

Galaxies, Cosmology and the Accelerating Universe

Revised syllabus

In this class we will look at nature on the largest scales. Our Sun is one of hundreds of billions of stars in our Milky Way Galaxy, and the Milky Way is one of billions of known galaxies. We'll learn our place in our Galaxy, and see the many beautiful forms that other galaxies can take. We'll learn how the universe can have a shape, and why we think that shape is expanding. Turning the clock backwards, we discover that the universe was smaller in the past, and that there was a time when all matter was in a small, hot space: the Big Bang. The story of how these things were discovered from nothing but starlight is itself fascinating. The mysteries of dark matter and the recently discovered acceleration of the expanding universe show us that there is still much to understand about the universe.

Class 1: Perspectives – What do we see when we look up at the night sky? How did we figure out the relationship between the various things we see? The discovery of the Milky Way Galaxy. The realization that other galaxies were far away, outside the Milky Way. The expanding universe and the hot big bang

Class 2: Distances. Astronomical distance units: the light year and the parsec. Distances to stars. The cosmic distance ladder. Parallax, star brightness, variable stars and the period-luminosity relation. Measuring the distance to galaxies. Type 1a supernovae. Clusters of galaxies. Looking into the past

Class 3: Stars and Starlight. Spectral lines of the elements. The composition of stars, gas and dust. Different types of stars and their life cycles. Star formation, death and black holes. The Doppler effect and the measurement of motion.

Class 4: Mapping the Universe: The current map of our Galaxy. The thick and thin disk, the bulge and halo. The orbits of stars in our Galaxy. The black hole at the center of our Galaxy. The missing mass problem: first hint of dark matter. The sizes and shapes of galaxies. Active and quiet galaxies. Galaxy motions and collisions. Groups of galaxies. The discovery that distant galaxies are moving away from us. Redshift as a distance measurement.

Class 5: The expanding universe. What does it mean for the universe to be expanding? What does it mean for the universe to have a shape? Gravity as the curving of space and time, which gives the universe an overall shape.

Class 6: The Big Bang. If the universe is now expanding, it must have been smaller in the past. What happens when the universe is very small (and what that means). The hot big bang and the creation of light elements. The evidence for the big bang: the abundance of light elements; we see light from the big bang.

Class 7: What happened after the Big Bang. Detailed measurement of light from the big bang. Galaxy formation. Why is the shape of the universe so close to flat?

Why is matter in the universe so evenly distributed? Inflationary cosmology. Speculations on why the big bang happened and whether it happened more than once.

Class 8: The big mysteries: Dark Matter and the Accelerating Universe. Gravity between galaxies seems too strong. Is there more matter than we see or is our theory of gravity wrong? Evidence that the expansion of the universe is speeding up. Speculation about why.

Class Web Site:

Direct link: <http://stevepur.com/galaxies/>, where you'll find each week's slides and handouts as well as links to interesting websites.

If you can't remember this link, it is also linked from the OLLI class notes website.

Recommended Reading

Here are some books that I am familiar with and recommend. There are many books that I am not so familiar with, so they do not appear here. So if I don't mention a book that does not mean that the book would not be recommended. This list will grow over time, so be sure and check this document on the class web site.

The Day We Found the Universe by Marcia Bartusiak (2009) A wonderfully readable book about the early discoveries of our place in the Milky Way and the expansion of the universe. Concentrates on the personalities.

Miss Leavitt's Stars: The Untold Story of the Woman Who Discovered How to Measure the Universe by George Johnson (2006) A short, very readable book that covers much of the same material as the Bartusiak book but from a more cursory perspective. Uses Henrietta Leavitt's story as a jumping off point. This book has personal stories not found in Bartusiak's book. The two books together make a good complimentary pair.

The First Three Minutes: A Modern View Of The Origin Of The Universe by Steven Weinberg (1984) A classic popular account of the hot big bang. A little dated so it's missing some of the recent advances, but what's there is still correct.

Conceptions of Cosmos: From Myths to the Accelerating Universe: A History of Cosmology by Helge Kragh (2007) A serious book of broad scope by a major historian of science, this covers the development of cosmological concepts from pre-history to last decade. More work than the two books above, but worth it.