Search for dark matter in space

Aldo Morselli
INFN and University of Roma "Tor Vergata", Rome, Italy
E-mail: aldo.morselli@roma2.infn.it

Abstract. The detection of gamma-rays, antiprotons and positrons due to pair annihilation of dark matter particles in the Milky Way halo is a viable technique to search for supersymmetric dark matter candidates if there is the possibility to separate the signal from the background generated by standard production mechanisms. Here we discuss the status of this indirect search and the prospective for the future experiments GLAST and PAMELA.

Figure 1. Fit of the EGRET Galactic Center γ-ray data for a sample WIMP models with $M_\chi = 80.3 \text{ GeV}$ and $W^- W^+$ annihilation channel.

Figure 2. The same fluxes with the kind of statistical errors that it is expected in three years with GLAST

1. The GLAST experiment
GLAST [1] is a next generation high-energy gamma-ray observatory designed for making observations of celestial gamma-ray sources in the energy band extending from 20 MeV to more than 300 GeV. The principal instrument of the GLAST mission is the Large Area Telescope (LAT) that is being developed as a mission involving an international collaboration of particle physics and astrophysics communities from 26 institutions in the United States, Italy, Japan, France and Germany. The main scientific objects are the study of all gamma ray sources such as blazars, gamma-ray bursts, supernova remnants, pulsars, diffuse radiation, and unidentified high-energy sources. A description of the main GLAST parameters can be found in [2]. GLAST could be of particular interest for the search of dark matter candidates. Figure 1 shows the EGRET
data located within $2^\circ$ the Galactic center together with 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 [3] Figure 2 shows the same fluxes of figure 1 with the kind of statistical errors that is expected in two years with GLAST [4] It can be seen that GLAST will have the necessary statistical and energetic accuracy to distinguish the two kind of spectral shape. A complete study in the minimal supergravity (mSUGRA) framework can be found in [4] where it is shown the GLAST capability to probe in two years the supersymmetric dark matter hypothesis.

Recentry the H.E.S.S. experiment has discovered a powerful TeV gamma-ray source in the galactic center (see figure 3 and ref. [5]. The source position is consistent with SGR A* to 6” and slightly extended (see figure 3) with an unbroken power-law with $\Gamma = 2.2$ and no evidence for variability on a variety of time scales. There have been studies to connect the H.E.S.S. flux with neutralino annihilation [6] but as can be noted from figure 4, the extrapolation of the H.E.S.S flux to the EGRET energies with the same power law give a flux that is a factor hundred less and then it is very likely that the two sources are different.

2. The PAMELA experiment
The search for supersymmetric signal with GLAST will be complementary to the search for neutralinos looking at the distortion of the secondary positron fraction and secondary antiproton flux that will be performed with PAMELA [7] and AMS [8]. To be able to distinguish the possible exotic contribution from the standard one we have performed an analysis of the uncertainties of the standard fluxes with the use of GALPROP code [10]. Similar studies was made also for others propagation codes [11].

Figure 5 shows the PAMELA expectations for the antiproton flux for the best standard production and propagation model [10] obtained with the use of PAMELA geometrical factor and detector characteristics [9]. In addition it is shown the SUSY contribution to the $\bar{p}$ flux for a neutralino mass of 1 TeV (obtained from a particular choice of mSUGRA parameters) and a clumpiness factor $f_d$ of $5 \times 10^4$ that has been computed using the public code DarkSUSY.

For the discrimination between the standar and exotic contributions we request the following conditions: 1) The total antiproton flux $\phi_{tot} = \phi_{bkg} + \phi_{susy}$ gives a good fit of the experimental data. 2)Difference between $\phi_{tot}$ and the DC model $\phi_{bkg}$ is detectable by PAMELA.

In [10] is shown that PAMELA will be able to disentangle a neutralino induced component
Figure 5. Antiproton absolute flux: theoretical predictions for total uncertainty and best B/C fit for DC model (dashed lines). Experimental data are from [9]. The PAMELA expectations points (red squares) for DC background are for three years of data taking. The dash-dotted line is a neutralino induced contribution for a neutralino mass of 1 TeV (see text) and a clumpiness factor \( f_d \) of \( 5 \times 10^4 \) while the solid line is total contribution calculated with the addition of the DC background and the red circles are the corresponding PAMELA points.

for halo models that has \( f_d \) as low as \( \sim 10 \) and this kind of search is very complementary to the GLAST search.

References

[1] Bloom E, Godfrey G and Ritz S 1998 Proposal for the Gamma-ray Large Area Telescope SLAC-R22
Morselli A 1997 XXXIIInd Rencontres de Moriond, Very High Energy Phenomena in the Universe, Les Arcs, France, January 18-25 1997 Editions Frontiers pp 123-6
[2] Morselli A 2002 Astroparticle and Gamma ray Physics in Space Frascati Physics Series vol XXIV pp 363-80 http://www.roma2.infn.it/infn/aldo/ISSS01.html
Bellazzini R et al 2002 Nucl. Phys. B 113 303-9
Morselli A 2004 Nucl. Instrum. Methods A 530 158-62
[3] Morselli A, Lionetto A, Cesarini A, Fucito F and Ullio P 2002 Nucl. Phys. 113 213-20
[4] Cesarini A, Fucito F, Lionetto A, Morselli A and Ullio P 2004 Astropart. Phys. 21 267-85 (Preprint astro-ph/0305075)
[5] Aharonian F et al [The HESS Collaboration] 2004 Preprint astro-ph/040814
[6] Profumo S 2005 Preprint astro-ph/0508628
Bergstrom L, Bringmann T, Eriksson M and Gustafsson M 2005 Preprint hep-ph/0507229
[7] Bongi M et al 2004 IEEE Transactions on Nuclear Science 51 3: 854-9
[8] Aguilar M et al 2002 Phys. Rep. 366 331
[9] Picozza P and Morselli A 2003 J. Phys. G: Nucl. Part. Phys. 29 903-11
[10] Lionetto A, Morselli A and Zdralkovic V 2005 J. Cosmol. Astropart. Phys. JCAP09(2005)010 (Preprint astro-ph/0502406)
[11] Donato F, Fornengo N, Maurin D, Salati P and Taillet R 2003 Phys. Rev. D 69 06350
Bottino A et al Preprint hep-ph/0507086