A study to understand Dark Matter

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Abstract

Dark matter does not do interaction with electromagnetic radiation and thus they do not emit, reflect or absorb light, this is the reason it is difficult to find dark matter. Their existence can only be observed or confirmed by the gravitational effect of dark matter on visible matter. Effort has been made in this work to do a study about Dark Matter, their properties, and various experimental method incorporated over the years to detect possible candidates of dark matter in the galactic halos.

Introduction

The universe is complex, expanding and full of mysteries. It has always been difficult and challenging to explore the universe. Many questions remain unanswered and with this the understanding of the abnormal expansion of the universe beyond a measurable pace. There have been many attempts to fully explain this unusual behaviour of the universe, made by scientists since the late 1900s. Among them the most promising one is the concept of existence about the dark matter and dark energy. Different scientific approximation models have designed and discovered using some set of cosmological observations. According to the observations and research work, it has been observed that universe is made up of almost maximum dark energy (i.e. 68%) and, 27% dark matter, rest that is approximately 5% is normal matter.

Experimental and Theoretical techniques to measure and understand dark matter

A lot of research has been carried out to understand the universe, dark matter. Work of few researchers is reported in this research paper.

Detection of certain dark matter candidates: Authors in this research work has provided some useful insight on how dark matter can be detected in the darkness of space. According to the authors there are three typical candidates of dark matter that can be detected with the help of a neutral current neutrino detector. For feasible dark matter detection the galactic halos presents a role. It consists of different particles like particles having very weak coherent force and masses of 1-10^6 GeV ; or particles with spindependent interactions and masses 1- 10^2GeV; or they should be strongly interacting particles with masses of 1-10^{13}GeV. A research work was carried for the detection of dark matter which summarizes the ideas from experiments which can be proposed for the detection of dark matter. The suggestions include nuclear recoil detectors for heavy neutral particles and electromagnetic detectors for light axioms. It was also suggested in the research work that further experiments would be capable of improving the limits of detection (2). Research work in 1994 was carried out by Scott Dodelson presenting Sterile neutrinos as Dark Matter (3). Authors explained that sterile right handed neutrinos formed in the early universe proves to be a warm candidate for dark matter with mass being almost equivalent to 100eV. Another work published in 1996 explains dark matter on the basis of the Structure of Cold Dark Matter Halos (4) In his research paper, Julio Navarro discussed the method to find correlation between the dynamics of galaxy and the luminosity of the galaxies for the binary galaxies and their companions in bright spiral galaxies. Structure of the halos of dark matter which surrounds the bright spiral is very much similar to that of the halos of cold dark matter. Super Symmetric Dark Matter explanation was given by the authors in their work suggesting that the dark matter also consist of particles which are known as Weakly Interacting Massive Particles (WIMP) (5). Gerard Jungmanhas proposed the methods for detection of neutrino dark matter and the methods to calculate the abundance in cosmic and the rates of the events for the direct and indirect detection schemes. Research has been carried out on Dark Matter Substructure within Galactic Halos. The authors have done research and suggested that on the galactic scales there is occurrence of the dark matter substructure survival, this leads to appearance of galaxy halos as a scaled version of galaxy clusters (6). Ben Moore, Sebastiano Ghigna and Fabio Governato, computational methods were developed to examine this dark matter substructure presence within galactic and cluster mass halos which are formed in the hierarchial universe. There is big difference between the actual observations and cosmological model view of cold dark matter which shows an overly dense core in galaxy centres and clusters and abnormally large no. of halos within the local group. Spergel and Steinhardt proposed a solution to this conflict by suggesting that the cold dark matters are self-interacting with a large cross-section but negligible annhillation or dissipation (7). David Smith and Neal Weiner, tried to demonstrate that dark matter as inelastic dark matter by explaining that dark matter can only scatter by making a transition to a slightly heavier state (m = 100 keV). The suggested research work can solve a lasting conflllict in experiments done by DAMA NaI, which reported an annual modulation in the event rate consistent with a WIMP relic (8). Kaluza-Klein Dark Matter was explained by authors in a research. In contrast to this proposal they mentioned that the lightest kaluza-klein particles make an excellent candidate for dark matter if the standard model particles propagate in extra dimensions and the kaluza klein parity is conserved. These conclusions are generic to bosonic dark matter candidates. Dark matter can be explained as hot and cold dark matter. Research has been carried out in detection of Cold Dark Matter candidates (9). The author has proposed the use of superheated superconducting colloids for detecting this weakly interacting galactic halo particles (for eg; photinos, massive neutrinos, and scalar neutrinos) (10). Discussion has been done on realistic models for these galactic halo detectors. Theoretically it was observed that, if the detector is maintained below 50mK and noise is reduced below 5 x 10^{-4} flux quanta, using SQUID electronic read out with the system, then particles with mass as low as 2GeV can be detected.

Various techniques has been explained for the detection of dark matter candidates in the universe.

Conclusion

The research work explains that universe is dominated by the presence of dark matters, although its presence can't be observed because they are very weakly interacting particles in the galactic halos. These weak interacting particles are responsible for the expansion of the entire universe (fraction of which is only our observable universe). This concludes that these particles are able to explain the effects of the gravitational field. Thus, study carried out in the paper shows that dark matter is matter with repulsive gravitational properties, or negative gravity matter. It has also been observed that dark matter detection of dark matter candidates, is possible in the galactic halos and is fruitful to find the existence of new unknown particles in the process. Once the physical and chemical properties of these antigravity matter are understood, a new world of possibilities could be opened for mankind. Humans will be able to harness negative gravity within their own domain. There will be different impacts with the evolution, for example overcoming the escape velocity of the planet, using dark matter as the crafting material for crafting to outer horizons of space.

References

1. Mark W. Goodman and Edward Witten, Physical Review D, 31 1985

2. P.F. Smith and J.D. Lewin, Physics Reports (Review Section of Physics Letters) 187 (5) 1990

3. Scott Dodelson and Lawrence M. Widrow , Physical Review Letters, 72 1994

4. Julio F. Navarro, Steward Observatory University of Arizona Tucson, AZ 85721 U.S.A, https://doi.org/10.1017/S0074180900232452

5. G. Jungman, M. Kamionkowski, K. Griest , https://doi.org/10.1016/0370-1573(95)00058-5

6. Ben Moore, SebastianoGhigna, and Fabio Governato, The Astrophysical Journal, 1999

7. David N. Spergel and Paul J. Steinhardt, Physical Review Letters, 84(17) 2000

8. David Smith and Neal Weiner, Physical Review D, 64 2001

9. Hsin-Chia Cheng and Jonathan L Feng, Physical Review Letters, 89 (21) 2002

10. Andrzej K. Drukier , Physical Review D, 33 (12) 1986