**Astronomy 84: Black Holes**

***Physical Law***

**Discussion topic 3.2 Fall 2017**

On pages 84 to 86 of Kip Thorne’s book, *Black Holes and Time* Warps, he discusses the nature of physical law, the domains of validity for different kinds of laws, and how one can figure out where physical laws are incomplete or may need to change. You should prepare to discuss physical law and how it will apply to our study of black holes for the next class.

Here are several questions you should think about and prepare to address:

1. What criteria show us the domain where Newton’s laws might break down and Einstein’s new laws take over for moving bodies? How could Einstein know what kinds of thought experiments to do in deriving the new laws?
2. How do we determine “reality”? Newtonian physics corresponds broadly to our everyday experience (although one could argue that friction makes it impossible to see his law of constant motion without forces), but Einstein’s physics seems to defy our experience. Is this really a problem for our perception of reality? What aspect of our experiences should cast doubt on our intuition about space and time?
3. Using ideas about special relativity and energy to see where Newton’s laws might break down, can you guess at criteria in which Newton’s law of gravitation will break down and we need a new way of approaching gravity? Be quantitative. Find a relationship involving gravitational energy in which we should be suspicious of the validity of Newton’s laws. For example, a solar mass black hole will accelerate objects to high speeds when they fall in from a large distance. You can use Newton’s law of gravity to find the kinetic energy at different places in the gravitational potential well (total energy, *E*tot = ½*mv*2 – *GMm*/*r*) and see when relativistic effects become important.
4. Finally, there is a tendency in politics these days to use the label “theory” as meaning a principle is not well established or where there is room for debate. This label is often used to discredit new ideas and not distinguish between extremely well established theories, such as the principle of evolution in biology, and new ideas that are not yet accepted, such as string theory. For this reason, Thorne rejects the use of the term “theory” to apply to relativity preferring instead the term “physical law.” Discuss the elements of Darwin’s ideas of evolution that are non-intuitive and how scientists have overcome their intuition to establish evolution as a guiding principle of biology just as Newton and Einstein established new laws for physics. You may also enjoy thinking about how this reasoning applies to the current debates about developing scientific ideas such as human influence on climate change.