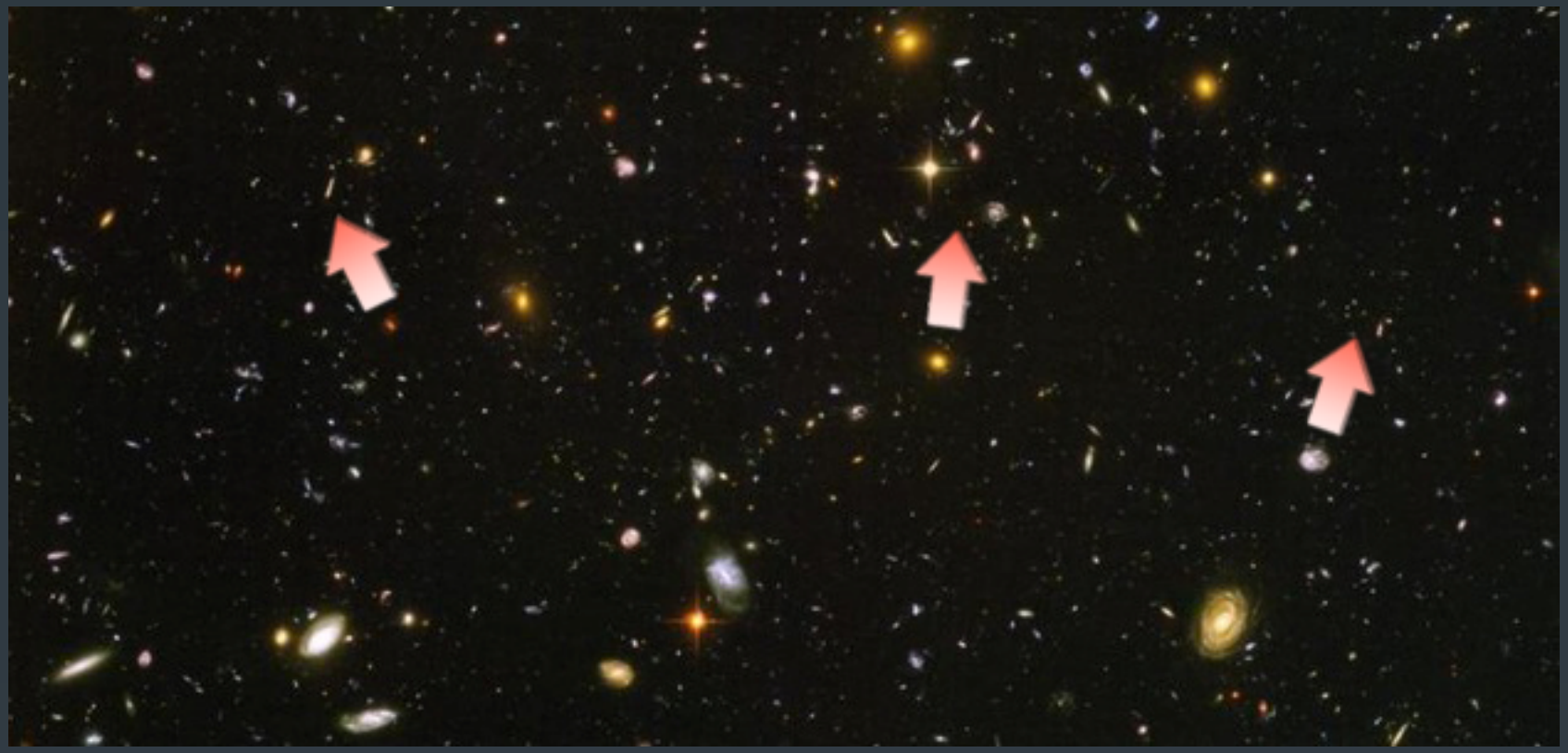
ASTR 1020

Lab 15: Hubble's Law

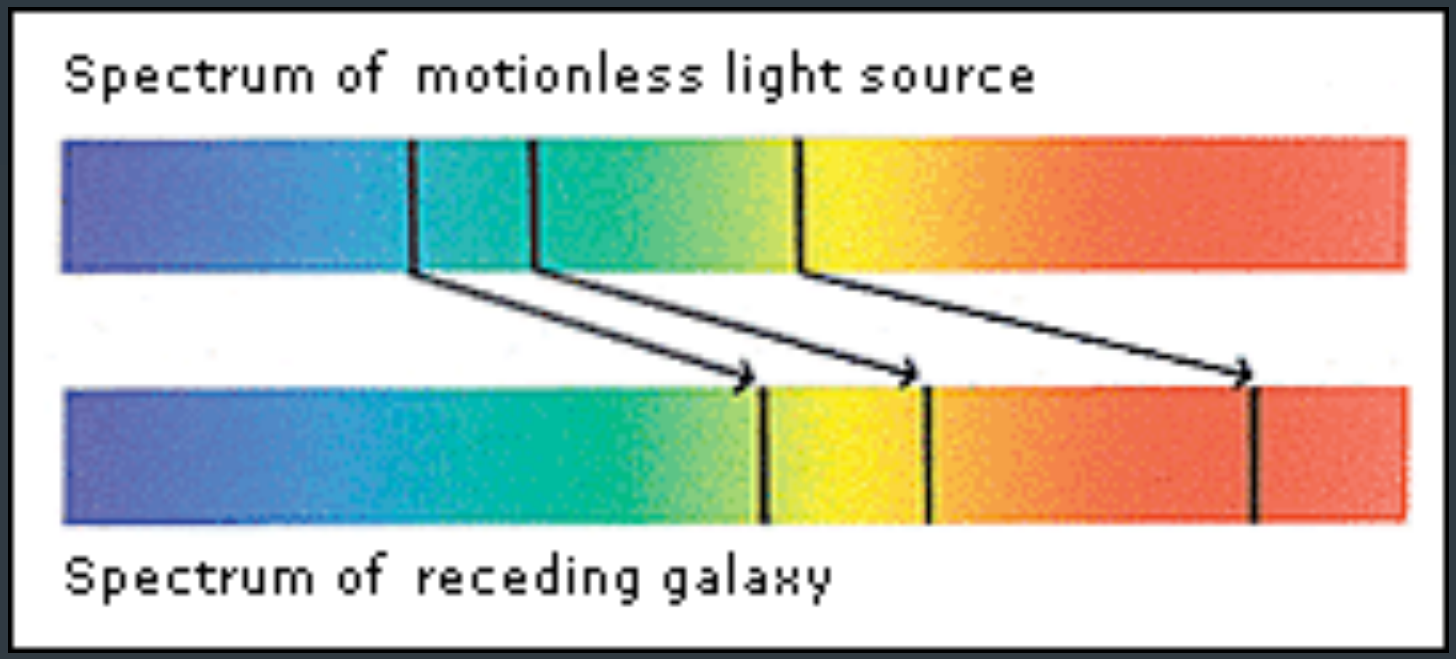
Motion of Other Galaxies

Hubble noticed something strange: Most other galaxies are moving away from us. This led Hubble to theorize the universe is expanding, in fact expanding at a faster and faster rate.



Redshift

How can we tell? Well, when the expansion of the universe moves galaxies away from us at high speeds, their light gets stretched to longer wavelengths (redder wavelengths). This is called **redshift**.



