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DARK MATTER IN THE UNIVERSE

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Abstract

Different physical phenomena, techniques, and evidences which give the proof for the existence of dark matter have been discussed.

Keywords: Baryonic matter; dark mtter; Chandra x-ray Observatory

1. Introduction

Until about three decades ago, astronomers thought that the universe was composed almost entirely of the "baryonic matter" (matter basically made up of electrons, protons and neutrons), ordinary stuff. However, in the past decade, there has been ever more evidence accumulating that suggests there is something in the universe that we can not see. Although it can not be seen, scientists have several reliable evidences that more than 90% of the total mass of the universe is composed of this undetected mass, called dark matter. Dark matter is so called because it emits no detectable radiation. Carl Sagan described it as dark, quintessential, deeply mysterious stuff wholly unknown on earth. There is currently much ongoing research by scientists attempting to discover exactly what the dark matte is; how much there is, and what effect it may have on the future of the universe as a whole. This **Review Article** attempts to survey and analyze the evidences of the existence of dark matter in the universe.

2. Discussion

Astronomers can not detect the dark matter directly because it does not emit or absorb light or radiation. The presence of dark matter can be inferred from different physical phenomena, techniques, and evidences. These physical phenomena, techniques and evidences are discussed below:

(1) By measuring the motion (more exactly orbital velocity) of stars, gas, and other matters present in the galaxies, astronomers can measure the mass of the galaxies by using Kepler's laws of planetary motion,

$$T^2 = \frac{4\pi^2}{GM} r^2 \quad \text{and} \qquad V = \sqrt{\frac{GM}{R}}$$

Here, T, r and V are orbital period, average radial distance of the star from the galactic centre and orbital velocity respectively. G is the universal gravitational constant and M is the mass of the stars . In our solar system, we can use the velocity of the earth ($\approx 30 Km/s$) around the Sun to measure the Sun's mass. If the sun were four times massive then the Earth would need to move around the Sun at about 60 km/s, otherwise the Earth would collapse on the Sun. We can use the velocity of the stars to measure the mass of the galaxy (the velocity of stars can be measured from the Doppler's shift of light).

Similarly, radio and optical observations of gas, stars and other detectable matter in a distant galaxy, enable astronomers to determine the mass of the galaxy. And here major problem arises. The mass that the astronomers infer for the galaxies is at least 5-10 times the mass of all visible stars and other matter in the galaxy. This missing mass component is considered to be the invisible dark matter, which was first suggest in 1993 by Astrophysicist Fritz Zwicky.

(2) There is another way to look at the mass problem with the spiral galaxies. One can plot a rotation curve, a group of velocity versus distance from the galactic centre for component stars. The Kepler's law shows that, for solar system, the planet's velocity decreases as the inverse square root of distance from the Sun. But for galaxies, measurements show that the curve is flat, showing constant speed, or even increases slightly with distance. The unexpected nature of the rotation curve was first noted by astronomers Vera Rubin and Kent Floyd in 1970, for the Andromeda galaxy. This implies that there must be a large amount of dark matter affecting the stellar motion; otherwise, the stellar galaxies would be flying apart.

(3) The shortfall in mass is much greater for galaxy cluster (a group of large number of galaxies) than that in individual galaxy. The coma cluster is found to be 90% missing, the Virgo cluster 98% missing.

(4) The US space agency (NASA) published in 2002 its Chandra x-ray Observatory has seen filaments of hot gas connecting the galaxies. These visible gas clouds within galaxy clusters also have added to the dark matter requirement. If there were not unseen mass to give the hot cloud of gas, it would quickly leak way from the cluster due to its high speed.

(5) The presence of dark matter has also been confirmed by the gravitational lensing, bending of light predicted by Einstein's Theory of General Relativity. Astrophysicists scrutinized and analyzed

the gravitational lensing. Using time-honored methods of calculating mass and expected velocity dispersion astrophysicists have found that there is much more mass than can be observed directly . Using the biggest telescopes in the world, an Institute of Astronomy, Cambridge team of researchers has made detailed 3D maps of galaxies. By analyzing these 3D images, the team has measured the mass of the galaxies very precisely. With the aid of 7000, separate measurements, the researchers have been able to establish that the galaxies contain 400 times the amount of dark matter as they do normal matter.

(6) From the Virial theorem, which can be applied for a gravitationally stable system and if galaxies are supposed to be gravitationally stable, the mass formula for the galaxy cluster is

$$M = \frac{3V^2R}{G}$$

Here V is the average of the squared radial velocity observed for member of galaxies within the cluster. R is an estimate of the geometric radius of the entire cluster and G is the gravitational constant. This formula provides the mass of Albell 1060, a cluster of about 200 galaxies located at 220 million light years away with V is about $7.14 \times 10^5\, m/s$ and R, 6.5 million light years is about 7×10^{14} solar masses. This is about 10 times higher than the known mass. The Albell 1060 galaxies probably do not contain this much extra mass. Instead the mass may exist as dark matter. A similar numerical discrepancy exists for every galaxy cluster, assuming they obey Virial theorem.

(7) Dark matter is also involved in the popular inflationary big bang model (almost universally accepted model) which predicts that the curvature of the universe must be flat. This means the density of the matter in the universe is exactly balanced with the critical density (the density that would need to have enough gravitational pull to overcome the expansion of the universe). Without dark matter, the ratio of actual density of the matter in the universe to the critical density (called Omega, Ω) lies somewhere between 0.1 and 0.01. Therefore a great amount of dark matter is needed to result in flat curvature of the universe.

3. Conclusion

It is seen that the dark matter is required if the laws of motion and gravity hold for galaxies, and if the galaxy systems are stable. There is no reason to except the failure of the laws of motion and gravity in the galaxies. Similarly, no evidence of instability of galaxies and clusters of galaxies is yet found. Moreover, gravitational lensing (Modern technique to measure the mass of distant massive objects), big bang inflationary model (universally accepted model), Virial theorem, all show that there must be much more matter in the universe than that detected till the date.

Thus, it is concluded that even though the dark matter is invisible and most of its components are yet to be detected there exists dark matter in the galaxies, if not elsewhere.

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