12.3: Hubble’s Law

Hubble’s Law

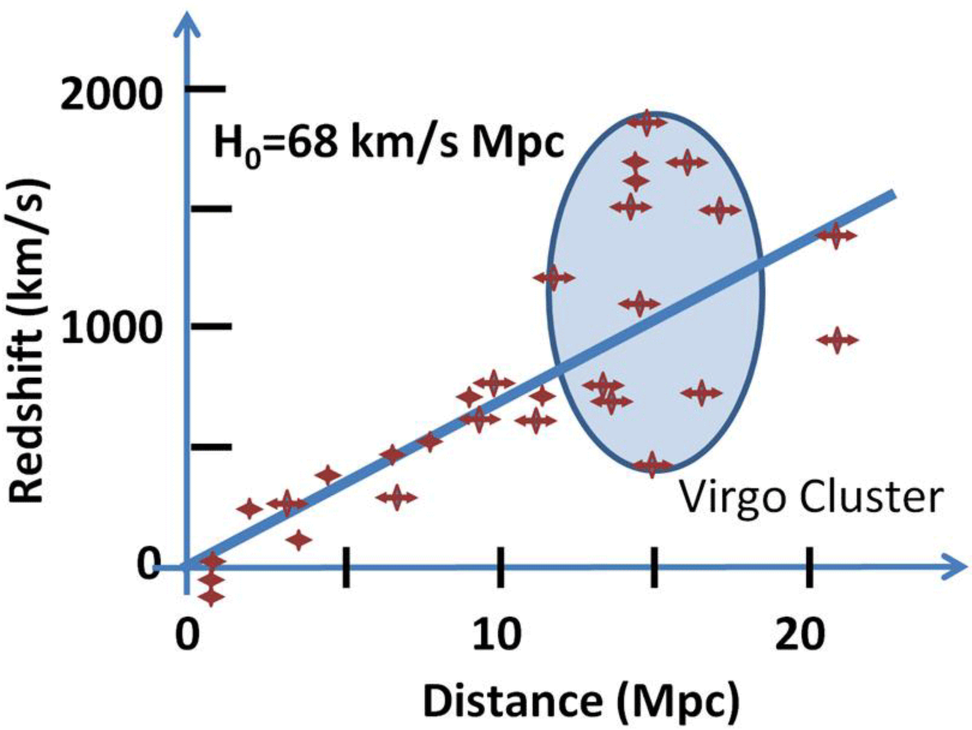
Two years later, in 1929, Hubble confirmed the Universe is expanding. Hubble also was able to infer the recessional velocities of a number of objects from the spectral redshifts he observed.

Hubble’s Law states that an object’s recessional velocity is proportional to the distance from the observer. In equation form, Hubble’s Law is described by:

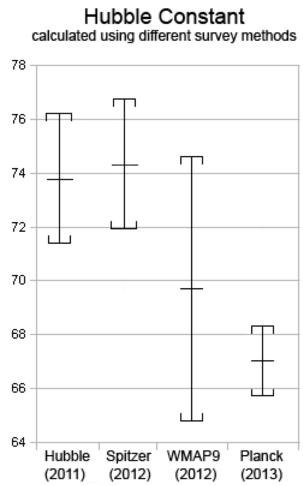
v = H $_o$ d

Where:

- *v* is the velocity of the object, in km/s
- *d* is the distance to the object, in megaparsecs, Mpc, where 1 Mpc = 1 million parsecs; and
- H $_o$, the Hubble constant or Hubble parameter, a proportionality between *d* and *v* ; also known as the rate of expansion, in (km/s)/Mpc or simply km/s/Mpc.



Astronomers take the data they observe — the distance to the object in megaparsecs (Mpc) and the object’s speed away from us from their spectral redshifts (km/s) — and plot these values to obtain values needed to determine the Hubble Constant, H $_o$. Hubble constant by Brews ohare is licensed under CC BY-SA 3.0



Different space telescopes have been used to determine the Hubble Constant, H_o. Each of these space telescopes — Hubble, Spitzer — WMAP, and Planck — look at the universe in different parts of the electromagnetic spectrum. Even though the H_o ranges for each space telescope vary, the data is more-in agreement than it was 10 years ago. Recent Hubble's Constant Values by Primefac is licensed under CC BY-SA 3.0

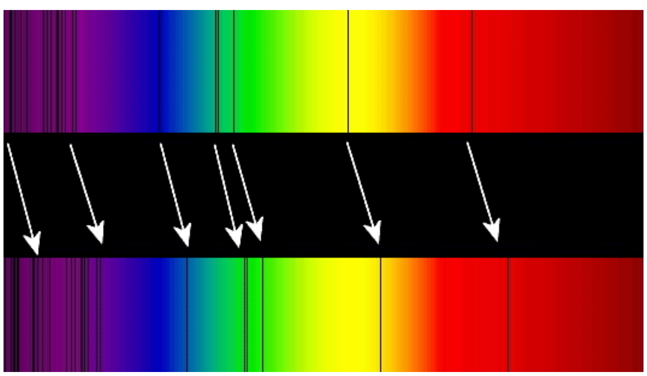
What does the km/s/Mpc unit mean? The km/s is a velocity, kilometers per second. Most of us are used to speeds in miles per hour, or mi/hr. A km/s velocity is much faster velocity than we are used to; 1 km/s is approximately 2,237 mi/hr. A megaparsec, Mpc, is a specific distance, about 3.26 million light years, 30.86×10^{18} kilometers, or 1.92×10^{19} miles. The km/s/Mpc is a unit of velocity per distance, velocity per megaparsec or about 3.26 million light years.

The Hubble's Law equation can be rearranged to solve for an object's distance:

v = H_o d

d = v/H_o

With Hubble's Law arranged in this form, one can determine the distance to an object like a distant galaxy or quasar by determining the object's recessional velocity from the object's spectral red shift and knowing the Hubble parameter.



A red-shifted absorption line spectrum, indicating the object is moving away from the observer (us here on Earth) Redshift horizontal by Georg Wiora is licensed under CC BY 2.5 / A derivative from the original work

With an understanding of the relationship between an object's redshift, its receding velocity, and distance, the work turned to determining the Hubble parameter value, H_o. A correct, or at least close, Hubble parameter would lead astronomers and cosmologists to not only determining the distances to these galaxies, but the age of the observable Universe itself. Hubble's Law applies to galaxies and objects that are extremely far away; specifically, more than 10 megaparsecs from the observer.