Hubble's Discovery Paper - 1929

\[ v = H_0 d \quad (H_0 = \text{Hubble's constant}) \]

\[ H_0 = 100h \text{ km s}^{-1} \text{ Mpc}^{-1} \]

\( h = 5 \)

Velocity (km)

Distance (parsecs)
$h = 0.72 \pm 0.03 \pm 0.07$ Freedman et al. (Hubble Key Project)

$h = 0.57 \pm 0.02$ Sandage, Tammann, et al.

Hubble's data

Riess et al astro-ph/9410054
Hubble’s Law

\[ V_{\text{rec}} = H r \]

- Hubble’s constant has dimensions of inverse time
  - Implies an age for the universe
  - A dense universe
    - We also know that it was hot.
The Cosmological Principle

- At first glance it may seem that since everything appears to be moving away from us, we must be at a special location. This is not the case. No matter where we go in the universe, it will always appear that everything is moving away.
The Universe is Homogeneous
&
Isotropic

- More like an assumption
  - This is something to be tested
    - Galaxy counts and so forth
    - The dark night sky
- Implied by Hubble Law
Looking Out is Looking Back

- What is the dark night sky?
  - As far way as possible?
  - As early as possible?

- A glowing body at 2.73 degrees Kelvin
The Early Universe

- At the first moment of time the universe was nothing more, or less, then extremely hot, dense soup of sub-atomic particles.
The Surface of Last Scatter

- If we look far enough away, we should be able to observe the birth of the universe. When we do so, we see this wall of fog 1/3 million years after the universe formed - the surface of last scatter.
And the light separated from the darkness...

- Attempts to look farther (earlier) are frustrated by the very high opacity of the universe at times earlier than 380,000 years after its birth.
  - At that time the temperature was 3000 degrees K
  - Doppler shifted to 2.73 degrees K today - the dark night sky
- The seeds for the structure that we see today began to form