Evidece for a dark matter particle

YUKIO TOMOZAWA
Michigan Center for Theoretical Physics, University of Michigan

Abstract: A prediction and observational evidence for the mass of a dark matter particle are presented.

Keywords: dark matter particle, cosmic rays, gamma rays, AGN

1 Introduction

It has been reported by HESS that there are excess gamma rays above the TeV range from some gamma ray emitters. In PKS 2005-489 gamma ray data, they have observed excess gamma rays above 2 TeV, which is above the power law extension of the low energy data[1]. However, it is difficult to draw a conclusion from data from an individual object due to poor statistics. If one is interested in gamma rays from dark matter particle (DMP) and antiparticle annihilation, one can combine data from various sources, since a sharp peak at the same energy can be expected. To prove a point, I have selected part of their data that was obtained from 8 sources which are located in neighboring space and time and have comparable statistics, with an energy range of 1 to 20 TeV.

2 Theoretical prediction for DMP mass

Recent data from the Pierre Auger Project has reported a strong correlation between sources of high energy cosmic rays and AGN[2]. The author has predicted this data since 1985. In his model, the author has shown that quantum field theory yields a repulsive component at short distances for gravity and that black hole collapse results in an explosion by repulsive forces. The knee energy of cosmic ray energy spectrum is an inter-phase of radiation-dominated expansion and matter-dominated expansion, similar to the expansion of the universe[3],[4],[5]. This necessitates the existence of a mass scale at 3 PeV, the knee energy of cosmic rays. This mass scale may be an indication of new physics. If itcorresponds a supersymmetric multiplet, the lowest mass particle (LMP) is a candidate for DMP.

In order to have a mass scale of 3 PeV and a DMP of relatively low mass, one has to have a supersymmetry with a large mass ratio. Such a theory has been proposed by GLMR (Giudice, Luty, Murayama and Rattazzi). Assuming the absence of singlets, GLMR derived a large mass ratio[6],

$$M_2 = \frac{\alpha}{4\pi \sin^2 \theta_W} m_{3/2} = 2.7 \times 10^{-3} m_{3/2}, \quad (1)$$

among other parameter relations, where α and θ_W are the fine structure constant and the weak interaction angle respectively. Since this is the largest mass ratio obtained, one may choose the highest mass scale to be

$$m_{3/2} = 3\,\text{PeV}; \quad (2)$$

then one gets[7]

$$M_2 = 8.1\,\text{TeV}, \quad (3)$$

which is the mass of LMP, i.e., the DMP mass. Being a weakly interacting particle, this particle must be produced by a pair in an accelerator experiment. This makes it impossible to discover these particles directly in LHC experiments at the presently planned energy scale. The accuracy of the prediction is in the range of 10 % from the determination of the knee energy of the cosmic ray energy spectrum.

3 Data of TeV gamma rays

In a recent HESS report[8], high energy gamma rays from 8 unknown sources have been recorded. The data from each source cover the energy range of 1 to 40 TeV and have similar statistics, since they have been obtained in a recent systematic survey. That the sources are unknown may not be a drawback for dark matter gamma ray search, since unknown sources mean that the sources may not be ordinary AGN or other known astronomical objects. If the source is an AGN type object consisting entirely of dark matter particles, it may not have the signature of an ordinary AGN, since such a signature needs ordinary matter to emit atomic photons. The presence of abundant dark matter favors 2 gamma ray emission of DMP and anti-DMP annihilation.

One does not need to exclude gamma ray emittors such as ordinary AGN etc, since one expects a DMP environment in such a case as well. The simple sum of gamma rays from these 8 sources are plotted in Fig. 1. The error bars are estimated from the existing data. The sum clearly showes a peaking at 7.6±0.1 TeV. This is consistent with the predicted value of 8.1 ± 0.8 TeV.
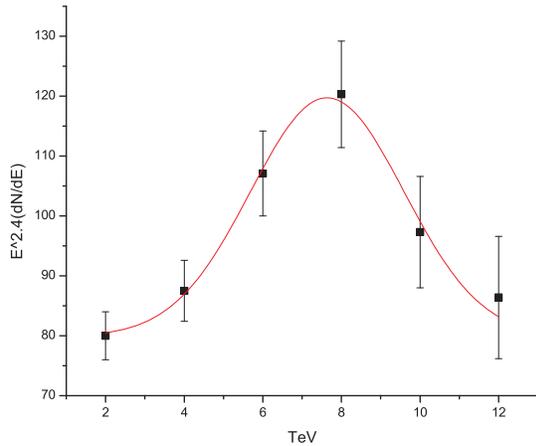

Fig. 1

Sum of spectra of 8 unidentified sources. The y axis is E^{2.4}dN/dE in the units of (TeV)^{0.4}(erg /cm^2 s).

Clearly, I have chosen a small subset of HESS data. In order to get a more accurate estimate of this peaking phenomenon, it is desirable to analyze much more data. Here are some suggestions.

1) In order to get a sensible conclusion, one has to sum up data from many sources, as is done in this article. For a DMP + anti-DMP $\to 2\gamma$ search, this is a reasonable approach.

2) Choose all data with an exceess in the multi-TeV energy range. The data that do not have excess in multi-TeV range contribute only to increased statistical error bars.

3) Sum up data in the 1-15 TeV range, since the error beyond this energy range tends to increase due to the scarcity of events.

4) The sources can be identifid or unidentified. The latter should not be excluded, since there is a chance to have more dark matter contributions from such events.

5) A systematic survey is welcome, since such an approach tends to have a consistent statistical significance.

References

[1] HESS Collaboration, Acero, F. et al., ArXiv:astro-ph.0911.2709 (2009).

[2] The Pierre Auger Collaboration, Science 318, 933 (2007).

[3] Tomozawa, Y., Magnetic Monopoles, Cosmic Rays and Quantum Gravity, in the Proc. of 1985 INS International Symposium on Composite models of Quarks and Leptons (Tokyo, edit. Terazawa, H. and Yasue, M., 1985) pp. 386.

[4] Tomozawa, Y., Cosmic Rays, Quantum Effects on Gravity and Gravitational Collapse, Lectures given at the Second Workshop on Fundamental Physics, University of Puerto Rico, Humacao, March 24-28, 1986. This lecture note can be retrieved from KEK Kiss NO 200035789 at http://www-lib.kek.jp/KISS/kiss_prepri.html

[5] Tomozawa, Y., MPLA 23, 1991 (2008), arXiv: 0802.0301; High Energy Cosmic Rays from AGN and the GZK Cutoff, arXiv: 0802.2927 (2008).

[6] Giudice, G. F., Luty, M. A., Murayama, . and Rattazzi H, R., JHEP 12, 027 (1998).

[7] Tomozawa, Y., Cosmic Rays from AGN, the Knee Energy Mass Scale and Dark Matter Particle, to be submitted (2010).

[8] Aharonian, F. et. al., Astron. & Astroph. 477, 353 (2008).
.