Galaxies
Astronomy 154 Lab 6

A collection of Hubble Heritage Galaxy Images

Galaxies, like the ones pictured above, are massive gravitationally bound collections of stellar systems, gas, dust and dark matter. Galaxies vary in size from dwarfs with around ten million stars, to giants with around a hundred trillion stars. The mass of galaxies is generally expressed in units of Milky Way Masses, or Solar Masses. Astronomers observe galaxies in every geometric orientation to Earth. Edge-on, disk-on, and everything in between. Additionally, galaxies can have a wide variety of shapes including elliptical, spiral, and irregular. Galaxies are categorized according to their shape using the Hubble Galaxy Classification Sequence, better known as the Hubble Tuning Fork.

Diagram of the Hubble Tuning Fork
Elliptical Galaxies make up the arm of the tuning fork. An ellipsoid is the three dimensional version of an ellipse, it looks like a squashed circle. An elliptical galaxy has an ellisoidal shape, so no matter how it is oriented with respect to the Earth it appears to be an ellipse. Elliptical galaxies are designated by the letter “E” on the tuning fork. The letter is followed by a number 0 to 7 representing how elongated the ellipse is. An E0 galaxy would be perfectly spherical, and an E7 galaxy is an extremely elongated ellipse, nearly squashed to a disk.

Elliptical galaxies tend to have older lower mass stars, with less interstellar gas and less star birth activity. Elliptical galaxies come in all sizes, but the largest galaxies recorded are elliptical in shape, and are thought to have formed by gravitational accretion of smaller galaxies.

Spiral Galaxies have a central bulge around which a disk of stars and interstellar gas rotates in spiral arms coming out from the central bulge. Spiral galaxies are designated by an “S” on the tuning fork. Spiral galaxies are divided into two groups, the spirals, and the barred spirals. Many spiral galaxies have a bar of stars that extend in a line from the central bulge, then appears to spiral. These galaxies are designated by a “B” after the “S”. Plain spiral galaxies are placed on the top arm of the tuning fork, and barred spirals on the bottom fork.
Spirals are then characterized by the size of their central bulge and the tightness of their wound arms by a “0” or the letters “a, b, c.” An S0 or SB0 spiral galaxy has a disk shape with a central bulge, but no well-defined arms, they are also often referred to as Lenticular Galaxies. An Sa or SBa galaxy has a large central bulge with tightly wound and poorly defined spiral arms, so it is hard to distinguish one arm from another through the whole disk. An Sc or SBc galaxy has a smaller core, and open well-identified separate arms. Sb and SBb galaxies fall in between “a” and “c” classes with medium bulges, and well-identified separate arms.

The spiral arms are thought to be areas of high density affected by a galactic density wave. The higher density areas have more mass, and therefore more gravity, which affects the velocity of the stars and gas going into the wave. As the matter leaves the density wave, its velocity returns to normal. The spiral arms are visible because of the intense star formation and young hot OB class stars glowing inside them. This star formation is also thought to be due to the compression of inerstellar gas by the density wave. Statistically, about two-thirds of observed spiral galaxies are barred spirals. A Spitzer Space Telescope survey confirmed that our own galaxy, the Milky Way is a large Barred Spiral.

Peculiar galaxies are those whose shape comes from gravitational distortion. Ring shaped galaxies are an example where it is thought a smaller galaxy passed through the disk of a spiral galaxy, distorting it into a ring. Peculiar galaxies are outside the tuning fork and denoted by a “P.”
Irregular galaxies are those that can't be classified into any of the other categories. If the irregular galaxy has some structure and shape, but doesn't fit into the tuning fork, then it is an Irr-I. If the irregular galaxy has no discernible structure like that on the tuning fork, it is an Irr-II. The Large and Small Magellenic Clouds, neighbors of the Milky Way, are dwarf irregular galaxies.

In Part 1 of this exercise, you will look at the twenty galaxies pictured below and place them on the Hubble Tuning Fork by identifying their type. When you look online at the Hubble Tuning Fork, you may see additional classifications than are not included here, but just use the simpler version outlined here.

In Part 2 of this exercise, look at the last images of this document. They are the Hubble Deep Field, Hubble Ultra Deep Field, and Hubble Extreme Deep Field. There are large poster sized versions of these images printed out at the front of the class room. They are also available in high resolution on every desktop. To take the images, the Hubble Space Telescope used different cameras and over many observations, pointed at a seemingly empty part of space for an accumulated 1 million seconds (HUDF), and for 2 million seconds (HXDF)! How many galaxies can you count? Can you find an example of all the different galaxy types that were mentioned in the explanatory portion of this exercise? The only stars in the image have rays from the diffraction of their light and are easy to identify. Count the stars! Everything in the image without diffraction rays is a galaxy. Come up to the printed images for a better look! Compare the three images, what differences can you see?
1. M100

2. Saggitarius Dwarf Galaxy
3. NGC 1300

4. The Antenna Galaxies
5. Grand Design Galaxy M81

6. The Whilpool Galaxy (a) and Companion Galaxy (b)
7. Odd Galaxy Couple (a) and (b)

8. Hoag's Object
9. Small Magellanic Cloud

10. NGC 4603

11. COSMOS 3127341
12. M81

13. NGC 1316
14. The Mice NGC 4676

15. NGC 4314
16. NGC 5584

17. NGC 4622
18. NGC 4458

19. NGC 3982
20. Galaxy Triplet ARP 274, from largest to smallest a, b, c.
Hubble Ultra Deep Field
Hubble Extreme Deep Field
Astronomy 154 Galaxies Lab Worksheet

Part 1 – Put Galaxies 1 to 20 on this Hubble Tuning Fork Diagram. Label the parts of the tuning fork.

Part 2 – The Hubble Deep Field Images: Write your observations below!