**Galaxy Classification**

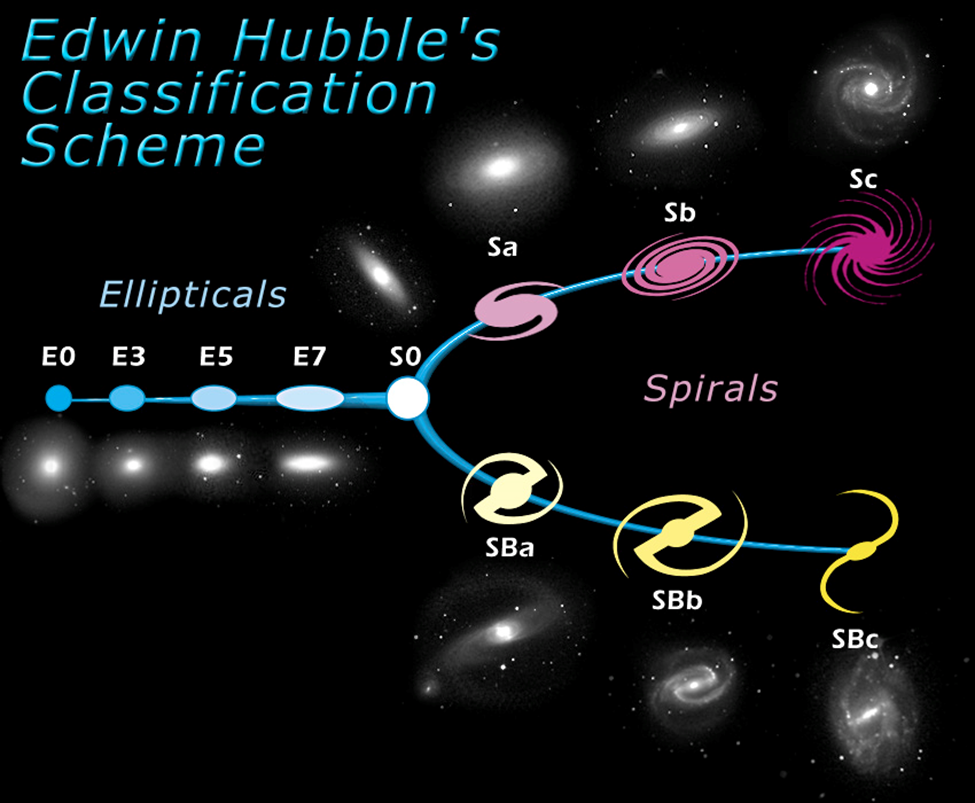
**Purpose:** To look at some of galaxies and learn about those galaxies: how to classify them, what their important characteristics are.

**Procedure:**

**Part I: Hubble Tuning Fork Classification**

1. Go to the link <http://skyserver.sdss.org/dr15/en/proj/basic/galaxies/classification.aspx> Click on the Field number to get image of each galaxy. Pretend that you are an astronomer to come up with a way to classify the galaxies. Look at the image of galaxies. Divide them into groups based on features they have in common. There is no set number of groups. You can use their field numbers to identify them.
2. Go to the link <http://skyserver.sdss.org/dr15/en/proj/basic/galaxies/spirals.aspx> . Read about description of spiral galaxies, elliptical galaxies and irregular galaxies to answer the following questions.
3. What are the differences between spiral and elliptical galaxies (e.g., shape, etc)?
4. What are irregular galaxies?
5. How does a barred spiral galaxy differ from a normal spiral galaxy?
6. How does a lenticular galaxy differ from a normal spiral galaxy?

