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Indirect constraints to branon dark matter

V. Gammaldi*, J. A. R. Cembranos*, A. de la Cruz-Dombriz^{†,**} and A. L. Maroto*

**Departamento de Física Teórica I, Universidad Complutense de Madrid, E-28040 Madrid, Spain.*

[†]*Astrophysics, Cosmology and Gravity Centre (ACGC), University of Cape Town, Rondebosch, 7701, South Africa.*

** *Department of Mathematics and Applied Mathematics, University of Cape Town, 7701 Rondebosch, Cape Town, South Africa.*

Abstract. If the present dark matter in the Universe annihilates into Standard Model particles, it must contribute to the gamma ray fluxes detected on the Earth. Here we briefly review the present constraints for the detection of gamma ray photons produced in the annihilation of branon dark matter. We show that observations of dwarf spheroidal galaxies and the galactic center by EGRET, Fermi-LAT or MAGIC are below the sensitivity limits for branon detection. However, future experiments such as CTA could be able to detect gamma-ray photons from annihilating branons of masses above 150 GeV.

Keywords: branons, dark matter, gamma rays

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INTRODUCTION

According to present astrophysical observations and collider experiments, dark matter (DM) cannot be accommodated within the Standard Model (SM) of elementary particles. In the framework of indirect detection of DM, gamma photons might be observed as products of DM annihilation into SM particles. The magnitude of such a contribution depends on the particular DM candidate and the astrophysical target. Brane fluctuations (branons) are massive and weakly interacting particles which appear as natural DM candidates in brane-world models [1, 2, 3]. Even if branons are stable, they can annihilate by pairs into ordinary particles in different astrophysical objects (galactic haloes, Sun, Earth, etc.) and generate cascade processes whose products could contribute to the gamma ray flux.

This differential gamma ray flux from annihilating DM particles in galactic sources can be written as [4]:

$$\frac{d\Phi_{\gamma}^{\text{DM}}}{dE_{\gamma}} = \frac{1}{4\pi M^2} \sum_i \langle \sigma_i v \rangle \frac{dN_{\gamma}^i}{dE_{\gamma}} \times \frac{1}{\Delta\Omega} \int_{\Delta\Omega} d\Omega \int_{l.o.s.} \rho^2[(s)] ds \quad (1)$$

where the second term on the r.h.s. of this equation represents the astrophysical factor and the first term is the particle dependent part, with $\langle \sigma_i v \rangle$ the thermal averaged annihilation cross-section of two DM particles into two SM particles (labeled by the subindex i). The number of photons produced in each decaying channel per energy interval $dN_{\gamma}^i/dE_{\gamma}$ can be simulated by means of the PYTHIA particle physics software [4]. In the case of heavy branons, the main contribution to the photon flux comes from

Figure 1. Branon annihilation branching ratios into SM particles. See text and Ref.[5]

branon annihilation into ZZ and W^+W^- (Fig. 1). In this case, the produced high-energy gamma photons could be in the range (30 GeV-10 TeV), detectable by Atmospheric Cherenkov Telescopes (ACTs) such as MAGIC (with a threshold of 60-70 GeV). On the contrary, if $M < m_{W,Z}$, the annihilation into W or Z bosons is kinematically forbidden and it is necessary to take into account the rest of channels, mainly annihilation into the heaviest possible quarks (Fig. 1). In this case, the photon fluxes would be in the range detectable by space-based gamma ray observatories such as EGRET (Energy range of 0.02-30 GeV) and FERMI (20 MeV-300 GeV).

ANALYSIS AND RESULTS

The best targets to search for a DM annihilation signal are dwarf spheroidals (dSphs) and the Galactic center. The astrophysical part $\langle J \rangle_{\Delta\Omega}$ of the gamma-ray flux (1) of each target depends upon the DM density. A Navarro-Frenk-White (NFW) profile is assumed for the Draco, Sagittarius and Canis Major dSphs and for the Galactic Center [6], and an Einasto profile for SEGUE 1. The minimum flux Φ_γ required for a detection with a significance above 5σ can be obtained from [6]:

$$\frac{\Phi_\gamma \sqrt{\Delta\Omega A_{eff} t_{exp}}}{\sqrt{\Phi_\gamma + \Phi_{Bg}}} \geq 5. \quad (2)$$

where t_{exp} is the exposure time, A_{eff} the instrument effective area and $\Delta\Omega$ the angular acceptance. The evaluation of the background Φ_{Bg} and its value depends both on the experiment and on the source. In [5] the astrophysical factor, the technical details of

Figure 2. Sensitivity of different targets to constrain gamma rays coming from branon annihilation. The straight lines show the estimated exclusion limits at 5σ for satellite experiments (FERMI and EGRET). The thick dashed line corresponds to the photon flux above 1 GeV coming from branons with the thermal abundance inside the WMAP7 limits ($\Omega_{\text{CDM}}h^2 = 0.1123 \pm 0.0035$). The area on the upper left corner above the corresponding lines is excluded by LEP and TEVATRON experiments for both $N = 1$ and $N = 7$, number of extra dimensions [3].

