Combined search in dwarf spheroidal galaxies for branon dark matter annihilation signatures with the MAGIC Telescopes

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Abstract

One of the most pressing questions for modern physics is the nature of dark matter (DM). Several efforts have been made to model this elusive kind of matter. The largest fraction of DM cannot be made of any of the known particles of the Standard Model (SM). We focus on brane world theory as a prospective framework for DM candidates beyond the SM of particle physics. The new degrees of freedom that appear in flexible brane world models, corresponding to brane fluctuations, are called branons. They behave as weakly interacting massive particles (WIMPs), which are one of the most favored candidates for DM. We present a multi-target DM search in dwarf spheroidal galaxies for branon DM annihilation signatures with the ground-based gamma-ray telescope MAGIC leading to the most constraining branon DM limits in the TeV mass range.

Introduction

Astrophysical and cosmological evidences propose that non-baryonic cold DM accounts for 84% of the matter density of the Universe. Nevertheless, the nature of DM is still an open question for modern physics, as this elusive kind of matter can not be made of any of the SM particles. In this contribution, we model the gamma-ray emission in the source region with the branon DM model and perform a multi dwarf spheroidal galaxies (dSphs) DM analysis using *gLike*[a] and *LikelihoodCombiner*[b], open-source analysis tools for multi-target and multi-instrument DM searches.

Branon dark matter

Brane-world theory [1] has been put forward as a prospective framework for DM candidates. The characteristics of the suggested massive brane fluctuations in this theory match the ones of weakly WIMPs, which are one of the most favored candidates of cold DM. The left panel of Fig. 1 shows the branon branching ratios Br_i as a function of the branon mass m_χ. The differential photon yield per branon annihilation dN/dE is depicted for a set of **branon DM masses** (from light to dark: **0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50 and 100 TeV**) in the right panel of Fig. 1.

[a]https://github.com/javierrico/gLike

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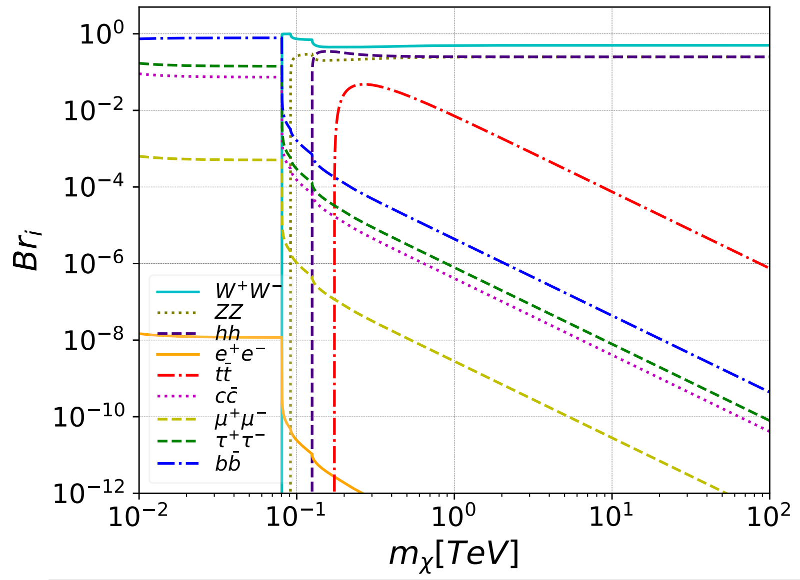
Dwarf observations with the MAGIC telescopes

MAGIC recently published in [2] a combined model independent DM search in the dSphs **Segue 1** (158h), **Ursa Major II** (95h), **Draco** (52h), and **Coma Berenices** (49h) with a **total exposure of 354h**.

Results

We present the observational 95% confidence level (CL) upper limits (UL) on the thermally-averaged cross-section $\langle\sigma v\rangle$ (see Fig. 2) and on the brane tension *f* (see Fig. 3) for branon DM annihilation obtained with 354h of multi-dSph observations with the MAGIC telescopes. We perform a model dependent search for branon DM particles of masses between 100 GeV and 100 TeV. As expected from the no significant gamma-ray excess in the data, our constraints for branon DM annihilation are located within the 68% containment band, which is consistent with the no-detection scenario. We obtain **our strongest limit** $\langle\sigma v\rangle \approx 5.9 \times 10^{-24} cm^3 s^{-1}$ for a ~0.7 TeV branon DM particle mass.



