 10^{29}\text{cm}^2\text{s}^{-1}$, $B = 1\mu$G (right). The diffusion index $\gamma = 0.7$ is assumed in all the cases. See the text for details.

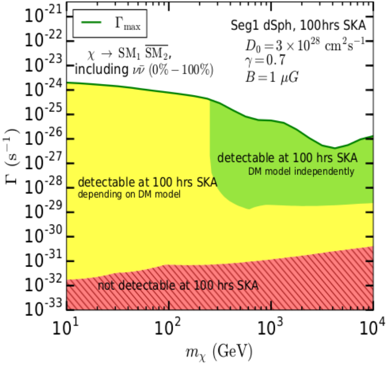

Figure 11. Classification of the DM parameter space (spanned by m_χ and Γ) based on the detectability at the SKA (for 100 hours of observation towards the Seg 1 dSph) is presented for Case 2, i.e., including DM decays to $\nu\bar{\nu}$ with arbitrary branching fractions. The choice for the astrophysical parameters made here are $D_0 = 3 \times 10^{28} \mathrm{cm}^2\mathrm{s}^{-1}$, $\gamma = 0.7$ and $B = 1\,\mu$G. $\Gamma_{\rm max}$ (the green solid line) is the upper limit obtained by using the data of Planck, Fermi-LAT, AMS-02 and Super-Kamiokande. See the text for details.

"A really good scientist is one who knows how to draw correct conclusions from incorrect assumptions"

Otto Frisch