Figure 3. Same as Fig. 2 for ground-based detectors. In this figure, the continuous thick dashed line corresponds to the photon flux above 50 GeV coming from branons with the thermal abundance inside the WMAP7 limits.

each experiment, the background estimations and the resulting values of the minimum detectable gamma-ray fluxes for each sources are reported.

By using the estimated minimum detectable flux at 5σ significance and the particular astrophysical factor ($J_{\Delta\Omega}$) of each target, the sensitivity on $N_\gamma^{(5)} \langle \sigma v \rangle$ has been obtained

as a function of the WIMP mass depending on the particular detector. The corresponding curves for the different targets and detectors are shown in Figs. 2 and 3. The theoretical value for $N_\gamma \langle \sigma v \rangle$ for branons has been obtained by integrating the differential spectrum $\sum_i \langle \sigma_i v \rangle \frac{dN_\gamma^i}{dE_\gamma}$ taking into account the energy threshold of 1 GeV for satellite experiments (Fig. 2) or 50 GeV for ACTs (Fig. 3). The resulting $N_\gamma \langle \sigma v \rangle$ with the WMAP constraints on the relic density, is a function of M [5].

CONCLUSIONS

As shown in Fig. 2, present experiments (EGRET, FERMI or MAGIC) are unable to detect signals from branon annihilation for the targets considered. However, as shown in Fig. 3, future experiments such as CTA could be able to detect gamma-ray photons coming from the annihilation of branons with masses higher than 150 GeV for observations of the Galactic Center or above 200 GeV for Canis Major. In the same figures (2 and 3), it is possible to see the present constraints from collider experiments. These searches are complementary and probe, in general, a different area of the parameter space of the model.

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REFERENCES

1. J. A. R. Cembranos, A. Dobado and A. L. Maroto, Phys. Rev. Lett. **90**, 241301 (2003); J. A. R. Cembranos, A. Dobado and A. L. Maroto, Phys. Rev. D **68** 103505 (2003); J. A. R. Cembranos, A. Dobado and A. L. Maroto, hep-ph/0402142; hep-ph/0406076; hep-ph/0411076; astro-ph/0411262; Int. J. Mod. Phys. D **13**, 2275 (2004) [hep-ph/0405165]; astro-ph/0503622; astro-ph/0512569; astro-ph/0611911; A. L. Maroto, Phys. Rev. D **69**, 043509 (2004); Phys. Rev. D **69**, 101304 (2004); J. A. R. Cembranos *et al.*, 0708.0235 [hep-ph]; JCAP **0810**, 039 (2008)
2. A. Dobado and A. L. Maroto, Nucl. Phys. B **592**, 203 (2001); J. A. R. Cembranos, A. Dobado and A. L. Maroto, Phys. Rev. D **65** 026005 (2002); hep-ph/0107155
3. J. A. R. Cembranos, A. Dobado and A. L. Maroto, Phys. Rev. D **70**, 096001 (2004)
4. J. A. R. Cembranos, A. de la Cruz-Dombriz, A. Dobado, R. Lineros and A. L. Maroto, Phys. Rev. D **83**, 083507 (2011); J. Phys. Conf. Ser. **314**, 012063 (2011); AIP Conf. Proc. **1343** 595-597 (2011); <http://teorica.fis.ucm.es/PaginaWeb/downloads.html>; <http://teorica.fis.ucm.es/PaginaWeb/descargas/damasco.C>
5. J. A. R. Cembranos, A. de la Cruz-Dombriz, V. Gammaldi, A.L. Maroto, arXiv:1111.4448 [astro-ph.CO], accepted for publication in Phys. Rev. D; A. de la Cruz-Dombriz, V. Gammaldi, Proceedings PHOTON11, arXiv:1109.5027
6. N. W. Evans, F. Ferrer and S. Sarkar, Phys. Rev. D **69**, 123501 (2004)