

AST 301 (Scalo): A guide to the main topics to be covered on the last exam.
This exam (Friday, May 8, last class day) will cover chapters 26 and 27.

Ch. 26 has to do with the evidence concerning the basic questions:
Has the universe always been the same? If it has changed, how?
Is it meaningful to ask why?

The Hubble relation between redshift and distance was fundamental in showing that the universe is expanding.

We will concentrate on how the Hubble relation allows us to easily obtain the age of the universe, and allows us to discuss how to determine what the future fate of the universe will be.

A surprise will be the evidence for a mysterious “dark energy” that comprises *most* of the mass–energy of the universe.

I'd like to finish this material by Wednesday's class, leaving enough time for questions, review, and the very unusual material in chapter 27.

The next and final part of the course tries to trace back the history of the universe, to a time when the temperature and density were so high that there were no galaxies, stars, even atoms. This begins at the end of ch. 26, and continues through all of ch. 27. Major topics are:

- A. The cosmic microwave background radiation (CBR) and its origin;
- B. The era of the production of deuterium and helium;
- C. A still earlier phase in which the fundamental particles were created as matter–antimatter pairs;
- D. “Cosmic inflation,” an unbelievably rapid (10^{-30} sec!) expansion of all of space–time at a speed far greater than the speed of light, increasing the distances between points in the universe by a factor of 10^{50} . That's why it's called inflation!
- E. A time earlier than which we know nothing, because gravity and quantum effects occur on the same scales; this time is called the Planck time.

We end by discussing the currently accepted model for the origin of structure in our universe: Galaxies began as waves propagating through the universe. We can actually see the imprint of the waves on the CBR, and can test the idea that galaxies and their clusters are these waves amplified by gravity, using computer simulations of this process. The agreement with the observed structure is amazingly good, but *only* if these simulations include a large dose of dark matter, another “proof” of its existence.

The *source* of these waves, and hence all the structure in our universe, was...literally nothing, the absolute vacuum.