ASTRO190 HOMEWORK #6, DUE March 13.

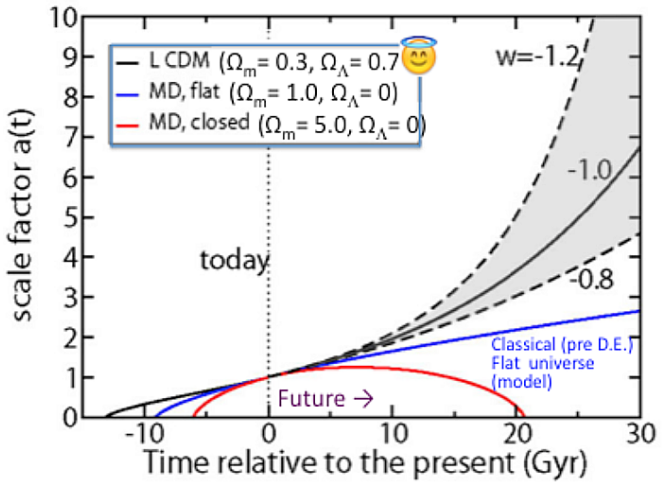
1. (4 pts) You must be able to read graphs to answer this question. Get help early if you need it! Please see the graph to the right. The scale factor of the present universe is 1. Presume that our universe grows as the LCDM* universe in which $\Omega_m = 0.3$, $\Omega_\Lambda = 0.7$, and w = –1 (black line).

a. In how many years will the present universe double in size?

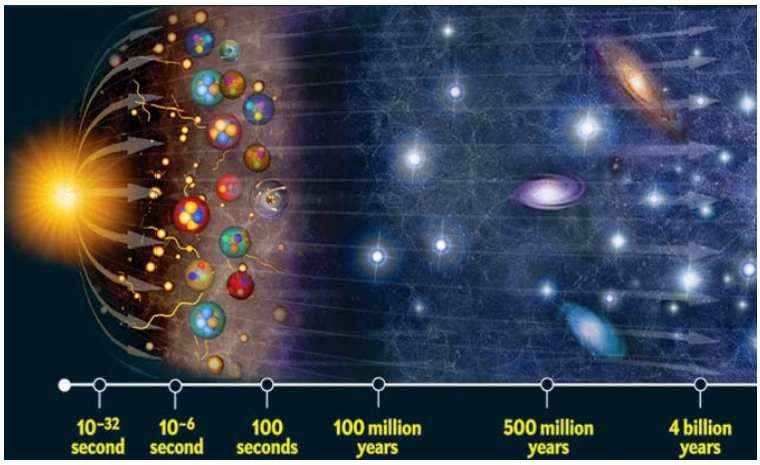
b. Approximately what fraction of the total cosmic energy will ordinary and dark matter represent when this happens? (Use the charts of relative energy density to the right.)

c. As you know, the radius of the present visible Universe, R_{vis}, is 13.8 billion ly. How large will R_{vis} become in 2 x 13.8 = 27.6 billion yrs from now?

d. Recall the most distant galaxy ever observed, "GN-z11", from HW2. GN-z11 presently lies at a distance of around 13.4 billion light years from the Earth. Will it still lie within our visible horizon, R_{vis}, in another 27.6 billion years? Explain.



2. (3 pts) The image to the right is a schematic timeline of the major eras of cosmic history. Attach a descriptive label (such as "first helium forms") at each time shown (10^{-32} s, 10^{-6} s, etc), and, in one or two sentences, describe what processes dominated the characteristics of the Universe at the start of each era.



3. (3 pts) Objects in the Universe will evolve as the Universe ages. Describe the major changes in the state of five familiar objects, the Earth, the Solar System, the Sun, nearby stars, and the Milky Way, when the age of the Universe increases from its present value by about a factor of 100. Reference http://www.bbc.com/future/story/20140105-timeline-of-the-far-future.

For example, you might state that the planets of the solar system will fall into the Sun (not true). Or you might say that the radius of the Milky Way will be increased by the accelerating expansion of the Universe (also not true).