Distance

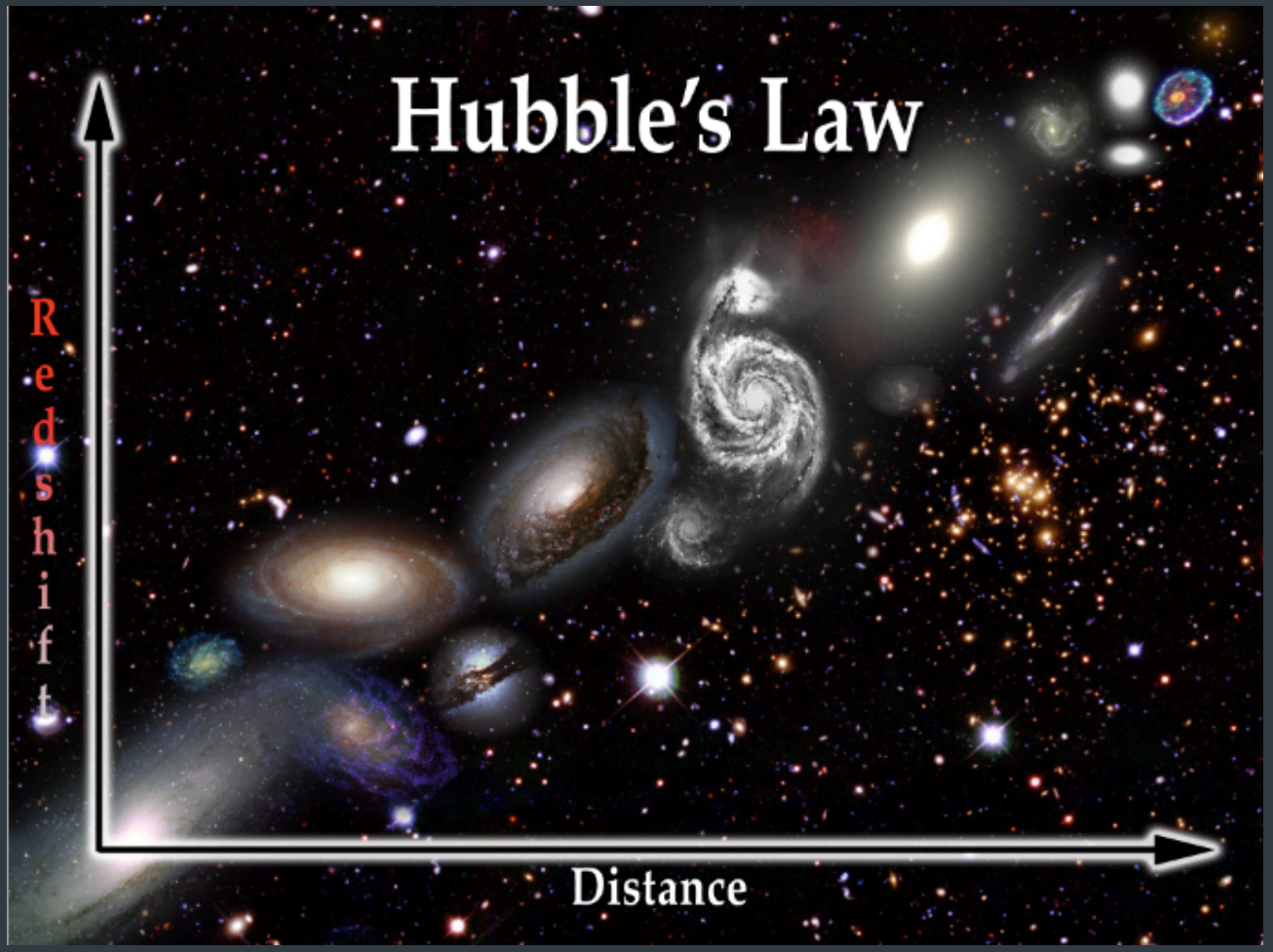
Galaxies come in many different sizes but, overall, look smaller when they're farther away, just like everything else.

Close

Far

Hubble's Law

If we graph these two quantities (redshift of galaxy vs. distance to galaxy), we get Hubble's Law. The slope of the line describes how fast the universe is expanding: V = HD. H is Hubble's Constant in km/s/Mpc.

