Dark Matter

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What is Dark Matter?

Dark matter is a fictitious matter that cannot be observed with a telescope. In the universe 27% of the matter is dark matter and only 5% of the matter we can observe. The rest 68% is Dark Energy.

History

In the 1960s and 1970s, astronomer Vera Rubin was observing the rotation of spiral galaxies. Rubin expect to see that the farther out from the center of the galaxy the gas cloud was, the slower it would be moving, just like more distant planets from the sun move more slowly in their orbits. What she got though was the opposite.

For many galaxies, the farther out from the center you got the faster the clouds were moving.

Back in the 1930s, astronomer Fritz Zwicky had drawn a similar conclusion measuring the speeds of galaxies in galaxy clusters. The member galaxies were moving too quickly to stay in the cluster at the measured speeds they should have been flying off. Over the years, more observations have only confirmed Rubin's measurements.

Why do we use the concept of Dark Matter?

According to the Newton's Law of Universal Gravitation, the gravitational force on a star is inversely proportional to the square of distance from the center of the galaxy.

$$\mathbf{F = \frac{GMm}{r^2}}$$

Therefore, a star near the center of a galaxy has large angular velocity. As the distance from the center of the galaxy increases, the angular velocity of a star must decrease.

However, the gas clouds on the edge of the galaxy are rotating much faster than expected around the center. For that, in addition to the center of the galaxy's impact, strong gravity must exist on the gas cloud. This made it possible for a galaxy to have a higher mass than the observable matter.

Here are two ways to find the mass of a galaxy:

1. Using luminosity
   The luminosity of the entire galaxy is divided by the average luminosity of a star and multiplied by the average mass of the total number of stars in the galaxy. Here the total mass of the planets is neglected compared to the mass of a star.
2. Using the Newton's Law of Universal Gravitation
   Since we can find out the angular velocity of a star on the edge of the galaxy by using Doppler effect we can calculate the total mass of the galaxy by using above equation and $\mathbf{F= mw^2r}$.

The same answer must be obtained when calculating using both of these forms. However, the answer obtained from 2nd method is five or six times larger than the answer from the 1st method. It also proves that the mass of a galaxy is greater than its visible value. This extra mass is known as the Dark Matter.

Dark Matter vs Dark Energy

After the Big Bang, billions of years ago, the galaxies started to move away from each other and the universe expanded under the influence of dark energy. Because of the gravity of the dark matter it minimizes the expansion of the universe while dark energy tries to expand the universe.