

## EDWIN HUBBLE AND THE EXPANDING UNIVERSE

Hubble was born on November 20, 1889. Happy birthday, Edwin! The Hubble Space Telescope is named for this astronomer. Why? It's because Hubble's work was pivotal in changing our cosmology, our idea of the universe as a whole.

100 years ago most astronomers believed that the whole universe consisted of just our own Milky Way. In the late 1920s, Hubble picked up the idea of a changing universe, proposed earlier by **Alexander Friedman** (Russian) in 1922 and **Georges Lemaitre** (Belgian) in 1927, and set out to prove it scientifically by comparing the brightness of Cepheid Variable stars in nearby galaxies with the redshift of light received from those galaxies.

In 1908 **Henrietta Leavitt** had discovered a relationship between the period and luminosity of these variable stars and by timing its period, astronomers could work out the true luminosity of a Cepheid – and by comparing the true luminosity with the observed brightness, they could work out its distance. This worked fine for judging distances inside the Milky Way, but it wasn't until the 1920s that telescopes existed that were powerful enough to observe Cepheids in other galaxies. Using the new 100-inch Hooker Telescope at Mount Wilson, Hubble spotted his first Cepheid in the Andromeda 'spiral nebula' in 1924. He published his theory in 1929 and was among the first to recognize that there is a universe of galaxies located beyond the boundaries of our Milky Way. He also showed that, contrary to the then prevailing belief, our universe is expanding.

At the time, many astronomers believed that the Andromeda nebula was located within the Milky Way. Hubble's findings showed that this patch of light was really a separate galaxy – what we know today as the Andromeda Galaxy – the nearest large spiral galaxy beyond our Milky Way.

**As soon as those nebulae were revealed as separate galaxies, the known universe suddenly got much bigger! But was this huge universe stationary? Or was it expanding, or contracting?**

By analysing the spectrum of the light from distant galaxies, astronomers observed that their frequency seemed to be shifted toward the red end of the spectrum. This Doppler Effect is interpreted as a sign that the galaxies are moving away from us. On March 15, 1929 Hubble and his colleagues published the observation that farther galaxies are moving away faster than closer ones. **This insight became known as Hubble's Law. It was the first recognition that the galaxies are moving away from each other – that our universe is expanding.**

Hubble's Law has been revised several times over the years and at present is listed as 71km/sec/Mega parsec, that is, an increase in recessional speed of 71km per second for each million parsec (a parsec is about 3.3 light years).

It's said that **Albert Einstein** was elated to hear of Hubble's work. Einstein found that his General Theory of Relativity (1915) implied that the universe must either be expanding or contracting. **But Einstein himself rejected this notion in favour of the then accepted belief that the universe was stationary and eternal, and inserted a special balancing force (Lambda) into his equations. When Hubble presented his evidence of the expansion of the universe, Einstein called his adherence to the old idea "my greatest blunder."**

Hubble was a multi-talented man. Although he majored in science as an undergraduate at the University of Chicago, and was also an amateur heavyweight boxer, he returned to science as a graduate student at Yerkes Observatory in Wisconsin and in 1919 accepted a position at the prestigious Mount Wilson Observatory in California.



This image is the Hubble eXtreme Deep Field, released in 2012. Nearly every speck of light here is a separate galaxy, beyond our Milky Way.