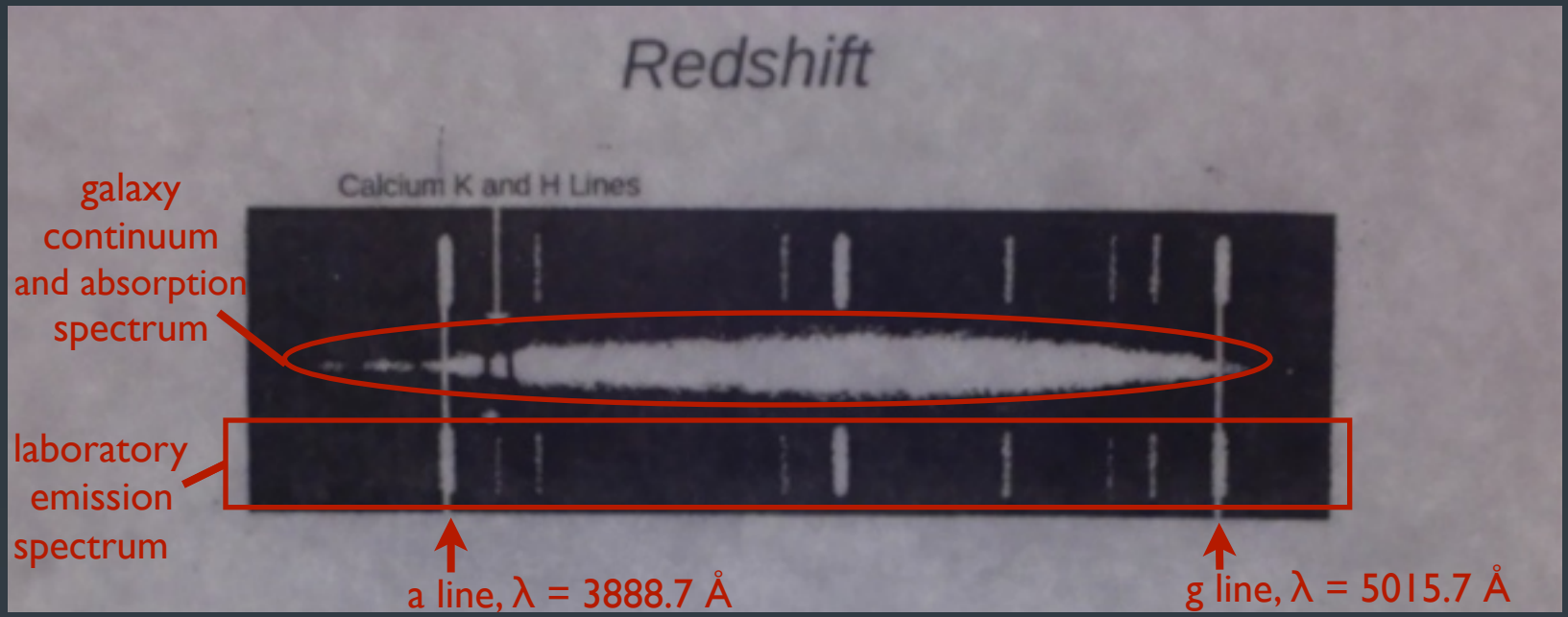


Step I: Scale Factor

To get wavelengths from the photograph, you need to set up a scale factor:

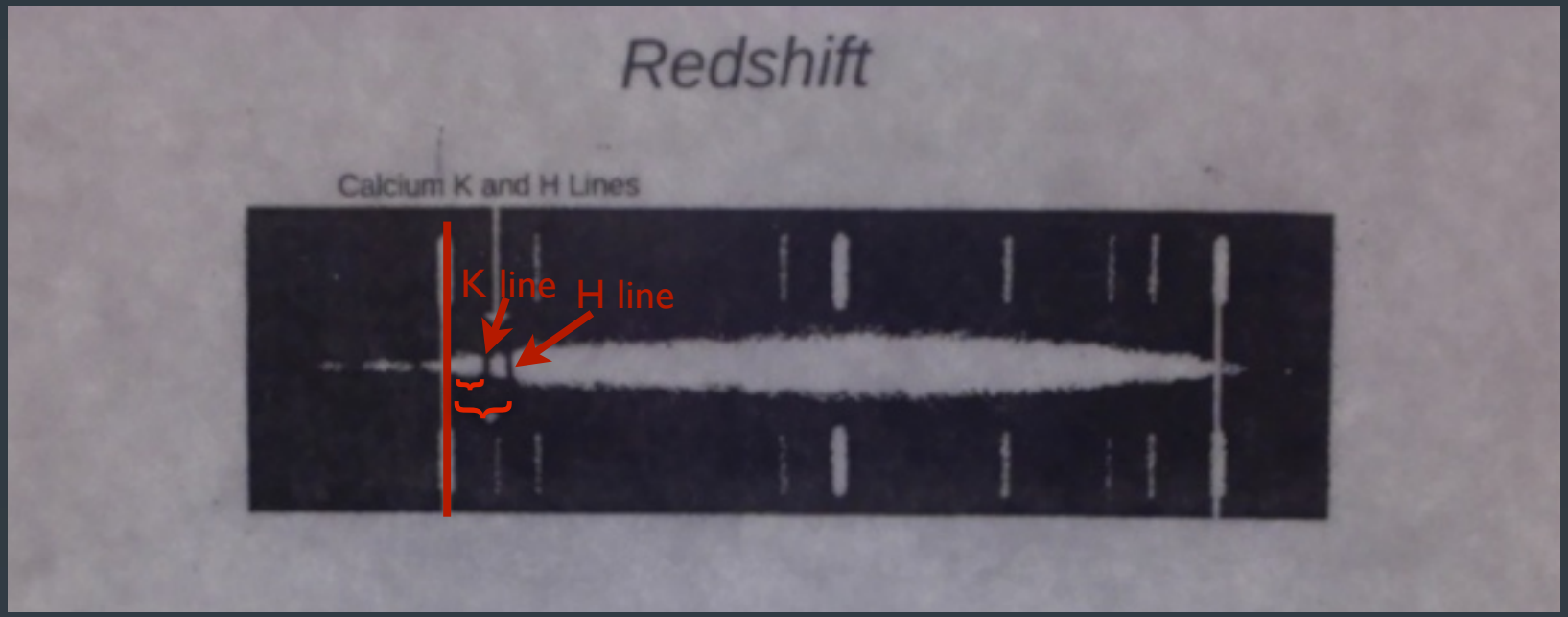
$$\frac{\text{length in Å}}{\text{length in mm}}$$

For the approximate one-size-fits-all scale factor, measure the mm distance between the a line and g line and divide the difference in wavelength by the mm distance.



