Evidence for a dark matter particle

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Abstract

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

It has been reported by HESS that there are excess gamma rays above the TeV range from some gamma ray emitters. In the PKS 2005-489 gamma ray data, excess gamma rays appear above 2 TeV, which is above the power law extension of the low energy data\cite{1}. However, it is difficult to draw a conclusion from data for 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. The only necessary procedure is statistical weighing to sum up data of different quality. To prove a point, I have selected part of the HESS data 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.

II. 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\cite{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 the cosmic ray energy spectrum is an inter-phase of radiation-dominated expansion and matter-dominated expansion, similar to the expansion of the universe\cite{3},\cite{4},\cite{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 it corresponds to a supersymmetric multiplet, the lowest mass particle (LMP) is a candidate for a 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\cite{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 \(\alpha\) and \(\theta_W\) 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

\[ m_{3/2} = 3 \text{ PeV}; \]  

(2)

then one gets\[ M_2 = 8.1 \text{ TeV}, \]  

(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.

III. TEV GAMMA RAY DATA

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 20 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 a dark matter gamma ray search, since unknown 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 from DMP and anti-DMP annihilation. One does not need to exclude gamma ray emitters such as ordinary AGN etc, since one expects a DMP environment in such a case as well. The simple sum of gamma rays from the 8 sources is plotted in Fig. 1. The error bars are estimated from the existing data. The sum clearly shows a peak at 7.6 ± 0.1 TeV. This is consistent with the predicted value of 8.1 ± 0.8 TeV.

Clearly, I have chosen a small subset of HESS data. In order to get a more accurate estimate for 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 → 2\gamma search, this is a reasonable approach.
2) Choose all data with an excess in the 1-15 TeV energy range. Data that do not have excess in multi-TeV range contribute only to increased statistical error bars without adding a significant contribution to the peak value.

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 identified 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.

It is hoped that this report will encourage a systematic DMP mass search in the 1-15 TeV energy range.

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Figure caption

Fig. 1. Sum of gamma ray energy spectra of 8 unidentified sources[8]. The y axis is $E^{2.4}(dN/dE)$ in units of $10^{-12}(\text{TeV})^{0.4}(\text{erg cm}^{-2}\text{s}^{-1})$. 