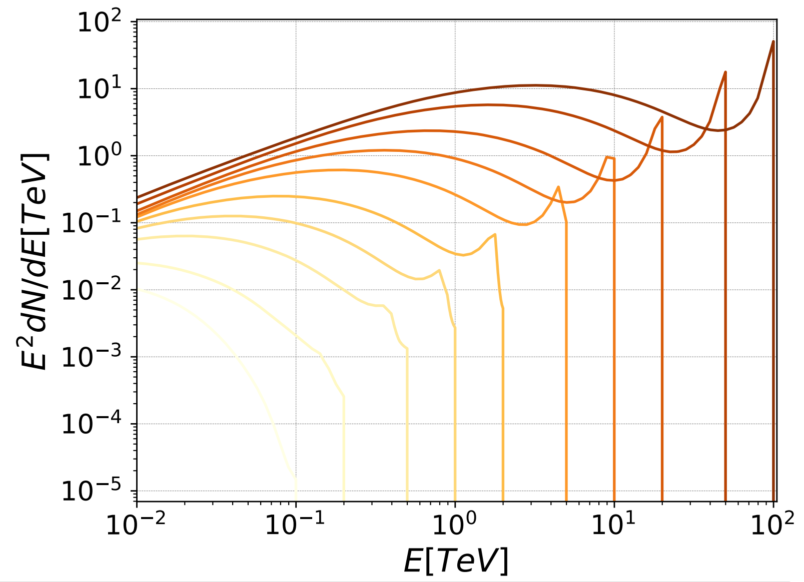


Fig. 1: Branon branching ratios (left) and differential photon yield per branon annihilation (right).

