Big-Bang Cosmology

Course Short Name: **Cosmology**

Prereq: Good high school math (AP not required) *Accessible* <=+= | === | ===> *Hard*

Overview

In 1929, Edwin Hubble used Cepheid variable stars to obtain the distance-redshift relationship that we now know as a Hubble plot. In 1998 Riess *et al*, and independently and one year later Schmidt, Perlmutter, and collaborators, confirmed the essential distance-redshift relationship using supernovae instead of Cepheids. Their research was exciting because it also established a subtle deviation, for which the present explanation is dark energy. Riess, Schmidt, and Perlmutter were awarded the Nobel Prize in 2011.

We will study the observational and theoretical developments that are the milestones in more than a century of history, starting somewhat before Hubble's 1929 paper and finishing in the present, as the JWST is now confronting us with further subtle deviations from Big Bang predictions. Do not be misled by clickbait claiming that the Big Bang is being overthrown. To understand these deviations, one first needs to understand the overall framework, and you will see that it can have trouble explaining specific observations while not being under serious threat.

To do justice to the subject of cosmology and to the scientific method, our class will use mathematics, but the mathematics will mostly be limited to algebra and trigonometry. Every physics and cosmological theory that we are confident of, we are confident of precisely because it has been tested quantitatively as well as qualitatively. Similarly, wherever we have doubt in established theories it is because they are having trouble with detailed predictions. We need mathematics and quantitative predictions to appreciation this tension.

The course will first focus on fundamentals such as the properties of light and the black-body spectrum, and the fusion processes in the interior of stars. It will then proceed to the classification of nearby stars and the contents of our galaxy. With these fundamentals, you will be prepared to move farther out into the cosmos. Near the end of the course, we will finally get to the complications of the properties of galaxies and the observed acceleration of the expansion rate that so far can only be explained by dark matter and dark energy, respectively.

Materials

I will be using for our outline the well-regarded 2nd Edition of *Foundations of Modern Cosmology*, John F. Hawley and Katherine A. Holcomb, Oxford, 2005. However, I would digest the material into handouts and provide supplemental readings rather than having you directly read their textbook, which is somewhat too advanced for a course with no prerequisites. At right is a redshift vs. distance diagram from p. 290 of Hawley and Holcomb.