8.0: Dark Matter Introduction

Video Transcript

Small children on a merry-go-round hold on tight as it spins around. Holding on, they resist the forces acting on them because of the circular motion.

Just as the children circle around the center of the merry-go-round, water swirls around a drain before disappearing, and tires on a car rotate around the car's axle.
In the vastness of the Universe, among the objects that we can see, we've discovered many similarities and differences. One prominent similarity is the tendency for objects to be spinning and revolving - to have an angular momentum. Planets and stars spin about their axes, moons orbit around their planets, planets orbit around their stars, and stars and gas orbit within their parent galaxy.

It was Johannes Kepler who, in the 17th century, discovered the relationship between a planet's distance from the Sun and its orbital period. Building upon that, less than 70 years later, Isaac Newton deduced that the force between a planet and the Sun depends on the distance between them and their masses. According to Newtonian theory, for two objects orbiting around each other gravitational forces determine the distance and speed at which they rotate about their common center of mass.
For centuries, Newtonian gravity was tested against observations of the planets and moons and they almost uniformly agreed. Then, in 1915, Einstein's general relativity supplanted Newton's understanding of gravity and changed almost agreed to totally agreed. According to general relativity, gravity is not a force at all, but is instead a stretching and twisting of space and time.

Whether using Newton's view of gravity as a force or Einstein's view of gravity as distortion in spacetime, astronomers have discovered that something is amiss at the largest of size scales: the mass to orbital period relationship that works so perfectly at describing the orbits of planets, that placed astronauts on the moon and robots on Mars, appears to break down when predicting the motions of stars and gas within a galaxy or of the galaxies themselves within their clusters.
In this chapter, we will explore this mystery and the new theory scientists have proposed to explain why the old explanations no longer seem to work at these large scales.

Previously, we looked at Newton's law of gravitation and how it provides an explanation for the motion of falling objects near Earth's surface, the motion of the Moon and satellites around Earth, and the motion of the planets around the Sun.

In this chapter we step up in scale, applying the law of gravity to the motions of stars and gas in galaxies and galaxy clusters. These larger-scale gravitational studies began early in the 20th century and continue to the present. They have resulted in surprising revelations about our Universe and its composition. Here we begin to explore some of these revelations.