

In this activity, we are going to measure our own Hubble’s Law! We will use real spectra and images of galaxies to measure redshifts and distances, then fit a line to the results and find the Hubble constant.

1. The galaxies we will use are listed in the file “data.csv”. This is where you will enter your data.
2. We will be using the data on this website:
<https://depts.washington.edu/astroed/HubbleLaw/galaxies.html>.
 Open this link in your browser, and you should see a list of galaxies.

3. For each galaxy in the list, click on its corresponding spectrum / image link and measure the following:

- (a) Angular size – An image of the galaxy is shown to the left. Note that the images used in this activity are negatives, so that bright objects – such as stars and galaxies – appear dark. Note also that there may be more than one galaxy in the image; the galaxy of interest is always the one closest to the center.

Determine the extent of the long axis of the galaxy (as projected on the sky), ideally as far out as you can see any fuzzy disk. Click on one end of the long axis of the galaxy, then click on the other end of the long axis of the galaxy. The window will report the a pair of (x,y) coordinates where you clicked, and calculate the angular size of the galaxy in milliradians. Record the angular size in your data table. Unfortunately, there is no easy “back” link to use, so hit your browser’s back button a few times to get back to the galaxy list.

- (b) Wavelength – The full optical spectrum of the galaxy is shown at the top of the web page, and below it are enlarged portions of the same spectrum in the vicinity of the $H\alpha$ line (6562.8 Å) and the Ca II “K and H” lines of (3933.7 and 3968.5 Å, respectively). The enlarged portions of the spectrum are “clickable” and will return a wavelength value corresponding to where you clicked.

Choose to work with EITHER the Ca K or Ca H absorption line. Click on the deepest part of your chosen line, and the corresponding wavelength value will appear below the plot. Enter this value into your data table. Make sure you use the same Ca line for every galaxy! Click the “back” button to return to the galaxy list.

Note – we are not including ALL the galaxies from the website list, only the ones with hyphens before their name.

4. Once you filled in your data table, it’s ready to use in your python notebook! Continue this lab in your Colab notebook, making sure to upload your csv file.