Galactic Forces in Action!

Much of the nature and history of the universe can be understood as simply the pulling apart and pulling together of galaxies over time. Forces that pull galaxies closer together cause dense clusters of galaxies to form. Our Milky Way galaxy is part of a cluster of galaxies that also includes our biggest galactic neighbor, Andromeda, and numerous smaller galaxies. Other forces can pull galaxies apart to distances so great that they may not be visible to one another. You are already very familiar with the force that pulls galaxies together: gravity (F_G). Newton's Law of Universal Gravitation describes how any two masses, whether Earth and your body or the Milky Way and Andromeda galaxies, attract each other.

One of the most surprising findings in all of modern science is that the universe is accelerating *outward*. This means that a force stronger than gravity is acting on galaxies with the net effect of pulling them apart. So what is this force pulling galaxies apart, and how can it be stronger than the immense gravitational attraction among entire galaxies full of stars? The truth is, scientists do not know! Because of its mysterious nature, scientists have given the source of the force pulling apart galaxies the name "dark energy." Though it might seem strange, not understanding what exactly dark energy is hasn't stopped scientists from being able to measure its effects.

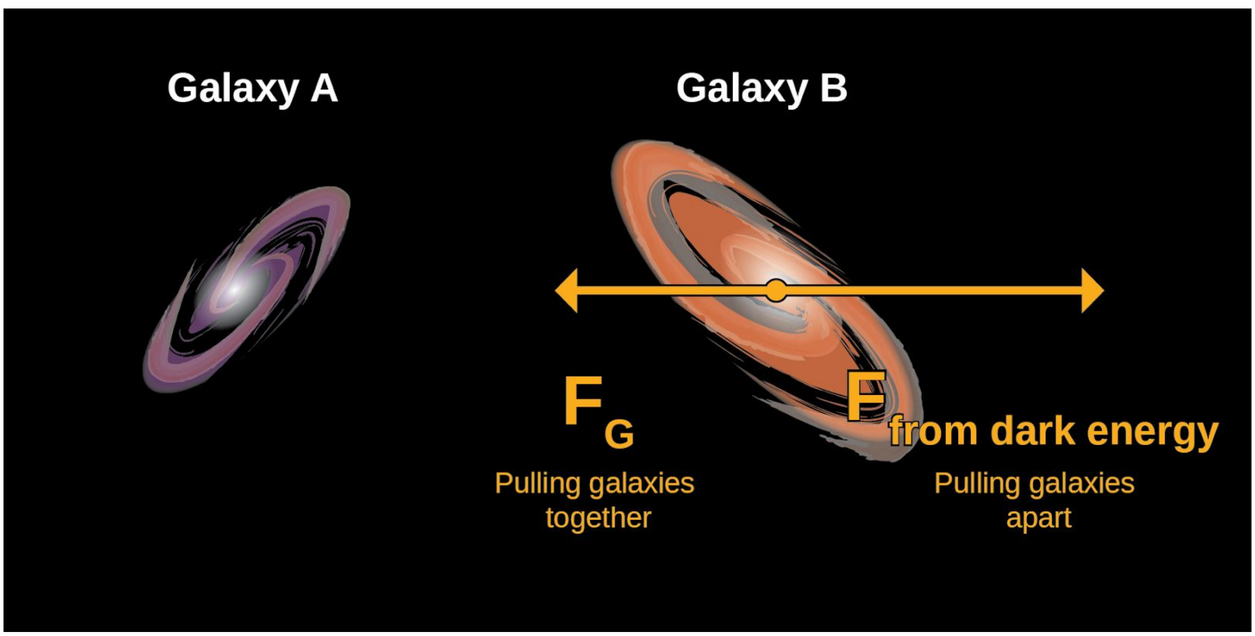

Figure 1. Galactic Forces. Model of forces acting on adjacent galaxies.

Since the 1980s, even before dark energy was discovered, it has been thought that human-like life could not exist in a universe with too-strong a force pulling apart objects in space. Too much of this force would have prevented massive structures like galaxies from ever forming by gravitational attraction. Obviously, since human-like life *does* exist (or else you wouldn't be reading this), galaxies *did* form, so there must *not* be too-strong a force pulling astronomical objects apart...which means that there must *not* be “too much” dark energy in the universe. Phew.

Recently, a team of researchers from across the globe explored the effects of dark energy on the formation of life in the universe. In the paper describing their work, the scientists argue that there not being “too much” dark energy is only half the story. They suggest that *too little* dark energy would have also prevented life from ever existing. This is because of a type of extremely energetic class of stellar explosions, called **gamma ray bursts**, that typically occur in relatively small galaxies. Without a force to pull them apart, gravity would pull all galaxies close together. In that case, even big galaxies (like the Milky Way) would have formed in close proximity to many small galaxies. Gamma ray bursts within the smaller galaxies emit not only gamma rays but also a sustained blast of x-rays, UV rays, and other forms of radiation. Having all of the high-energy radiation strike Earth would have, according to the researchers, prevented life from getting started.

Over the next years and decades, look for astronomers to make more progress on understanding the workings and nature of dark energy. As these mysteries are resolved, we will start to learn the answers to some of the biggest unresolved questions in cosmology and enhance our understanding of how the universe was formed, has evolved, and will evolve over time.

Reference

Piran, Tsvi, Raul Jimenez, Antonio J. Cuesta, Fergus Simpson, and Licia Verde. "Cosmic Explosions, Life in the Universe, and the Cosmological Constant." *Physical Review Letters* 116, no. 8 (2016). doi:10.1103/physrevlett.116.081301.

BiteScientist Profiles

Nathan Sanders is an astrophysicist and statistician working in industry. His astronomical research focused on core-collapse supernovae, the explosive deaths of the most massive stars in the universe. Like the science in this bite, those explosions rely on laws of physics at scales unlike anything we experience day to day on Earth. Nathan’s statistical work focuses on helping entertainment companies understand, predict, and serve consumers’ interests and preferences for film, TV, and other content. In his free time, Nathan enjoys hiking, gardening, and analyzing volumetric flow data from municipal combined sewer systems.

Kristen L. Cacciatore is a full-time chemistry and physics teacher at Charlestown High School, an urban public school. Kristen, who has a doctorate in green chemistry, has led a high school-elementary school science mentoring program and the Advanced Placement science enrichment and support program for the Boston Public Schools. She also serves as a mentor for beginning and pre-service teachers. In her free time Kristen likes to run, cook and travel the world.