Physics 725: Special and General Relativity

Thornton 425, San Francisco State University (c) 2011 Andisheh Mahdavi Fall 2011, MWF 3:10PM

Homework 9 Due 12/7

While I may have consulted with other students in the class regarding this homework, the solutions presented here are my own work. I understand that to get full credit, I have to show all the steps necessary to arrive at the answer, and unless it is obvious, explain my reasoning using diagrams and/or complete sentences.

Name **Signature:**

1. Hartle 21.18
2. Hartle 22.13
3. (a) Do Hartle 22.14.
   (b) What does the exotic matter distribution look like for $f(r_s) = 1 - r_s^4/R_s^4$ clipped at $r_s = R_s$? It's not spherical. Use `ParametricPlot3D` in Mathematica to plot at least three different isodensity surfaces centered on the ship, including the highest density surface. Make sure the surfaces do not extend beyond $r_s = R_s$.
   (c) The exotic matter distribution appears to be the symmetric in $|x - x_s(t)|$. Why is it then that there is a preferred travel direction?
   (d) Negative energy densities can be created via the Casimir effect. Imagine positioning a series of massless, concentric, perfectly conducting surfaces to create the warp field $f(r_s) = 1 - r_s^4/R_s^4$. Quantum mechanics tells us that the vacuum energy density between these surfaces is negative and given by

$$E_0 = -\frac{\hbar c \pi^2}{240 a^4}$$

   Where a is the separation between the shells. Suppose we can reliably keep these shells as close as 1 nm away from each other. How big does the size of the warp field R_s need to be to let us travel at 10 times the speed of light?
4. Hartle 22.15