Astronomy 350 Fall 2012
Homework #11: The Final Frontier

Due in class: Friday, Dec. 7

1. *The Planck Epoch*

   (a) [**5 points**]. What is the Planck epoch? Why is it of interest?

   (b) [**5 points**]. What is quantum gravity? How would a theory of quantum gravity be useful in addressing the question of what happened at the big bang ($t = 0$)?

2. *Particle Dark Matter*

   (a) [**5 points**]. What is a WIMP? How might they originate in the Early Universe? Why are these good candidates for dark matter?

   (b) [**5 points**]. What are examples of experiments to detect WIMPs? Why are they located underground (or under mountains)? What signal would the dark matter create in a WIMP detector?

   (c) [**5 points**]. What is the current status of WIMP experiments? That is, what results do we already have? What controversies exist among the competing experiments?

3. *Inflation*

   (a) [**5 points**]. Why is it puzzling that the observed CMB temperature is almost exactly the same on opposite sides of the sky? How would this result be explained in cosmology theories that do *not* include inflation?

   (b) [**5 points**]. What is the cosmic epoch of inflation in the early universe? How is this different from the usual expansion of the universe? What similarities and differences are there between inflation and dark energy?

   (c) [**5 points**]. How does inflation answer the puzzle from part (a)? What other properties of the *homogeneous* universe does inflation explain?

4. *The LHC and Cosmology.* The Large Hadronic Collider at CERN collides protons at energies higher than have ever before been attained in the laboratory. Thus, the LHC has the potential to discover new particles born as a result of these collisions, and the LHC thus re-creates the microscopic conditions of the very early universe. This makes the LHC important not only as a "microscope" to understand the subatomic world, but also a "telescope" to probe the big bang.

   Two competing experiments in the LHC announced the discovery of a "Higgs-like particle" on July 4, 2012.

   (a) [**5 points**]. What is the Higgs particle? Why is it important in our understanding of the Standard Model of particle physics?

   (b) [**5 points**]. Give at least one reason why the Higgs particle important for cosmology.

(c) [**5 bonus points**]. The LHC will continue to run for about another 10 years; one of its major goals will be to search for new, previously unknown particles. Imagine that the LHC *does* discover a new particle. Why would this be very important for *both* cosmology and for our understanding of elementary particles?