Search for supersymmetric Dark Matter with GLAST

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Abstract

The EGRET telescope has identified a gamma-ray source at the Galactic center. We point out here that the spectral features of this source are compatible with the gamma-ray flux induced by pair annihilations of dark matter weakly interacting massive particles (WIMPs). We show that the discrimination between this interpretation and other viable explanations will be possible with GLAST, the next major gamma-ray telescope in space, on the basis of both the spectral and the angular signature of the WIMP-induced component. If, on the other hand, the data will point to an alternative explanation, we prove that there will still be the possibility for GLAST to single out a weaker dark matter source at the Galactic center. The potential of GLAST has been explored both in the context of a generic simplified toy-model for WIMP dark matter, and in a more specific setup, the case of dark matter neutralinos in the minimal supergravity framework. In the latter, we find that even in the case of moderate dark matter densities in the Galactic center region, there are portions of the parameter space which will be probed by GLAST.

1. Introduction

Unveiling the nature of non-baryonic cold dark matter (CDM) is one of the major challenges in science today. Weakly interacting massive particles (WIMPs) are among the leading dark matter candidates. Considerable effort has been put in the search for dark matter WIMPs in the last decade, with several complementary techniques applied (for a recent review, see, e.g., [1]). Among them, indirect detection through the identification of the yields of WIMP pair annihilations in dark matter structures seems to be a very promising method. In particular, we will focus here, as a signature to identify dark matter, on the possible distortion of the spectrum of the diffuse γ-ray flux in the Galaxy due to a WIMP-induced component, extending up to an energy equal to the WIMP mass.

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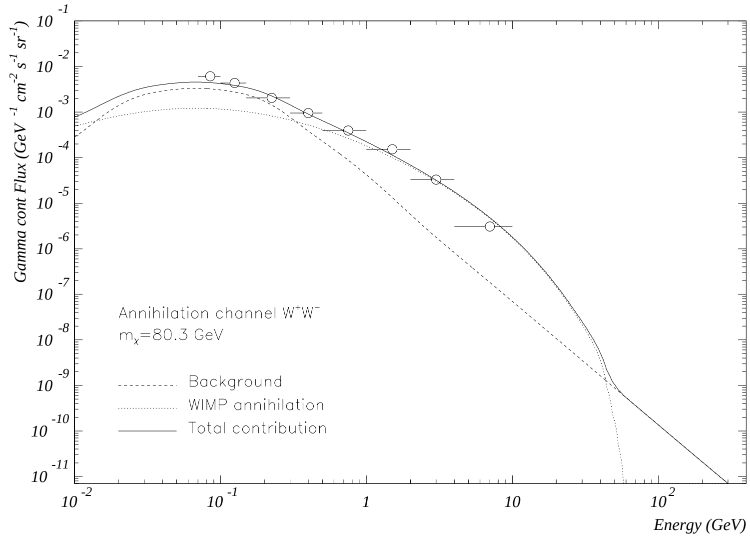

Fig. 1. Fit of the EGRET GC γ-ray data for one WIMP models with WIMP mass $M_\chi = 80.3$ GeV in the W^-W^+ annihilation channel. Signal and background components are indicated separately, while their sum is shown with a solid line.

The EGRET telescope on board of the Compton Gamma-Ray Observatory has mapped the γ-ray sky up to an energy of about 20 GeV over a period of 5 years. The data collected by EGRET toward the Galactic center (GC) region show [2] evidence for a gamma-ray source, possibly diffuse rather than point-like, located within 1.5° of the GC ($l = b = 0°$). The detected flux largely exceeds the diffuse γ-ray component expected in the GC direction with a standard modeling of the interaction of primary cosmic rays with the interstellar medium (see, e.g., [3]); the latter fails also to reproduce the spectral shape of the GC source. Although other plausible explanations have been formulated, it is very intriguing that the EGRET GeV excess shows, as basic features, the kind of distortion of the diffuse γ-ray spectrum one would expect from a WIMP-induced component, assuming that the dark matter halo profile is peaked toward the GC.

In figure 1 we show the EGRET data from the Galactic center, the diffuse gamma ray background flux expected from the standard interactions and propagation models of cosmic ray protons and electrons and an example of the flux due to neutralino annihilation in the dark matter halo. In this case the signal is for a ~ 80 GeV neutralino and for the W^-W^+ annihilation channel (the spectral shape of the other channels is very similar). More details of the calculation can be found in [5].

As it can be seen from figure 1, the fit to the data greatly improve when a neutralino component is added. Of course this cannot be assumed as evidence

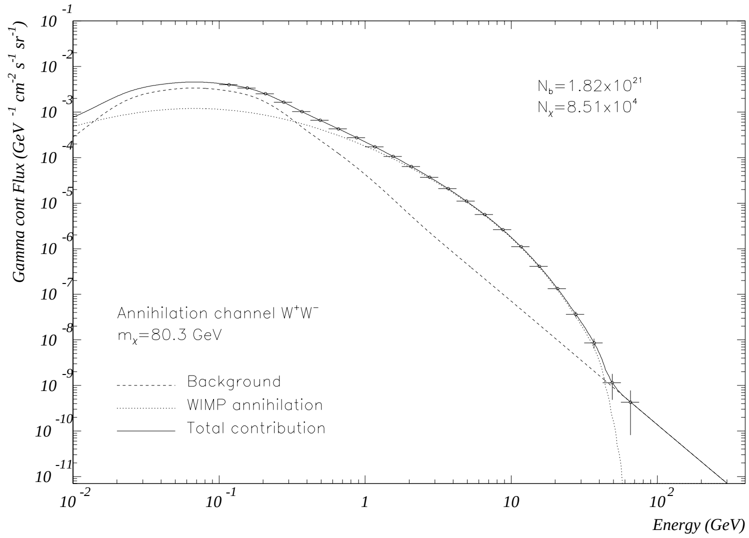

Fig. 2. Simulation of the data set which will be obtained with GLAST in 2 years, in case the EGRET GC excess is due to the WIMP-induced flux shown in Fig. 1. The error bars refer to statistical errors for the chosen energy binning and for the angular acceptance $\Delta\Omega = 10^{-3}$ sr.

