## Midterm, 29 October 2007

**Duration:** 50 minutes

**Examination aids:** Anything except communication devices.

**Note:** Answers can be brief and in point-form, but be sure that derivations can be followed.

1. We consider a comet flying by Jupiter, with closest approach at distance $d_{\min}$. We will approximate it as a sphere with radius $R_{\text{comet}} = 5\,\text{km}$ and density $\rho_{\text{comet}} = 500\,\text{kg}\,\text{m}^{-3}$.
   (a) [10 points] Write down general expressions (i.e., do not yet insert numbers for $R_{\text{comet}}$, $M_{\text{Jupiter}}$, etc.) for the acceleration at the comet's surface due to Jupiter's tides, as well as the acceleration due to the comet's self-gravity.
   (b) [10 points] Shoemaker-Levy 9 was a comet with the above properties, which was torn apart. Within what distance of Jupiter must it have passed (give your answer in Jupiter radii)? *(Aside: Shoemaker-Levy 9 is most famous for its impacts on Jupiter two years later.)*

2. We derive mass-radius relations.
   (a) [10 points] Use the Virial Theorem to show how radius scales with mass for balls of ideal gas that vary in mass but have the same central temperature.
   (b) [10 points] Do the same for balls of degenerate gas.

3. Suppose you are observing the Sun from $\epsilon$ Eridani, i.e., at a distance of 3 parsec.
   (a) [10 points] If you would measure radial velocities of the Sun, how large would be the signal due to Jupiter? And how large that due to Earth? (Assume you are viewing the Solar system edge-on.)
   (b) [10 points] What would be the maximum angular separation (in arcsec) at which you could see Jupiter from the Sun? And how about Earth?

**Bonus** [10 extra points] Estimate how bright Jupiter and Earth would be *relative to the Sun* in visual, reflected light. *(Feel free to ignore the planet's phase.)* Given your answer, are you surprised no planets have yet been detected in reflected light?