Chapter 2

Observations of Galactic Nuclei and Supermassive Black Holes

2.1 Structure of galaxies and galactic nuclei

2.2 Techniques for weighing black holes

2.3 Supermassive black holes in the Local Group

2.4 Phenomenology

2.5 Evidence for intermediate-mass black holes

2.6 Evidence for binary and multiple supermassive black holes

2.7 Gravitational waves

The amplitude, h, of a gravitational wave is a dimensionless quantity given by

$$h \approx \frac{G}{c^4}\frac{\ddot{Q}}{D} \approx \frac{GM_Q}{c^2 D}\frac{v^2}{c^2}, \qquad \text{(Merritt 2.55)}$$

where v is the internal velocity of the source, M_Q is the portion of the source's mass (in units of mass, not just 0–1) participating in the quadrupolar motions, and D is the distance to the source.

To understand the detector size needed to observe a gravitational wave, consider the ideal case, where the entire mass is participating in quadrupolar motions ($M_Q = M_{12}$), and the binary is located at a distance D from the observer and a from each other. Then we have $v^2 \approx GM_{12}/a$, and from (**??**) we have

$$\begin{aligned} h &\approx \frac{GM_{12}}{c^2 D}\frac{GM_{12}}{ac^2} \\ &\approx \frac{G^2}{c^4} M_{12}^2 a^{-1} D^{-1} \\ &\approx 2 \times 10^{-16} \left(\frac{M_{12}}{10^{-8} M_\odot}\right)^2 \left(\frac{a}{\mathrm{mpc}}\right)^{-1} \left(\frac{D}{100\mathrm{Mpc}}\right)^{-1} \end{aligned} \qquad \text{(Merritt 2.58)}$$