PHYSICS 717 PROBLEM SET 7

due: Monday, March 23, 2009, at the beginning of lecture

Problems

1.: Show that $\theta = \pi/2$ satisfies the geodesic equation in the Schwarzschild background.

2.: Fill in the steps between the equation

$$\phi = \phi_0 + \frac{2M}{b} + \arcsin(by) - 2M\sqrt{\frac{1}{b^2} - y^2}$$

and

$$bu = \sin(\phi - \phi_0) + \frac{M}{b}[1 - \cos(\phi - \phi_0)]^2 + O(\frac{M^2}{b^2}) \tag{0.1}$$

encountered in lecture 21. (i.e. Derive Eq. (0.1).)

3.: For the light deflection due to the sun discussed in the previous problem, what is the largest impact parameter for which the deflection can be measured if one can measure deflection angles $\delta\phi$ to an accuracy of 10^{-1} arcsec?

4.: Is the metric

$$ds^2 = -dt^2 + \frac{4}{9}[\frac{9M}{2(r-t)}]^{2/3}dr^2 + [\frac{9M}{2}(r-t)^2]^{2/3}d\Omega^2$$

static?

5.: Problem 3 on pg. 157 of Wald.

6.: Suppose a test particle is radially infalling towards the Schwarzschild radius ($r = 2M$). Suppose the particle is sending out a monochromatic electromagnetic signal out to $r = \infty$. The observer at infinity measures a redshift

$$\lambda_{particle} \sim \lambda_\infty e^{-t/k}$$

where k is a constant when the test particle is very close to crossing the horizon. (Here, $\lambda_{particle}$ means the wavelength of the emitted radiation from the particle's rest reference frame.) Express k in terms of the mass of the black hole.