Redshift and Galaxy Clusters

One application of redshift is to use it to determine how far from Earth an object is. Astronomer George Abell put together a catalogue of about 4000 galaxy clusters. A galaxy cluster is a group of galaxies with anywhere from hundreds to thousands of galaxies bound together by gravity. All the galaxies in a cluster are roughly the same distance from Earth, which means they have the same redshift as seen from Earth or the average redshift of the cluster.

We have seen how we can calculate a galaxy's velocity from or toward Earth using redshift & the speed of light.

$V_o = zc$ $z=(\text{Observed } \lambda - \text{rest } \lambda) / \text{rest } \lambda$ $c = 300{,}000$ km/s

We can also use redshift to calculate the distance to the galaxy cluster using the following equation.

$D = z\,c / H_o$ $H_o = 70.8$ km/s/Mpc = 70.8 km/s Mpc

Ho is a constant with the units Mpc and km/s. Mpc is a unit of distance called a megaparsec. A megaparsec is given by 1 Mpc = 3 x 10^6 light-years). This means that a galaxy 1 megaparsec away will be moving away from us at a speed of about 70 km/sec, while another galaxy 100 megaparsecs away will be receding at 100 times this speed.

Using the SDSS archive server and what you know about redshift, calculate the distances and velocities of the nine galaxy clusters.

You can get a list of SDSS objects in one location by using the Advanced Spectra Search webpage for SDSS http://dr9.sdss3.org/advancedSearch

Just put the RA and dec in and make the radius 0.08 which is 5 arcmin. Then click Submit

You can see the galaxy cluster by using the Navigate page for SDSS
http://skyserver.sdss3.org/dr10/en/tools/chart/navi.aspx

Put the RA and dec in and click Search. If you turn on the red boxes for spectra you can get an idea of where the galaxies might be in the cluster but not everything that had spectra taken was a galaxy.

The sky is split into 360 degrees, each degree is split up into 60 arc minutes, and each arc minute is split up in 60 arc seconds. The tip of your smallest finger (the pinky finger) will cover approximately one degree if you hold that finger out at arm's length. So we are looking at small bits of the sky.

Things to think about –

How can you tell if a galaxy is part of a cluster or just in our line of sight but not really part of the cluster? Will all the cluster members look the same? Is the distance they are from one another significant? What information can I get from a SDSS spectra list? How can I manipulate the data to easily see connections or data? What information can I get from an SDSS image?

What you need to turn in:

1. Excel spreadsheet with Cluster #, location, average z from cluster members, cluster distance, cluster velocity.
2. What patterns do you see in the data of redshift, velocity and distance for these clusters?
3. How fast are these galaxies moving? The numbers are so big it is helpful to compare these distances and velocities to something we know. Make a couple of comparisons to get a better understanding of how far away these galaxies are and how fast they are moving. Some possible comparisons are listed below.
    i. Circumference of the Earth = 40,000 km
    ii. Distance from Earth to the Moon = 384,400 km
    iii. Distance from Earth to the Sun = 150,000,000 km
    iv. Apollo 11 took 2 days, 11 hours and 55 minutes to get to the moon.
    v. Distance to dwarf planet Pluto = 5,900,000,000 km
    vi. Distance to nearest star, Proxima Centauri = 4.2 light years
    vii. Distance to nearest galaxy, Andromeda Galaxy = 2.56 light years
    viii. Diameter of Milky Way galaxy = 100,000 light years
    ix. Length of a light year = 9,500,000,000,000 km
    x. Length of one parsec (pc) = 3.26 light years.
    xi. Typical size of a cluster = 1 – 10 Mega parsecs
4. Choose one cluster to look at more carefully. From that cluster's list choose a galaxy that you are sure is in the cluster. Put its RA and dec in the Navigate page and click Search. An image of that galaxy will show up on the side.
    a. What color is it? What are the magnitudes like? Which color is the brightest?
    b. What shape does the galaxy look like? Is it spiral, oval, a blob? Can you even tell?
    c. Do this for at least five galaxies in your cluster.
    d. What general conclusions can you draw from viewing members of this cluster? Do you think these conclusions can be applied to other clusters on our list?

Cluster	RA	Dec
1	5.44	-0.89
2	12.13	1.43
3	14.09	-1.26
4	0.91	1.64
5	28.77	1.01
6	39.93	1.54
7	41.48	-0.64
8	151.24	-0.693
9	21.39	-1.51