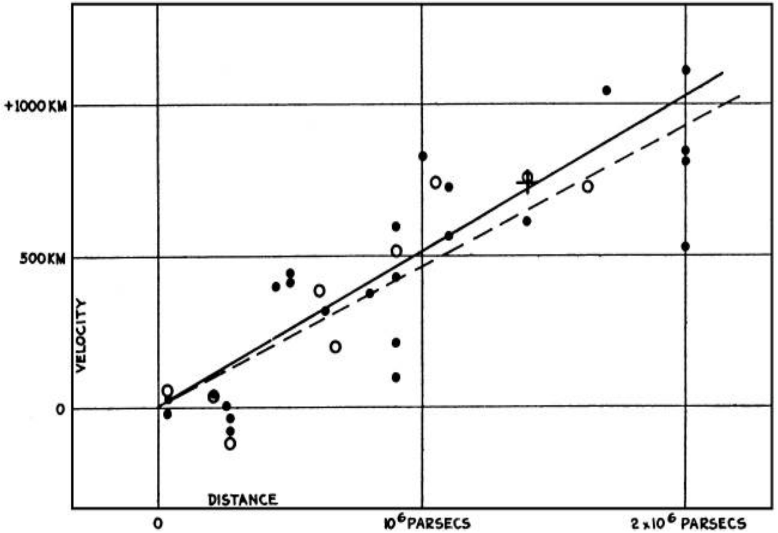
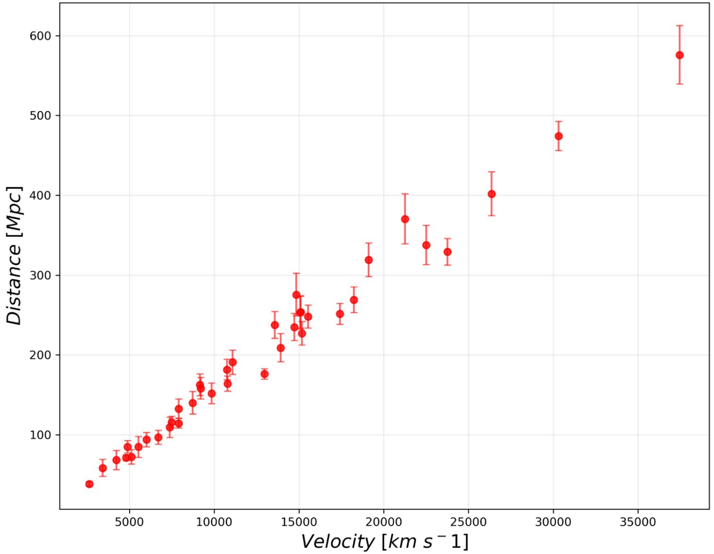
LAB 1: Hubble Time Jorge Casas, Pablo Drake

Today, we have data from high-redshift SN (*reference*), allowing us to compute H_0 and its related Hubble time. Through this calculation, we will answer the question: **what is the age of our Universe?**



Hubble, E. P. (1929) Proc. Natl. Acad. Sci. USA 15, 168–173.



Filippenko, A. V. & Riess, A. G., 1998, Physics Reports, 307, 31

Edwin Hubble (1929) plot of distant galaxies and redshifted recessional velocities. The first estimate of the Hubble Constant, H_0, was imprecise due to uncertainty inf distance to sampled galaxies.

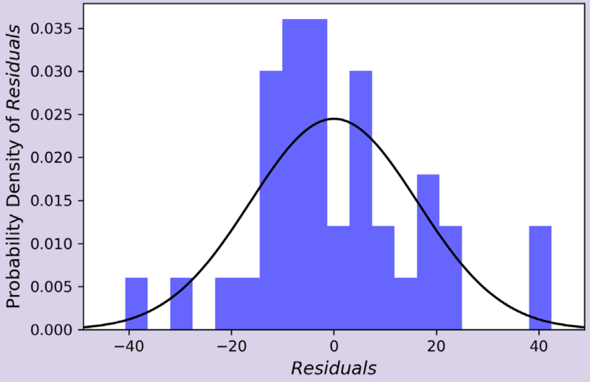
Type 1A Supernova sampling offers a more precise approach to measure the distance using these events as "standard candles" for the distance modulus to recalculate the Hubble Constant, H_0.

