

SCIENCE DISSECTED

A Close Look At Galaxies

The title of this article is misleading since the word “close”, in this case, refers to objects in the Universe that are from thousands to more than billions of light years away from us. The nearest galaxy beyond our own Milky Way is 25,000 light years away! From our point of reference, the Earth itself seems vast; so to seek the billions of galaxies outside of ours requires advanced technological instrumentation and some significant inference. The total number of galaxies in the Universe is a complicated number to even speculate given that our most powerful telescopes only make a fraction of it visible to us. Although the number of galaxies cannot be counted accurately - it is generally accepted that the observable universe alone contains as many as 100 billion. To estimate this number, astronomers count how many galaxies they see in a small area of the sky then use that figure to hypothesize how many galaxies there are in the total Universe.

A **light year** is defined as the **distance** light travels in one year. This ruler made of light measures ~ 6 trillion miles!

$$186,000 \frac{\text{miles}}{\text{sec}} \times \frac{60 \text{sec}}{1 \text{min}} \times \frac{60 \text{min}}{1 \text{hr}} \times \frac{24 \text{hr}}{1 \text{day}} \times \frac{365 \text{day}}{1 \text{year}} = 5.9 \times 10^{12} \text{ miles!}$$

A galaxy is a massive system consisting of millions or billions of stars, planets, stellar remnants, an interstellar medium of gas and dust, and empty space bound by a gravitational attraction. Some galaxies contain a black hole in their center. They are the largest masses in the Universe and are believed to have formed 10 to 20 billion years ago. Galaxies are classified into three major categories: Spiral, Elliptical, and Irregular.



Spiral Galaxies

Spiral galaxies are the most common of the galaxies visible to us. They are flat and disk shaped with a bulging nucleus at the center that consists of old stars. Surrounding the nucleus is an invisible cloud of dark matter. Spiral galaxies have one or more arms that spiral outward. Their spiral shape is caused by the rotation of stars, planets, dust, and gas around the galactic nucleus at a speed of hundreds of kilometers per second. Our galaxy, the Milky Way, is a large spiral galaxy in a cluster of galaxies known as the Local Group. It has four arms and about 100 billion stars.



Elliptical Galaxies

Elliptical galaxies can be either circular or egg-shaped. The size of these galaxies ranges between “giant” which are very bright and the largest galaxies in the universe to “dwarf” which are dim and some of the smallest in the universe. A giant elliptical galaxy may extend over two million light years which is 20 times the expanse of the Milky Way. These galaxies have little to no rotation because the stars they contain have irregular orbits. Elliptical galaxies and their contents are old, give little evidence of interstellar gas and dust, and no longer appear to be forming new stars. Only ~10% of observable galaxies are elliptical.

Key Points

- About 77% of the observable galaxies in the universe are spiral galaxies.
- Although there are smaller galaxies that are closer, the closest galaxy that is like our own Milky Way is Andromeda. It is 2.2 million light-years away from us.
- The light that we see from our nearest galaxy left that galaxy when the first humans were walking on earth.
- The Milky Way is so big that even at the speed of light, it would take 100,000 years to travel across it.

A Close Look At Galaxies continued...



Irregular Galaxies

Approximately 3% of observable galaxies do not fit the spiral or elliptical category. These asymmetrical galaxies have been labeled irregular galaxies. Originally, all galaxies without symmetry or identifiable forms were lumped into this rather broad classification. Today astronomers have made further distinction with respect to these galaxies by differentiating them as “Type I” or normal and “Type II” or peculiar irregular galaxies. Type I have similar characteristics to spiral galaxies because there is a systematic structure with discs and bulges but in a Type I galaxy the galactic bulges are located away from the center of the disc giving it an unbalanced appearance. Type II galaxies are distorted and remarkable looking objects. Astronomers believe that these galaxies were formed by collisions or gravitational interactions with a neighboring galaxy. Two irregular galaxies are visible with the unaided eye for those living in the southern latitudes. They are the Large and Small Magellanic Clouds and appear as luminous regions in the Milky Way.

Galactic Formation, Mergers, and Collisions

One of the greatest challenges astronomers have confronted through the years is discovering how galaxies form. After the Big Bang, the Universe was a somewhat chaotic composition of subatomic particles and radiation. There are several theories as to what happened next. One theory is that clouds of dust and gas imploded beneath their own gravitational pull allowing small particles to merge and eventually form stars, star clusters, and finally galaxies. Another theory that has gained support in recent years is that the Universe was first organized in “bundles of matter” that, depending on their size, either merged together or subdivided to form the first galaxies. As our Universe continues to evolve, the galactic formation process develops with it. Galaxies are massive with strong gravitational pulls. When in close proximity, the attraction between two galaxies can be so strong that they merge into one large galaxy. Most of the early galaxies were spirals but over time merged into neighboring spirals to form the larger elliptical galaxies that we see today. Because our Universe is somewhat “congested” with billions of galaxies, mergers and collisions occur frequently. Our Milky Way is on a collision course with the Andromeda galaxy, a close neighbor in the Local Group, which is 2.2 million light years away. The Andromeda galaxy is approximately the same age as the Milky Way but observations from the Hubble Telescope confirm the existence of younger stars in Andromeda. This evidence has led astronomers to conclude that Andromeda has had previous collisions with other galaxies. Galactic collisions are not likely to cause an impact between individual stars because the distance between stars in a galaxy is vast. However, a collision may send existing stars into a different orbit or even create millions of new stars from the force of gas and dust clouds colliding.



Student Activities



Make a Galactic Mobile

A fun and easy activity from NASA that allows students to learn the different types of galaxies by creating and decorating their own collection of galaxies and suspending them from a mobile. The materials for this project are easily obtained and patterns for the galaxies are included on the website. *Make a Galactic Mobile* can be enriched or simplified to accommodate a diverse group of learners at any grade level.



Your Galactic Address

We normally give our address in terms of street, city, and state, right? This enjoyable activity from the Lawrence Hall of Science encourages students to think on a much larger scale when writing their address. The students are challenged to address a letter to a friend in a distant galaxy specifying their exact location in the universe. The packet provided by the website includes pages for the students to pinpoint their location from their galaxy cluster all the way down to the position of their desk in the classroom. *Your Galactic Address* is cross-curricular and can be adapted to most grade levels.

NASA: What Are Galaxies? <http://science.nasa.gov/astrophysics/focus-areas/what-are-galaxies/>

NASA: The Hidden Lives of Galaxies Booklet http://imagine.gsfc.nasa.gov/docs/teachers/galaxies/imagine/imagine_book_2009.pdf