

# Physics 130 General Relativity Seminar

## Assignment 12 April 15, 2013

General topic: **The Einstein Equation**

### Part 1: Readings

**Hartle:** Chap 16 Gravitational Waves

**Hartle:** Chap 23- Sections 5-8 Gravitational Wave Emission

**Hartle:** Chap 23 Supplement - Derivation of Quadrupole Formula

### Part 2: Problems Hartle Problems

1. Hartle 16.03 Change in the distance
2. Hartle 16.04 Displacing light wave
3. Hartle 16.08 Properties of gravitational waves
4. Hartle 16.14 Binary star system
5. Hartle 23.06 No dipole radiation
6. Hartle 23.10 Gravitational waves from oscillating particles
7. Hartle 23.11 Gravitational waves from accelerating particle
8. Hartle 23.12 Binary neutron stars

### Boccio Extra Problems

#### 1. Gravitational Wave Stuff

- (a) Explain briefly why in Einsteins theory of general relativity it is impossible to have monopole or dipole gravitational radiation.
- (b) Suppose two compact stars, each of one solar mass, are in circular orbit around each other with a radius of one solar radius. What is the approximate rate of energy loss due to gravitational radiation from this system? What is the time scale for decay for this orbit? Take

$$\begin{aligned} \text{solar mass} &= 2 \times 10^{33} \text{ gm} \\ \text{solar radius} &= 7 \times 10^{10} \text{ cm} \end{aligned}$$

## 2. Waves from Colliding Battleships

In a desperate attempt to generate gravitational radiation artificially, we take two large battleships of 70,000 tons each, and we make them collide head-on at  $40 \text{ km/h}$ . Assume that during the collision the battleships decelerate at a constant rate and come to rest in  $2.0 \text{ sec}$ .

- (a) Estimate the gravitational energy radiated during the collision. Treat the battleships as point masses.
- (b) Could we detect these waves?