Homework #5

For these problems you may use a NS of mass $1.4 \, M_\odot$ and radius 10 km. Problem 2 will be discussed on Monday, Feb. 29.

1. The shortest known radio pulsar period is 1.4 ms. Assume that the NS reached this period by accreting matter from a companion star through a disk at the Eddington limit until it was spinning in equilibrium.

(a) Solve for the magnetic moment (and the magnetic field strength at the surface) of this neutron star.

(b) What was the magnetospheric radius of this pulsar while accreting?

(c) Assuming that this NS was initially rotating very slowly. Using conservation of angular momentum, estimate how much matter would have to be accreted to spin it up to a period of 1.4 ms, and how long would it take at the maximum accretion rate (corresponding to the Eddington luminosity). You may assume a constant moment of inertia.

2. A NS in a low-mass X-ray binary with a steady luminosity of $10^{37}$ ergs s$^{-1}$ undergoes repeated thermonuclear flashes in which about $10^{21}$ g of accreted matter from a helium-star companion in converted to iron.

(a) Calculate the energy released in the explosion, and the time interval between bursts.

(b) If this energy is emitted as blackbody at the Eddington limit over the entire surface of the NS, estimate the temperature of the burst radiation and the duration of the burst.

(c) If the frequency of a burst oscillation varies from 362 Hz to 364 Hz during a burst, estimate the height to which photospheric material is lifted, assuming that the frequency change is due to conservation of angular momentum.