

# Cosmological Model with Dark Energy and Dark Matter



## Mathematics

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**ABSTRACT** *In this paper we have investigated the astronomical evidences for dark matter which come from the wide variety of astrophysical measurements, its detection, along with study of dark matter. Also in this paper we have suggest that the eventual gravitational repulsion between matter and antimatter of nature of dark matter and dark energy if there is gravitational repulsion, virtual particle-antiparticle pairs in the vacuum , may be considered also we investigated the dark matter and dark-energy are not new, unknown forms of matter energy but an effect of complex interaction between the quantum vacuum and known baryonic matter.*

### 1. INTRODUCTION 1.1 DARK ENERGY

According to the current concordance model of cosmology, the Earth the stars, the Galaxies and everything we are familiar with (i.e. everything made form quarks and leptons as building blocks ), make up less than 5% of the total matter and energy in the Universe. The rest of 95% is dark energy and dark matter , roughly in the proportion 3:1. Hence the present day Universe is dominated by the “dark side”(it reminds me the human society). However no one knows what dark energy and dark matter are. Their nature greatest mystery of contemporary cosmology. We are living in the age of “precision cosmology”, i.e in the time of the understanding precision of observations; we are able to observe what’s happening but without understanding why it’s happening.

The simplest evidence for unseen “dark” matter comes form observation of spiral galaxies. A spiral galaxy is a disk of dust and stars (typically  $10^{11}$  stars) rotating about a central nucleus. The velocity  $v(r)$  of rotation of stars in the galaxy can be approximately determined as a function of distance  $r$  from centre. The surprise coming from observation is that, outside a radius that contains the most of the visible mass of the galaxy,  $v(r)$  remains approximately constant as far out as can be measured. But, if we have to trust the well established law of gravitation, one would expect the velocity  $v(r)$  at a radius  $r$  to be related to mass  $M(r)$  interior to that radius by a relation roughly like

$$\frac{GM(r)}{r^2} = \frac{v^2(r)}{r} \text{ i.e } v(r) = \sqrt{\frac{GM(r)}{r}} \dots \dots \dots 1.1$$

Thus, there is a big conflict between expectation that  $v(r)$  fall of  $r^{-1/2}$  and observation that  $V(r)$  is nearly constant. One possible solution is ad hoc assumption that visible matter of the Galaxy is surrounded by a spherical halo of some yet unknown and invisible “dark” matter. If we want the second of Equation (1) to agree with observation, the mass of dark matter  $M_{dm}(r)$  interior to a radius  $r$  must be proportional to that radius. Hence, the radial mass distribution  $M_{dm}(r)$ , and radial density profile  $\rho_{dm}(r)$  of dark matter are characterized with proportionalities:

$$M_{dm}(r) \sim \rho_{dm}(r) \sim r^2 \dots \dots \dots 1.2$$

Dark energy was incoked after the recent discovery [1], that the expansion of the universe is accelerating rather than slowing down. As well known [2], the easiest way for producing theoretical models with accelerated expansion of the universe is to assume a positive cosmological constant  $\Lambda$  in Einstein’s field equation. In addition to the usual course term, proportional to the energy momentum tensor  $T_{\mu\nu}$  Einstein’s equations for the gravitational field can accommodate an additional source term proportional to the metric field  $g_{\mu\nu}$  itself:

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi G}{c^4} T_{\mu\nu} + \Lambda g_{\mu\nu} \dots \dots \dots 1.3$$

Where  $R_{\mu\nu}$  and  $R$  denote the Ricci and scalar curvatures defined with the metric  $g_{\mu\nu}$

The key point is that such an ad hoc introduced cosmological constant has the same physical effect as if appropriate, constant mass (energy) density is attributed to the vacuum Equivalently everything that contributes to the mass (energy) density of the vacuum, contributes to the cosmological constant through linear relation:

$$\Lambda = \frac{8\pi G}{c^4} \rho_E \text{ and } \Lambda = \frac{8\pi G}{c^2} \rho_m \dots \dots \dots 1.4$$

