Extra Dimensions in the field of Dark Matter

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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. The most important ingredient of this whole creation namely 'Dark Matter' was for the first time identified by Fritz Zwicky of California Institute of Technology (Caltech) in 1933. 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 recent advancement in the field of dark matter search with reference to very high energy electrons from outer space [1-9].

***Keywords*: Dark Matter, Standard Model**

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.

Recently a debate about search of WIMP in Advanced Thin Ionization Calorimeter (ATIC) experiment by S.Dado and his cowerker was opened[3] but, Extra Galactic Background (EGB) in Fermi Large Area Telescope(LAT), and Fermi Gamma Ray Telescope(GLAST), Search by Esra Bulbul et al in study of XMM-Newton spectrum of 73 galaxy clusters spanning a redshift range 0.01-0.35 by Chandra X ray telescope, Alpha Magnetic Spectrometer (AMS) study positron fraction in primary cosmic rays, EPFL's Laboratory of Particle Physics and Cosmology (LPPC) and Leiden University believe they could have identified the signal of a particle of dark matter[6-12].

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 $\langle\sigma v\rangle$ 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. Hence Boltzmann equation may be appeared as

$$\frac{dY}{dx} = -f(x)\left(Y^2 - Y_{EQ}^2\right)$$

By another change of variable Δ = Y-Y_{EQ} so the above equation become

$$\frac{d\Delta}{dx} = -\frac{dY_{EQ}}{dx} - f(x)\Delta(2Y_{EQ} + \Delta)$$

This equation has no general closed solution. The common approach is to solve for solutions at very early and very late times, and to match these solutions. Numerical integrations of the Boltzmann equation have shown that this method is reasonably accurate. At early time when T >> T_F, where T_F is the temperature at which the particle get freezes out, and n in approximation equal to n^{eq}, the left hand side of the equation can be ignored and this is solved to get value of Δ which can be used to obtain the freeze-out temperature. The fraction of the energy density of the universe composed of the particle in question is then given by:

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

The final goal of this exercise is to obtain the dependence of the relic density, x_F and to determine the values of , a and b in terms of of the LKP mass. Consider first the most popular case when the $B^{(1)}$ particle is the LKP. Expanding the $B^{(1)}B^{(1)} \rightarrow f\bar{f}$ in terms of T/m, the coefficients of the first two terms are: $= \frac{1547\pi\alpha_1^2}{324 m_{KK}^2}$, $b = -\frac{1547\pi\alpha^2}{2592 m_{KK}^2}$

II. DETECTION OF LIGHTEST KALUZA KLIEN PARTICLE (LKP) DARK MATTER:

We present here an analysis based on results obtained by [9,10] for annihilaton cross section over various annihilation process of dark matter with different masses from 10-5000GeV range. The reactions which are considered here are eigther producing fermion or higgs.

III. RESULTS AND CONCLUSION:

Results of data collected by Fermi Gamma Ray telescope are analysed here the graph suggests that cross sectional area is increasing for annihilation of heavier dark matter candidates suggested by Kaluza Klien theory. Additional imminent to recognize dynamics of dark matter is required.

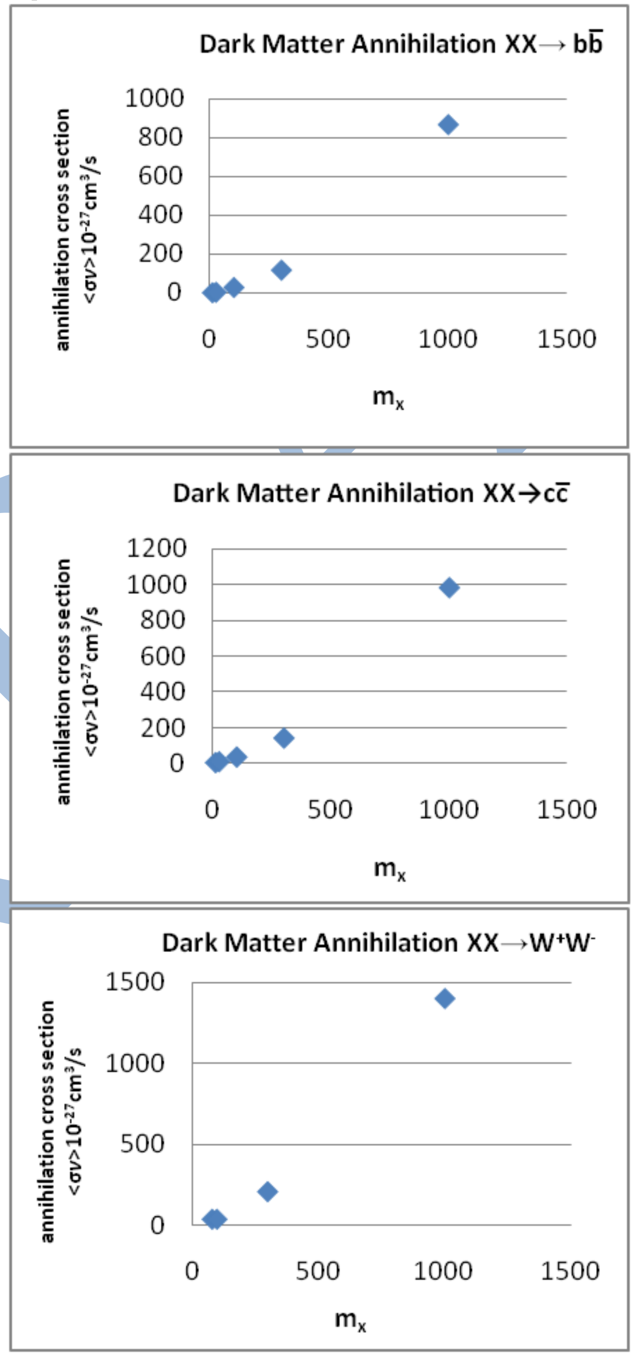

Figure: Dependance of annihilation cross section on mass of LKP dark matter.

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