Science 100

Questions for Discussion VII (be prepared to discuss on Wednesday, February 23)

Instructions: Same deal as before. Due midnight on Wednesday.

Davies, The Last Three Minutes

1. (pages 21-22) Is the relationship between the distance a galaxy is away from us and the speed at which it is receding away from us **linear** or **inverse square**? Find a phrase or sentence in the text that supports your choice. (Hint: if this is still confusing, do a search on "Hubble Law")

2. (page 23) Many people ask: "What space did the Big Bang explode into?" and "What was there before the Big Bang?" Give a reason why these questions are **meaningless**.

3. (pages 25 and 26) What evidence exists of a **more uniform** (less clumpy) universe long ago, just after the Big Bang? How can we know this after all this time?

4. (pages 30 and 31) The **Heisenberg Uncertainty Principle** is one of the cornerstones of modern **quantum mechanics**, the branch of physics that deals with motion at the subatomic level. Davies gives as an example the idea that an electron's position and its momentum (basically, its speed) can never be precisely determined. Find a resource that will answer the question, "how can I tell that the Randy Johnson fastball coming at my face at 100 mph (so says the radar gun) is really going to hit me? Doesn't the Heisenberg Uncertainty Principle say that we can't really tell the fastball's position or its speed?" Cite your reference.

5. (pages 33 and 34) When is a vacuum not a vacuum? In other words, how can space that has no particles at all in it suddenly teem with particles? Though the energy expenditure would be enormous, we could all be composed of "**virtual**" particles; in that case, what would our inevitable end be, and would there be any warning?

6. (pages 53 and 54) Give three pieces of evidence that Cygnus X-1 is a **black hole**.

7. (page 57) At last! A way to distinguish between the fundamental forces. What reason is given here to explain the **relative weakness** of the gravitational force (compared to the nuclear strong, nuclear weak and electromagnetic forces)?

8. (pages 60 to 62) How can a star turning into a black hole not be the end of its energy-generating phase? In other words, how can one **extract useful energy out of a black hole**? State what type of energy is converted into useful (kinetic) energy via a black hole. Note the name Roger Penrose (one of the Seattle Science Lecture series speakers) shows up here.

9. (page 71) Has the question of whether a **neutrino** having a **non-zero rest mass** been cleared up yet? Go to the site http://hyperphysics.phy-astr.gsu.edu/hbase/particles/neutrino.html#c3 and to the best of your ability, determine (a) if the neutrino has a non-zero rest mass and (b) the experiment or observation that showed that to be the case. Note: Physicists report masses of particles as "eV" (electorn-volts) because they like to report the energy a particle has, rather than its equivalent ($E = mc^2$) mass, because the energy is more readily measureable.

10. (page 73) In addition to **WIMPs**, there are **MACHOs**. What are MACHOs, in the context of the mass of the universe? Hint:
http://antwrp.gsfc.nasa.gov/apod/ap960202.html. Find a more recent reference; are MACHOs thought to be a significantly large portion of universal mass?

11. (page 79) What is the reason cosmologists want to find the mass of the universe? Equivalently, how does the fate of the universe depend on its mass?

12. (page 80) Finally, how does the initial **inflationary phase** of the universe determine the fate of the universe, untold billions of years later?