Where  $\rho_E$  and  $\rho_m$ , are constant energy density and constant mass density of the vacuum At first sight, it looks a welcome “meeting point” between General Relativity and Quantum Field Theories (QFT). In fact , from the point of view QFT, the vacuum is not just an empty space as in non-quantum theories , but a still poorly understood “kingdom” of virtual particle-antiparticle pairs and fields. Hence, in principle , QFT can provide a mechanism producing the vacuum energy density and estimate the numerical value of such density. But what a catastrophe! The confrontation of equation (1) with observation [3], places an upper bound on  $\Lambda$ , and consequently on  $\rho_E$  and  $\rho_m$ :

$$|\Lambda| < 10^{-52} m^{-2}; |\rho_m| < \frac{10^{-26} kg}{m^3}; |\rho_E| < \frac{10^{-9} J}{m^3} \dots \dots \dots 1.5$$

While QFT predict value [2] which are minimum a few tens order of magnitude larger than these observed value. This dramatic discrepancy (called cosmological constant problem) is the key obstacle for attractive identification of dark energy with the vacuum energy.

### 1.2 DARK MATTER

In the present paper we have tride to highlight all the investigated astronomical evidence available for the dark matter with the remark that Dark matter in cosmology was observationally discovered, it was not predicted! However its nature is unknown, except that it is not beryonic.

From the research finding we can consider the fact that the 95% of the mass of the galaxies and clusters is made of the some unknown component of Dark matter which come from:

- (a) Rotational curves
- (b) Gravitational lensing
- (c) Hot gas in clusters

- **Rotational curves**

In 1970, Ford & Rubin discovered that rotation curve of galaxies are flat and latter in it expressed as galaxies must have enormous dark halos made of unknown dark matter. The baryonic matter. The baryonic matter which accounts for the gas & dust cannot alone explain the galactic curve.

- **Gravitational lensing**

Einstein's General theory of Relativity predicts that mass bends or lenses light. This effect can be used to gravitationally ascertain the existence of mass even when it emits no light. Gravitational lensing measurements confirm the existence of enormous quantities of dark matter both in galaxies and clusters of galaxies. The main features of success of lensing of dark matter to till date is the evidence that dark matter is seen out to much larger distances than could be established by rotational curve. The Dark Matter is seen in galaxies out of 200kpc from the centers the galaxies, in agreement with N-body simulation.

- **Hot gas in clusters**

Another piece of gravitational evidence for Dark matter is the hot gas in clusters. The existence of this gas in the clusters can only be explained by large Dark Matter components that provide the potential well to hold on to the gas. Hot gas is held in the cluster by gravity, but mass of the galaxies is not enough to explain the pressure of the gas, which is at a very high temperature. This missing mass of unknown nature may be called as Dark Matter.

### 1.3 DETECTION OF DARK MATTER

- **Direct detection**

Many experimental efforts on a host of techniques have been made in the field of direct search of non-baryonic dark matter. Various detectors already reached sufficient sensitivity to begin to rest region of SUSY (super symmetric scenario) parameter space. On the basis of investigations, we can say that two classes of models are phenomenological interesting and working as benchmarks:

- a) The lightest neutralino in SUSY models when the R-parity is conserved.
- b) Lightest-Kaluza-Klein excitation predicted in models with universal extra dimensions.

- **Indirect Detection**

Indirect detection of dark matter consists of observing and measuring the flux of standard particles  $\psi, \gamma, e^+, \text{ and } \bar{\psi}$  issued from annihilations of neutralinos in the dark matter halo.

#### CONCLUDING REMARKS:

It may be concluded that 95% of the mass in galaxies and clusters of galaxies is in the form of an unknown type of dark matter. We know this fact from various evidences of dark matter as rotation curves, Gravitational lensing & hot gas in clusters. If we analyse the direct or indirect observation of cosmologist involving the three fundamental independent aspects in cosmology, the expansion rate matter contents & large scale structure.

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