Ph 136a 8 October 2002

CHAPTER 2: KINETIC THEORY

Reading:

Chapter 2 of Blandford and Thorne. Most of the applications of kinetic theory are in Example Exercises. These Examples are designed to give you some feel for how kinetic theory is used in practice. Some of them are also rather interesting. We urge you to read all Example Exercises as though they were part of the text, even though you will be working only a few of them.

Problems

A. Exercise 2.3: Observations of cosmic microwave radiation from moving earth.

B. Exercise 2.8: Vlasov implies conservation of particles and 4-momentum.

C. Exercise 2.7: Equation of state for electron-degenerate hydrogen. *Don't hesitate to use Mathematica or Macsyma or Maple to do the integrals you encounter, or to do any other part of this or any problem. This is not a course on mathematical methods. Our goal is to each you physics. If a problem turns out to involve heavy computations from which you learn little (if the grunge to learning ratio is outrageously high), find a way around the grunge, or skip the grungy part of the problem (but write a note in your solution saying you are doing that and why), or even abandon the problem entirely and focus your learning efforts elsewhere — e.g. pick some other problem to work instead, and say so.*

D. Do one of the following two exercises:
   - Exercise 2.9: Solar heating and the greenhouse effect. This one has the virtue that we lead you through it step by step.
   - Exercise 2.10: Olber's paradox and solar furnace. This one requires more independent thinking, and may be shorter than 2.9 if you think creatively.

E. Exercise 2.11: Diffusion coefficient in collision-time approximation. This is a rather long exercise, designed to give you experience doing a Boltzmann-transport analysis in the diffusion approximation. If you think you fully understood the Boltzmann-transport computation of thermal conductivity in the text, then we suggest that, in place of 2.11 you attempt
   - Exercise 2.12: Neutron diffusion in a nuclear reactor. Note that this exercise is labeled as a "challenge"; it is hard and there are few hints. You may need to go look at a textbook on nuclear reactors while trying to solve this problem, for example Stephenson (cited in the chapter) or Glasstone and Edlun, *The Elements of Nuclear Reactor Theory*. Note that in this problem the distribution function is independent of space (the reactor is regarded as homogeneous), independent of time (the reactor is assumed to be running in a steady state), and independent of the neutron direction of motion (the neutrons move isotropically); i.e., the distribution function depends only on the neutrons' (nonrelativistic) energy E. The Boltzmann transport equation is used to compute that dependence on E, and having done so, to determine the conditions the reactor must satisfy in order for at least half of the neutrons to trigger fusions.