Universal Extra Dimensional Particles Dynamics in Annihilation Channels: Proof of Dark Matter Evidence

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Abstract: The question as to how this universe came into being and as to how it has evolved to its present stage, is an old question. The answer to this question unfolds many secrets regarding fundamental particles and forces between them. Theodor Kaluza proposed the concept that the universe is composed of more than four space-time dimensions. In his work electromagnetism is united with gravity. Various extra dimensions formulations have been proposed to solve a variety of problems. Recently, the idea of more than four space time dimensions is applied to the search for particle identity of dark matter (DM).Signature of dark matter can be revealed by analysis of very high energy electrons which are coming from outer space. We investigate dynamical conditions of annihilation channels of Lightest Kaluza Klien particle LKP which is suggested to be concrete evidence of dark matter in galactic subhalos [1-9].

Keywords : **Dark Matter, Gravitational Lense**

I. INTRODUCTION

The perception that the universe is composed of more than four space-time dimensions was first proposed by Theodor Kaluza as a method of uniting electromagnetism with gravity. In the years since, various extra dimensions formulations have been proposed to solve a variety of problems. Recently, it has been applied to the search for the particle identity of Dark Matter (DM). Present confirmation shows that more than 80% of the matter in the universe is non-luminous, non-baryonic and not composed of ordinary standard model particles [5]. The proposal of a particle candidate that might explain this unidentified large piece of the universe has become a desirable characteristic of proposed beyond the Standard Model Theories. In particular, theories containing weakly interacting particles with weak-scale masses (WIMPs) are especially shows potential because they lead to WIMP relic densities near the observed dark matter densities without requiring significant parameter tuning. The extra-dimensional theory known as Universal Extra Dimensions (UED) is one such theory. The WIMP candidate this model proposes is known as Kaluza-Klein Dark Matter (KKDM). Although the nature of this particle varies greatly with the various input parameters of the theory, the properties of this particle can be inhibited by cosmological and collider data, as well as by many current and planned particle detectors. Such experiments seek either to directly observe KKDM interactions with ordinary matter or to indirectly detect its existence through observation of its annihilation products. After decades of search for Dark Matter, particles like Axion, Neutralino, Super Symmetry & UED particles are considered as most prominent non baryonic dark matter candidates which are to be detected in future accelerators[1-9].

II. UNIVERSAL EXTRA DIMENSIONS (UED)

Approach for extra-dimensional phenomenology is to look at models where all SM particles can propagate in a higher dimensional space. UED model can suggest dark matter candidate which will be able to explain nature of dark matter and its searches. UED model is conceptually extension of Standard Model. By adding extra dimensions in the SM, it provides a framework to discuss a number of open questions in modern physics. Theoretical and practical motivations to study the UED model include:

- The Model is simple as there are only two parameters (R, Λ_{cut}).
- A possibility to achieve electroweak symmetry breaking without and need to add an explicit Higgs field.
- Proton stability can be achieved even with new physics coming in at low-energy scales. In the Standard Model proton life is 10^{-30} Years whereas in UED proton life is calculated as 10^{35} Years.
- The model explains why there are three generations of particles.
- This model is especially true in the region of parameter space favored by having the dark matter in the form of Kaluza Klein particles.

- May be in future experiments at Large Hadron Collider (LHC) it will be possible to detect UED light KK particles.
- The UED model naturally includes a dark matter particle candidate [10-13].

III. UED DARK MATTER CANDIDATES

The model is applicable to the solution of the dark matter problem when one assumes conservation of momentum in the extra dimension. In space time continuum this leads to conservation of KK number (N_{KK}), which is given by its mode number. The Standard Model (SM) particles have $N_{KK} = 0$ and massive state of set have $N_{KK} = 1$. The folding and boundary conditions required to compactify the extra dimension breaks the conservation of KK number, but if symmetric boundary conditions are chosen, there remains symmetry in KK parity (under which particles of odd KK number are odd). The main consequence of the KK parity is that each interaction vertex in the theory must contain an even number of odd KK parity states. This leads to the stability of the lightest particle in the 1st KK level. This lightest particle is the UED Dark Matter candidate [9]. For the case of first KK mode gauge bosons, electroweak symmetry breaking induces mixing of heavy partners of the B and W_3, denoted by $B^{(1)}$ and $W_3^{(1)}$, in a way similar to the standard model.