Step II: H and K Absorption Lines

Next, from the center of the photo's a-line (not necessarily the same as the big thin white line we used earlier), measure the distance to the absorption K line ($\Delta\lambda_K$ in mm) and the distance to the absorption H line ($\Delta\lambda_H$ in mm). Convert to Å and correct with subtraction.

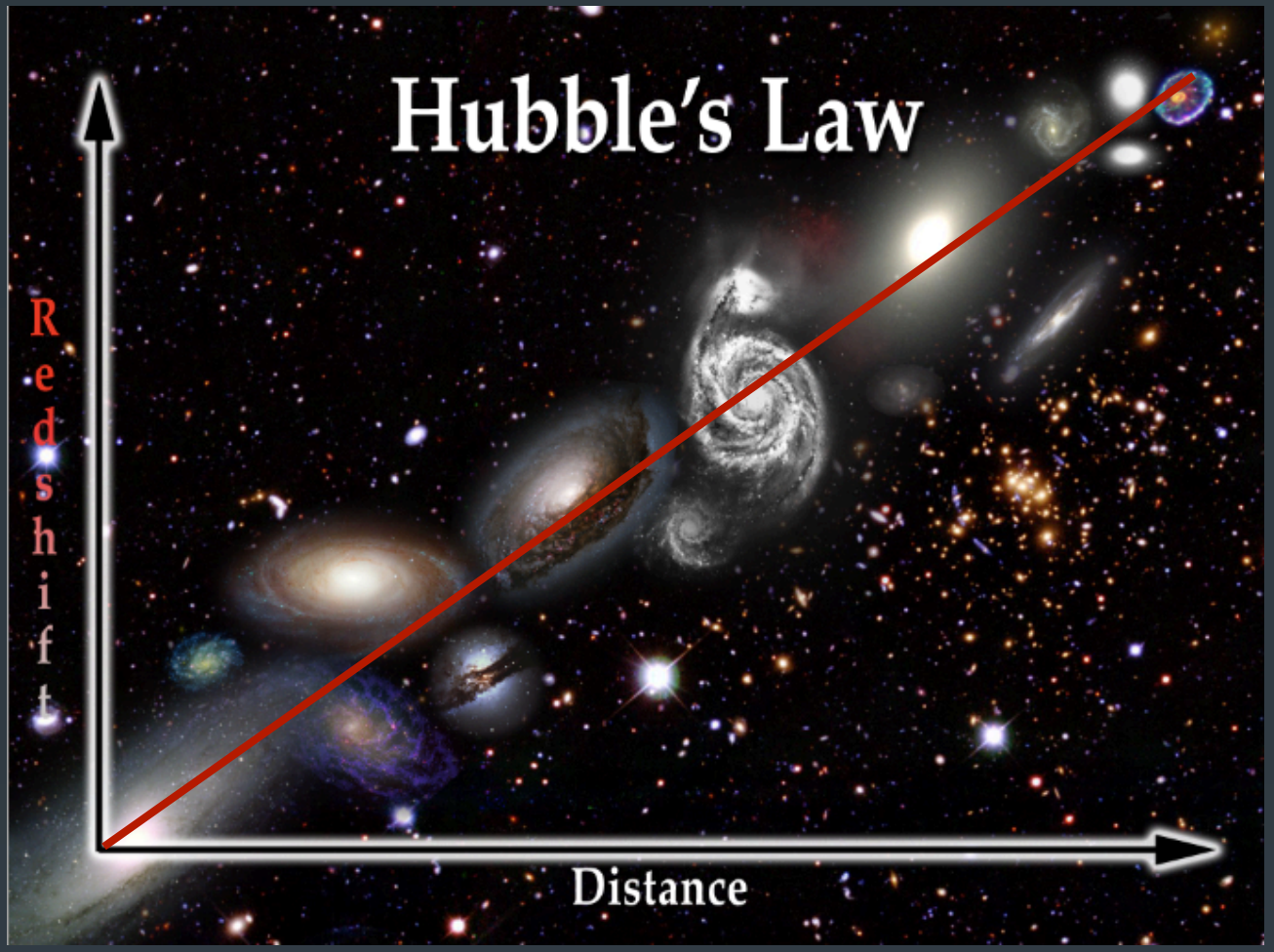


Steps III and IV: Distance from Angular

Get the scale factor for arc seconds per mm the same way you did for angstroms. Then, measure the smallest and largest diameter of each galaxy and take the average for d.

Step V: Hubble Constant from Slope

Graph the velocity V vs. distance D for each galaxy and get the slope of the V = HD line. The slope is the Hubble constant, H. From H, you can deduce the approximate age of the universe $T = 1/H * 10^{12}$ and size of the universe R = c/H.



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