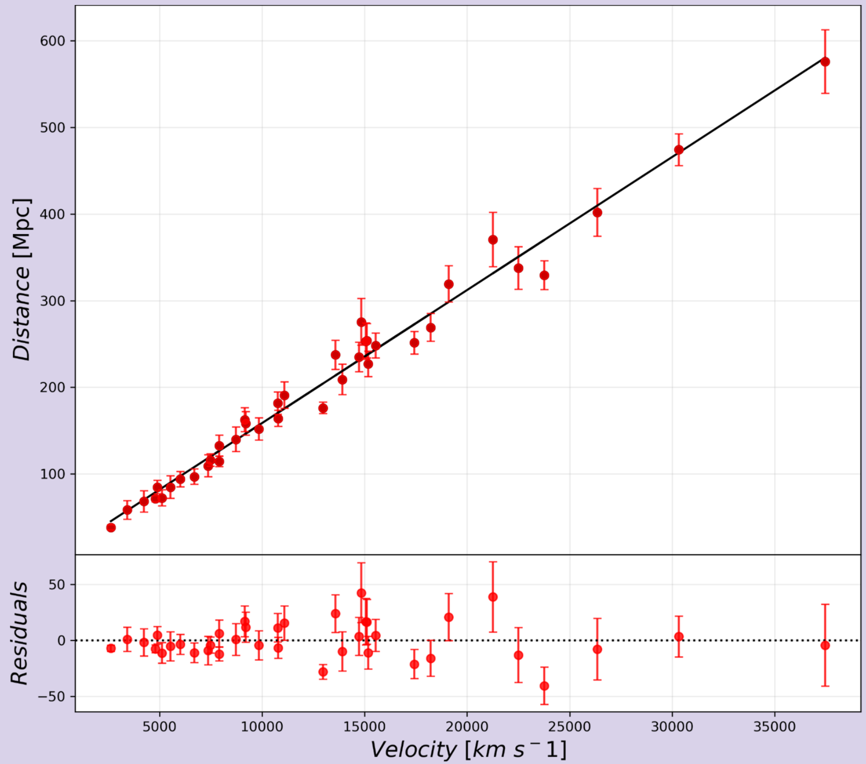
The relationship between distance and velocity seems linear
Furthermore, Hubble's calculation presupposes this linearity (by assuming a constantly expanding Universe)

Using the error data provided by *Filippenko, A. V. & Riess, A. G 1998,* we have carried out a weighted linear fit using np.polyfi

We have also solved the normal equation as a way to check t resulting gradient and y-intercept parameters

Lastly, we completed a bootstrapping approach, with 1000 samples. An error term was added to each sampled point in each bootstrap sample, determined by randomly sampling fror a Normal distribution with standard deviation equal to the measurement uncertainty of the respective sampled point.



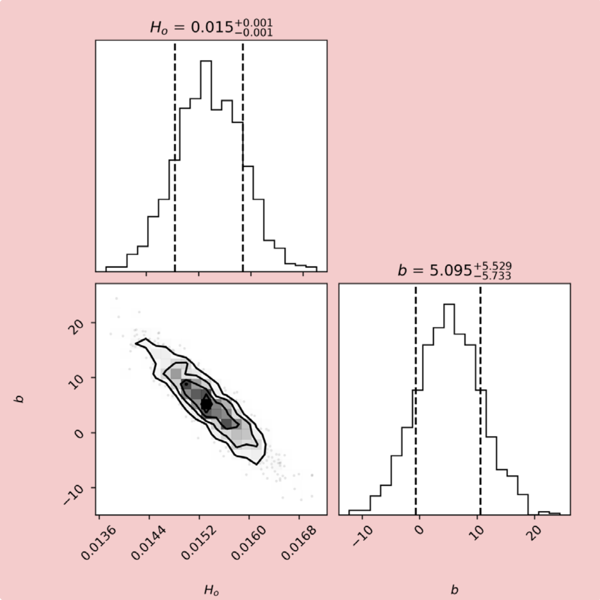


From the linear fit, we find:

Linear model slope, H_o^{-1}: **$(1.54 \pm 0.03) \times 10^{-2}$ [Mpc s km^{-1}]**

Age of the universe: **14.90 ± 0.28 [Gyr]**

From the bootstrap approach, we find a similar best-fit gradient, with a slightly larger uncertainty, as can be seen in the lower right-hand histogram.



Similarly, we can check the correlation between gradient and right intercept of the bootstrap approach in the corresponding corner plot.