13.0: The Expansion of the Universe Introduction

You might have heard that the Universe is expanding, but what does that mean? Does the Universe expand into pre-existing space, or is the expansion caused by the creation of new space? What does the expansion look like? Is expansion even the best phrase to use to describe what the Universe is doing? The opening video is a simulation of the uniform expansion of space. Galaxies are shown receding from each other as the space between them is stretched. The blue grid is provided to help you achieve a better sense of the three dimensional motions.

This video contains no audio

Notice how every galaxy in the visualization is moving away from every other galaxy. If you were located in any of these galaxies, you might not naturally conclude that you were moving at all. Instead you would see every other galaxy receding from you. From the video's point of view, however, we can see that there is no special place in the expansion; each place is just like every other. There is no sense of a center to the expansion, nor of a boundary or an edge. Also, notice that the galaxies themselves are not expanding, only the space between them is.

Every scientific visualization has been made to illustrate only some simplified aspects of the real Universe. At the same time, there are quite often liberties taken with other aspects. In the expansion visualization we are able to see the consequences of a uniform stretching of space, but it also contains several simplifications that we should be aware of.

First, the Universe is stretching very slowly. In the animation, distances are doubling in a few seconds. In the real Universe, several billion years are required for distances to double. Additionally, in the real Universe it is not individual galaxies that are being moved away from one another. Instead, every gravitationally bound structure rides the stretching, somewhat like a coin glued to a stretching piece of a rubber band. The largest bound structures are clusters of galaxies, so we observe clusters separating, not individual galaxies. Within the clusters, individual galaxies might actually be approaching each other, not receding. Another simplification is related to the evolution of galaxies. In the animation we do not see the galaxies changing (evolving or developing) with time. Over billions of years, the timescale depicted by the animation, galaxies change significantly. Finally, in the clip we see all of the galaxies at the same time. The real Universe is so large that it takes light a long time - perhaps hundreds of millions or billions of years - to travel across intergalactic distances. As a result of these enormous distances (and the finite speed of light), we observe distant objects as they were (and where they were) when the light from them was emitted, we do not see them where and as they are now.

In this chapter, we will begin to investigate the expansion of the Universe. In particular, we will look at the evidence for the cosmic expansion. We will see how an expanding Universe implies that at some time in the past everything we see around us must have been extremely close together, and we will learn how to calculate when that was. We should also not that the stretching history we see is consistent with the predictions of general relativity, our key physical theory for understanding everything we observe on large scales.
