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How does dark energy affect galaxies?

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Abstract

Scientists have known for a while that the universe is expanding, and it's doing so faster and faster. This strange phenomenon is caused by something we call dark energy. To understand this better, we need to think about a special number called the Cosmological Constant. It helps us describe how things move in space.

In our research, we aimed to uncover how dark energy causes objects like stars and galaxies to interact. As an example, we've been studying our neighbor galaxy – Andromeda. By looking at how it moves and at its mass, we can see how dark energy affects it.

Introduction

Imagine the universe as a gigantic balloon that just keeps growing and growing. You know how the air inside a balloon makes it get bigger? Well, our universe has something called **dark energy**, and it's a bit like that invisible air inside the balloon.

Think of dark energy as the opposite of gravity, or "anti-gravity". This is because while gravity normally works to pull things together, dark energy pushes them apart. Dark energy makes our universe expand, but we can't see or touch it because it's "dark" and very tricky to understand. We think up to 2/3 of the universe may be made up of this type of energy.

Our solar system is part of the **Milky Way Galaxy**. The Milky Way and its neighbor the Andromeda Galaxy are both part of a larger group of galaxies in space (Fig. 1). In this **Local Group**, dark energy is like an invisible force gently influencing how galaxies move.

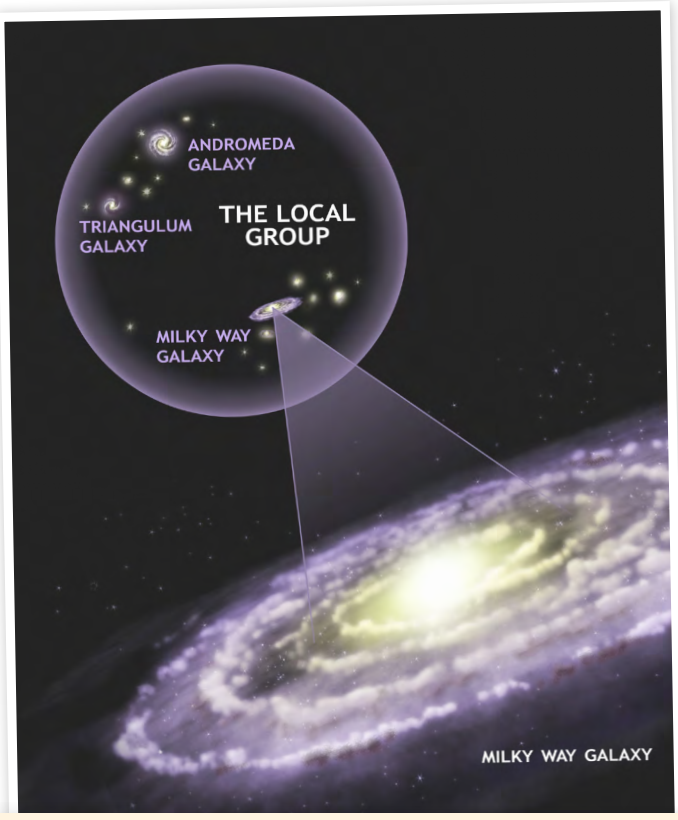

Figure 1: :The Milky Way is not an island universe, but a member of a small cluster of galaxies called the Local Group. The Local Group contains about three dozen known galaxies, clumped in two subgroups around two massive spiral galaxies: the Milky Way and the Andromeda Galaxy. In several billion years it is possible that the Milky Way and Andromeda will collide and merge to form one huge elliptical galaxy. (Image: NASA/Chandra X-Ray Observatory/M.Weiss)

Other galaxies are moving away from us due to the universe's expansion. But Andromeda is actually coming closer to us. We're on a collision course with Andromeda, but don't worry; it won't happen for billions of years! By studying Andromeda's **mass** and how it moves, we hope to see the effect dark energy is having on it.

One big clue in solving the mystery of dark energy comes from Albert Einstein. He came up with an idea called the **Cosmological Constant**. It is a vital clue in the dark energy mystery. It can help us understand how strong this mysterious force is and why the universe is expanding.

Methods

We focused on the Local Group of galaxies. These galaxies are pulled together by gravity. But they are also pushed apart by dark energy in our expanding universe. As a result, they have complex close **orbits**. We used **mathematical models** and simulations to see how dark energy and the Cosmological Constant affect their orbits.

Results

We calculated the maximal value on the Cosmological Constant only based on Andromeda's motion. It is 5 times greater than the value we measure from faraway galaxies. The result agrees with our known value of the Cosmological Constant. But it also opens new possibilities to test the Cosmological Constant in nearby galaxies.