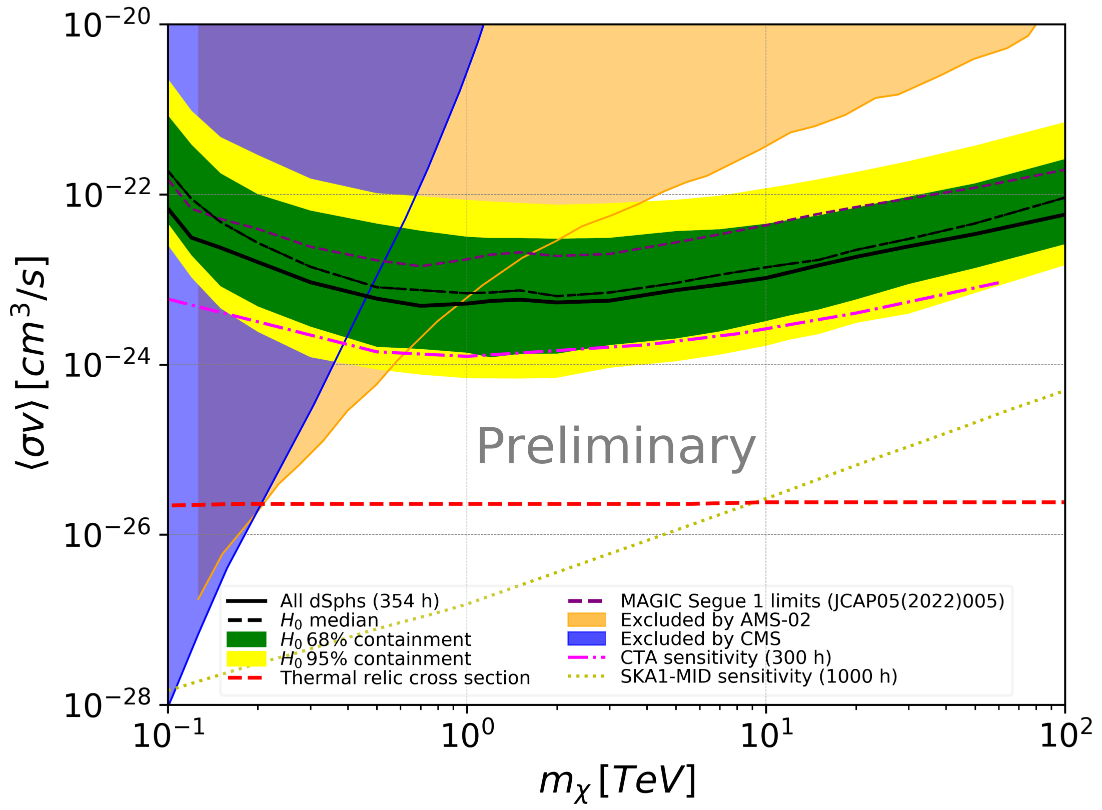


Fig. 2: Observational 95% CL UL on the thermally-averaged cross-section.

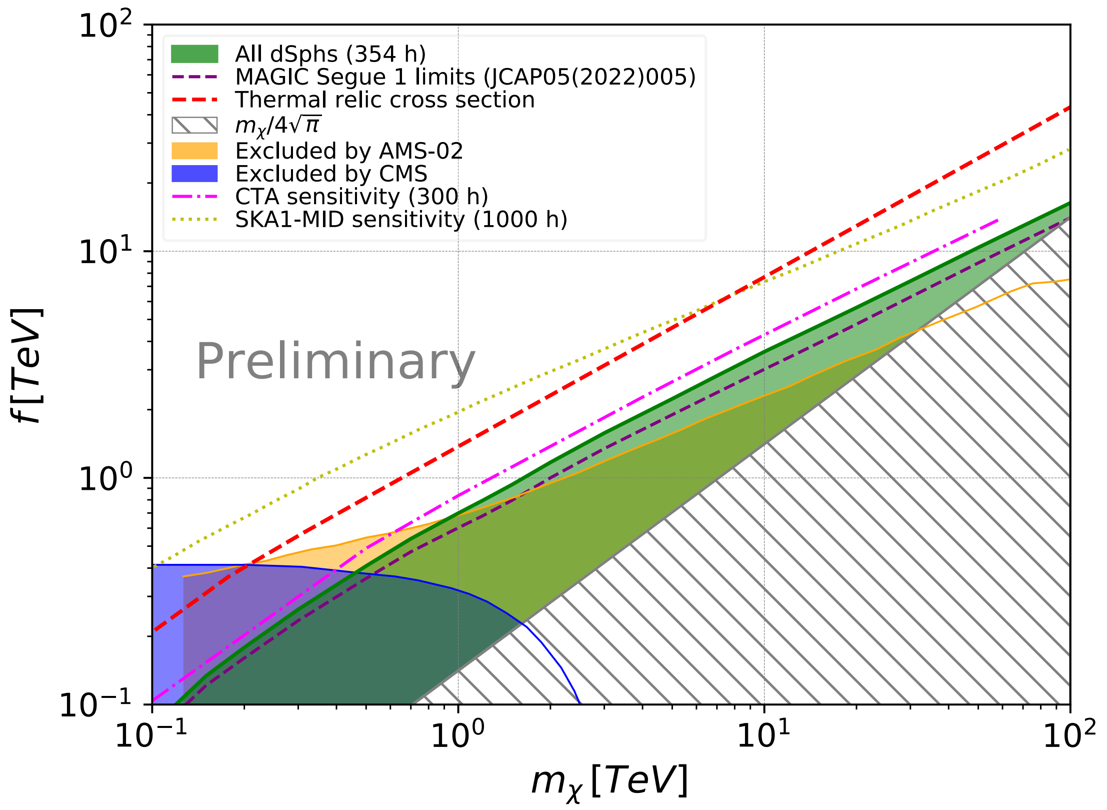


Fig. 2: Observational 95% CL UL on the brane tension.

Conclusion

This work leads to the **most constraining branon DM limits in the TeV mass range**, superseding previous constraints by CMS, AMS-02 and MAGIC Segue1 limits [3]. We can achieve even more stringent exclusion limits by adding further dSph observations of the MAGIC telescopes or other gamma-ray or neutrino telescopes to this analysis [4].

References

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[b]https://github.com/TjarkMiener/likelihood_combiner

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