for the existence of supersymmetric particles as the dark matter component of the halo, but as an indication that more experiments with greater sensitivity and exposure are needed. In the next session we present one future possibility, i.e. the experiment GLAST.

2. GLAST

The Gamma-ray Large Area Space Telescope (GLAST)[4] has been selected by NASA as the next major γ-ray mission, and it is scheduled for launch in the first half of 2006. Compared to EGRET, GLAST will have a much larger effective area, better energy and angular resolutions, as well as it will cover a much wider energy range. GLAST will perform an all-sky survey of γ-ray sources, with scientific objectives including the study of blazars, γ-ray bursts, supernova remnants, pulsars, the diffuse radiation in the Galaxy, and unidentified high-energy sources. In figure 2 we show the kind of statistical errors that it is expected in 2 years with GLAST in case the EGRET Galactic Center excess is due to the WIMP-induced flux shown in figure 1. In figure 3 we show contour plots of the neutralino density N_χ for mSUGRA parameter space that allows the detection of the neutralino γ ray signal with GLAST. An extensive description of the method used is presented in [5]. Here we would like to point out that even in case of mod-

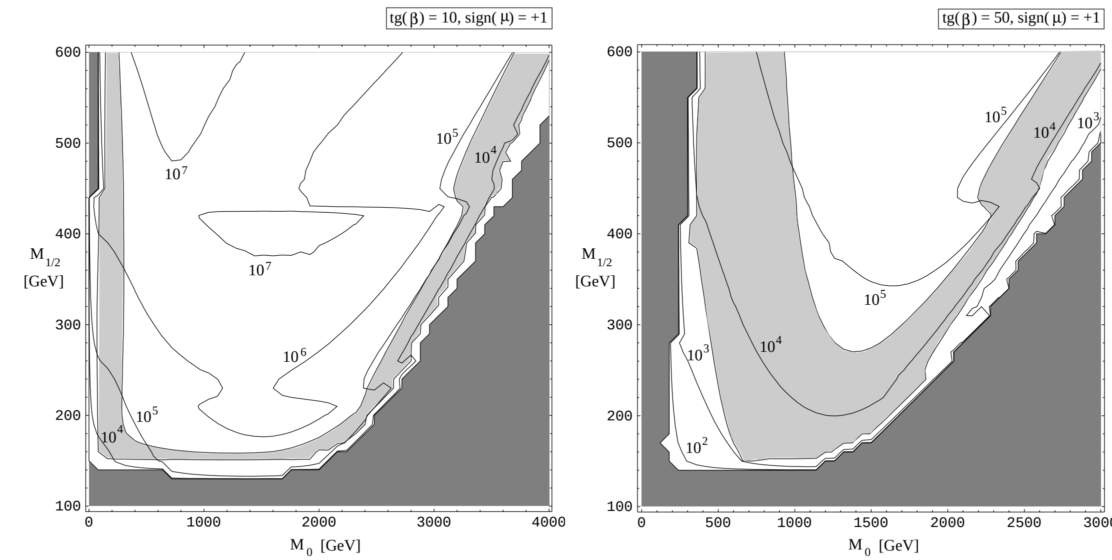

Fig. 3. Contour plots in the mSUGRA $(m_0, m_{1/2})$ plane, for the value of the neutralino density N_χ in a $\Delta\Omega = 10^{-5}$ sr region around the Galactic center, that allows the detection of the neutralino γ ray signal with GLAST. The light shaded region corresponds to the cosmologically favoured region where $0.1 \leq \Omega_\chi h^2 \leq 1$, while the dark shaded one corresponds to models that are excluded either by incorrect Electro-Weak Symmetry Breaking conditions, LEP bounds violations or because the neutralino is not the LSP.

erately singular dark matter profiles, there are regions in the parameter space which will be probed by GLAST.

References

[1] L. Bergström, Rept. Prog. Phys. **63** (2000) 793.

[2] H. Mayer-Hasselwander et al., Astron. Astrophys. **335** (1998) 161.

[3] A. W. Strong, I. V. Moskalenko and O. Reimer, Astrophys. J. **537** (2000) 763 [Erratum-ibid. **541** (2000) 1109].

[4] *http://www-glast.stanford.edu*. For a description of the apparatus see R. Bellazzini, Frascati Physics Series Vol.XXIV, 353, (2002); a discussion of the main scientific goals can be found in A.Morselli, Frascati Physics Series Vol.XXIV, 363, (2002), (http://www.roma2.infn.it/infn/aldo/ISSS01.html).

[5] A.Cesarini, F. Fucito, A. Lionetto, A.Morselli, Piero Ullio, astro-ph/0305075, submitted to Astroparticle Physics