In the early 1900s, Hubble classified the galaxies using a "tuning fork" system. The elliptical galaxies made up the fork's handle, and spiral galaxies and barred spiral galaxies make the fork's prongs. Hubble believed that galaxies started at the left end of the tuning fork when they were young, and moved toward the right as they aged. Therefore, he called elliptical galaxies "early galaxies" and spiral galaxies "late galaxies". We now know he was mistaken in this belief. Spiral galaxies have a great deal of rotation and elliptical galaxies do not. There is no way an elliptical galaxy could spontaneously begin rotating, so elliptical galaxies cannot turn into spiral galaxies. Although Hubble was wrong about his theory of galaxy evolution, the confusing names have stuck: today, elliptical galaxies are still referred to as early galaxies and spirals as late galaxies. So his classification system looked like this:



1. Go back to the galaxies from 1), go to the link <http://skyserver.sdss.org/dr15/en/proj/basic/galaxies/classification.aspx> and click on the field numbers to see pictures of the fields. Classify all the galaxies according to the Hubble Tuning Fork. Record the type of galaxy in the table below. You can choose from **E, S0, Sa, Sb, Sc, SBa, SBb, SBc or Irr**

|  |  |  |  |
| --- | --- | --- | --- |
| **Run** | **Camcol** | **Field** | **Type** |
| 752 | 1 | 244 |  |
| 2662 | 4 | 243 |  |
| 752 | 1 | 331 |  |
| 1737 | 6 | 11 |  |
| 756 | 4 | 198 |  |
| 2738 | 2 | 196 |  |
| 752 | 1 | 432 |  |
| 3325 | 3 | 176 |  |
| 3325 | 3 | 319 |  |
| 3325 | 2 | 216 |  |
| 3325 | 2 | 215 |  |
| 3325 | 3 | 230 left |  |
|  |  | 230 right |  |
| 2738 | 3 | 122 left |  |
|  |  | 122 right |  |
| 3325 | 3 | 352 |  |
| 3325 | 1 | 356 |  |
| 3325 | 1 | 359 |  |

1. Compare and contrast your classification system in 1) to Hubble's. How are they similar? How are they different?
2. Excluding image quality, what do you find to be most difficult thing in trying to classify each galaxy?

**Part II: Color Classification**

When you look at millions of galaxies as the SDSS does, you can't classify every one by looking at it and placing it on the Hubble Tuning Fork. To classify all the galaxies, astronomers need a faster method. Astronomers have known for a long time that galaxy type and color are related. Spiral galaxies tend to have more star forming regions, and younger, bluer stars. Elliptical galaxies tend to have mostly old, red stars. The researchers found that galaxies fell into the clearest groups when they looked at the difference between the ultraviolet (u) and red (r) filters. Specifically, the researchers found that most early galaxies (elliptical, S0, and Sa or SBa) had a u-r value greater than 2.22, and that most late galaxies (Sb or SBb, Sc or SBc and Irregular) had a u-r value less than 2.22.

1. Go to the link <http://skyserver.sdss.org/dr15/en/proj/basic/galaxies/colorclassification.aspx> . Look up the following galaxies in the Object Explorer by clicking on their object IDs in the table. Calculate their u-r values (u and r are located to the right of the galaxy's image), and record in the table below.
2. Classify them as **early** (E, S0, Sa or SBa) or **late** (Sb or SBb, Sc or SBc, Irr) galaxies from their u-r values. Record it in the column of color type. You can put either **early** or **Late**
3. Then, look at their images and classify them on the Hubble tuning fork. (Note: you may need to click on the image and open the Navigate tool to get a better view of the galaxy.) Record it in the column of Hubble type. You can choose from **E, S0, Sa, Sb, Sc, SBa, SBb, SBc or Irr**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Object ID** | **RA** | **Dec** | **u-r** | **Color Type** | **Hubble Type** |
| 1237655560403878129 | 248.920 | 0.331 |  |  |  |
| 1237662225706123901 | 254.768 | 16.715 |  |  |  |
| 1237648704068649509 | 248.295 | -0.213 |  |  |  |
| 1237648704068518498 | 248.051 | -0.304 |  |  |  |
| 1237655550207197707 | 248.275 | -0.189 |  |  |  |
| 1237648673997127724 | 248.064 | -0.050 |  |  |  |
| 1237662306744664864 | 256.022 | 16.764 |  |  |  |
| 1237668336864788995 | 249.860 | 11.211 |  |  |  |
| 1237662341631247030 | 256.384 | 17.304 |  |  |  |
| 1237662635841552623 | 246.455 | 6.336 |  |  |  |

1. How many of the galaxies' colors match their Hubble Tuning Fork types? How many do not?
2. Do you think color classification is a good (even if it is not perfect) way of classifying galaxies? Why or why not?