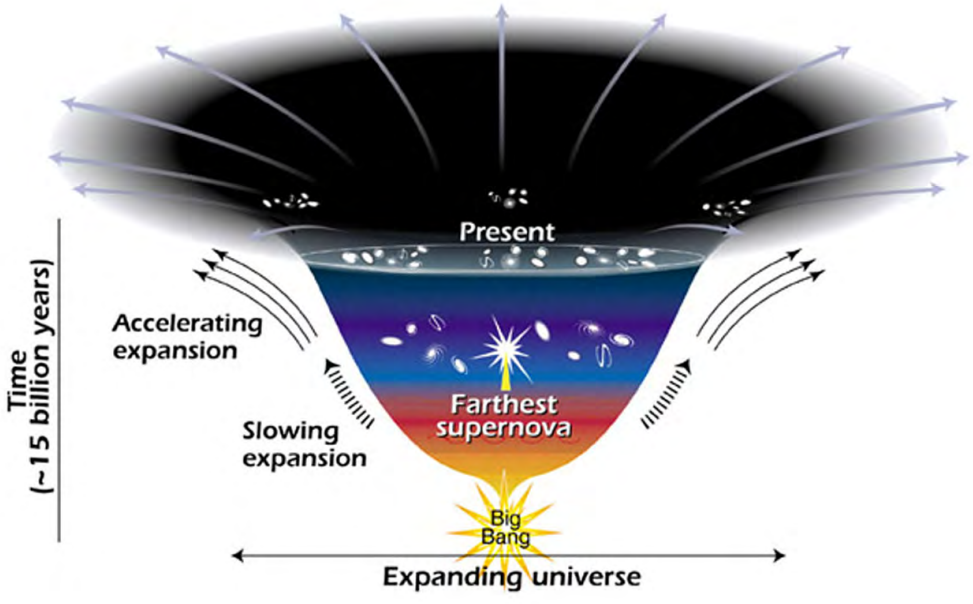

Figure 2:
We can see how fast the universe is expanding as it ages by using estimates of how much dark energy was in the universe at each time. We can see the universe got a lot bigger about 7.5 billion years ago. Dark energy may be speeding up this expansion. (Image: NASA/STSci/Ann Feild)

Discussion

We found that dark energy plays a major role in the galaxies' movement in our Local Group. Dark energy has a big impact on how objects move in space. Our method opens new directions to test the impact of dark energy, even from nearby galaxies in our local universe (Fig. 2). These findings provide us with valuable insights into how the entire universe operates and how it changes over time.

Conclusion

The universe's accelerating expansion and the role of dark energy are intriguing puzzles. It is truly amazing that we even have the capacity to think about these questions. After all, we are inhabitants of just a single planet in just one of the star systems in just one of the galaxies! A scientist's job is to ask interesting questions and design tests that can help answer them. What are you curious about? How can you learn more about it?

Glossary of Key Terms

Albert Einstein - a famous physicist who helped develop the theoretical physics behind our expanding universe.

Cosmological Constant (aka Λ, the Greek letter lambda) - a special number used to describe the value of dark energy in mathematical terms. Albert Einstein came up with this term. He thought it described a universe that does not expand. Later, when scientists discovered the universe was getting bigger, Einstein called it his "biggest blunder."

Dark energy - an invisible force that makes up approximately 68% of our universe. We can't see it, but we know that it's there because of measurements showing the universe started expanding faster about 7.5 billion years ago.

Expansion of the universe - our universe is getting bigger, and the space between galaxies is actually growing!

Galaxy - a large group of stars, planets, gas, and dust bound together by gravity. Galaxies come in various ages, shapes, and sizes.

Local Group - a group of nearby galaxies including the Andromeda Galaxy, the Milky Way, and the Triangulum Galaxy.

Mass - a measure of how much matter (that is, the total number of atoms) that are in an object. It is a fundamental property that does not change regardless of what forces are acting on it. It is different from "weight", which depends on gravity and other forces.

Mathematical models - a set of equations and rules that show how things in our universe (like stars and galaxies) move and behave. We can use models to make predictions about the universe and understand the physics behind certain astronomical events.

Milky Way - the galaxy we live in. It includes our solar system and hundreds of billions of other stars.

Orbit - the path of celestial objects moving in space

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Check your understanding

1. What is dark energy and how is it different from gravity?

2. What were the key findings about the impact of dark energy on nearby galaxies like Andromeda?

3. What causes galaxies to have complex orbits?

4. How did Albert Einstein's concept of the Cosmological Constant contribute to understanding dark energy?

5. How do you think studying dark energy and its influence on galaxies could benefit our understanding of the universe's evolution? Discuss potential advancements.

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