Hubble’s Law: The Distance – Redshift Relation for Galaxies

ASTRONOMY 106 Laboratory Worksheet

ο Use a computer to access the lab at http://astro.wku.edu/astrolab/Hubble_intro.html
ο Carefully read and complete the experiment as instructed. If something is not clear, please get help.
ο Neatness counts. Information which is difficult to decipher will not receive credit.
ο Everything turned in for a grade must be your own work.

I. Measure the largest size and observed wavelength of emission/absorption features

For each galaxy in the list below, follow the directions to measure the extent of the galaxy and the wavelength of the absorption lines known as Ca K and Ca H and the Hα emission line.

II. Calculate the distance and velocity

A. We can use the galaxy’s observed angular size to compute its distance, if we know its actual physical size.
   As stated in the on-line directions, we will assume a standard physical size of 22 kpc for all the galaxies.
   Following the instructions, use the measured angular size of each galaxy to calculate its estimated distance.

B. When there is no relative motion between the observer and the source, the wavelength of Hα is 6562.8 Å, Ca K is at 3933.7 Å, and Ca H is at 3968.5 Å. Use the definition of redshift (z) as given in the on-line instructions to calculate the redshift for each spectral line.

C. For each galaxy, calculate the average redshift from the value for each of the three spectral features.

D. Compute the recession velocity of each galaxy, using the relation v = cz.
III. Plot of Distance versus Redshift
   A. After plotting your distance and velocity data for each galaxy on the graph, draw a line through the data that is the best fit to all of the data points. This line may not go through any of the actual data points, but must be drawn so roughly as many points are above the line as are below it. On your plot, label this as the best fit line, representing the ideal relationship between the distance versus velocity for your data.
   B. The slope of this line or Hubble Constant, measured from your best fit line is __________________
   C. In addition to the best fit line, draw and label the steepest and shallowest possible lines that still go through any of your data. This represents the maximum uncertainty in the plotted data, indicating what values of the Hubble Constant can be reasonably excluded.
      From this data, the range for the Hubble Constant is _______ to _______ .
   D. Explain why the best fit line, steepest, & shallowest lines all must go through the origin of the plot, (0,0).

IV. Estimating the Age of the Universe
   A. Convert the Hubble Constant to inverse-seconds,  
      by dividing your value for the best-fit Hubble Constant by 3.09 x 10^19 km/Mpc: ______________
   B. Invert the above answer to find the “expansion age” of the universe in units of seconds: ______________
   C. The age of the universe in years is computed by dividing the above answer by 3.16 x 10^7 sec/year.
      Age of universe = ________________ years
   D. Compare your calculation for the age of the universe to the age of the Sun, computing a ratio of age of universe divided by age of Sun.
      The universe is ________ times older than our Sun.
   E. Use the web to find the oldest ages observed for globular clusters.
      Age of oldest globular clusters = __________ years
      Compare your calculation for the age of the universe to the age of the Sun, computing a ratio of age of universe divided by age of the oldest globular clusters.
      The universe is __________ times older than the oldest globular clusters.
   F. In your own words, concisely explain how the age of the universe you calculated above would compare to the actual age for a universe with a substantial contribution from dark energy.