IV. THE BOLTZMANN EQUATION

The Boltzmann equation for evolution of particle number density in the universe which is expanding is given as

$$\frac{dn}{dt} + 3Hn = -\langle \sigma v \rangle (n^2 - n^{eq\,2})$$

Where H is the Hubble constant, equal to the rate of acceleration of the universe and n^{eq} is the number density of the particle when it was in thermal equilibrium in the early universe. The <σv> is thermally averaged annihilation cross-section times the velocity of the particle. The above equation is reinstated by changing the term of number density by number of particles per comoving volume. Entropy density is such quantity. By considering Y= n / s and x = m/T. By solving above equation using change of variables one can find the fraction of the energy density of the universe composed of the UED particle is then given by:

$$\Omega = \frac{8\sqrt{45}\pi s_0 x_F}{3H_0^2 M_{Pl}^3 (a + 3b/X_F)\sqrt{\pi g_*}}$$

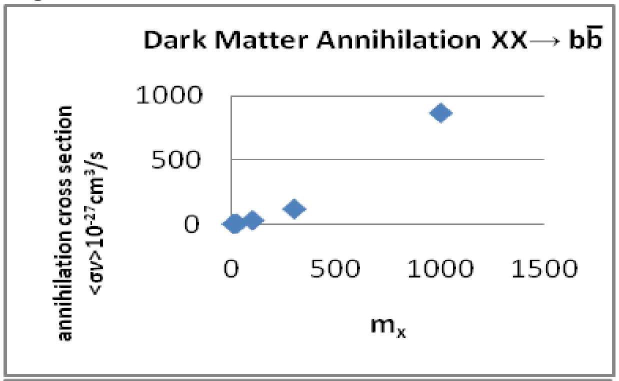
Annihilation of dark matter can produce either Fermions or Higgs in following way

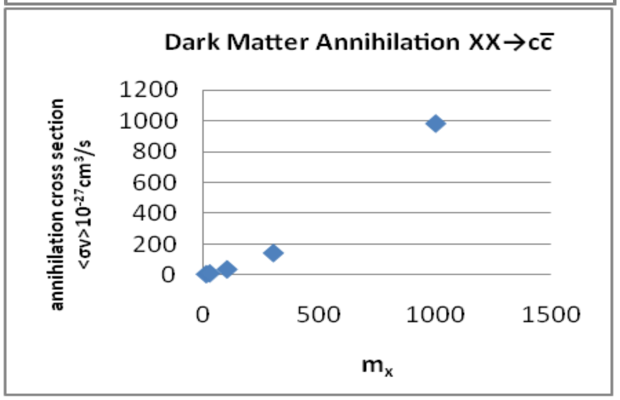
$XX \rightarrow b\bar{b}$ $XX \rightarrow c\bar{c}$

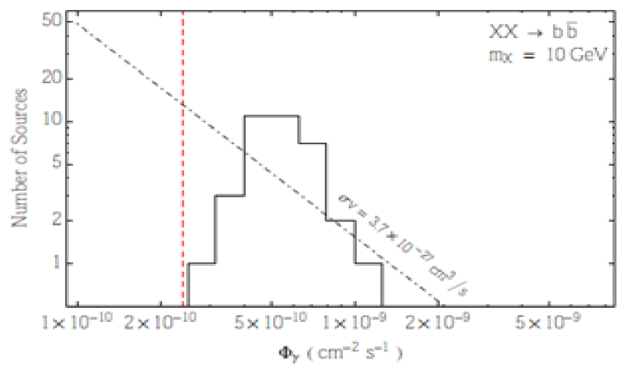
By solving the above channels one can obtain annihilation cross section.

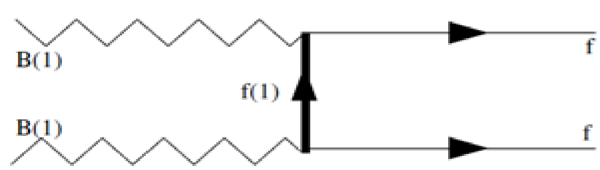
V. RESULT AND CONCLUSION

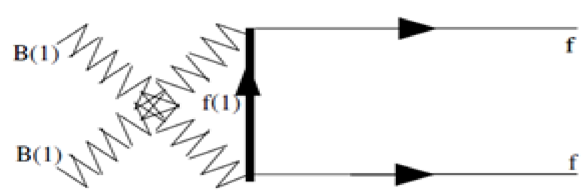
The data of Fermi Gamma Ray telescope and Cherenkov detector are used in the analysis below with LKP mass range 10-1500 GeV.











*Figures:*The annihilation cross section v/s mass graph(top first and second) are plotted with data of Fermi telescope. The lower third is presenting flux density for $b\bar{b}$ and (fourth) is the Feynman diagram used in calculation of cross section and mass limit.

Results shows that universal extra dimensional particles suggested by Kaluza Klien theory and their dynamics in annihilation channels prove of evidence of dark matter in the subhalos of galaxies.

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