Lecture 10
Gravitational waves

Gravitational waves

- Brief history
- Sources of gravitational waves
- Detection: resonant mass antennas and laser interpherometers
- Detectors and results

Literature:

- J. Weber, *Evidence for discovery of gravitational radiation*, Phys. Rev. Lett. 22 (1969) 1320
- LIGO and Virgo collaborations, *Observation of Gravitational Waves from a Binary Black Hole Merger* PRL 116, 061102 (2016) & arXiv:1602.03837
- LIGO and Virgo collaborations, *GW170814: A Three-Detector Observation of Gravitational Waves from a Binary Black Hole Coalescence*, Phys. Rev. Lett. 119, 141101 (2017)

Material for the lecture:

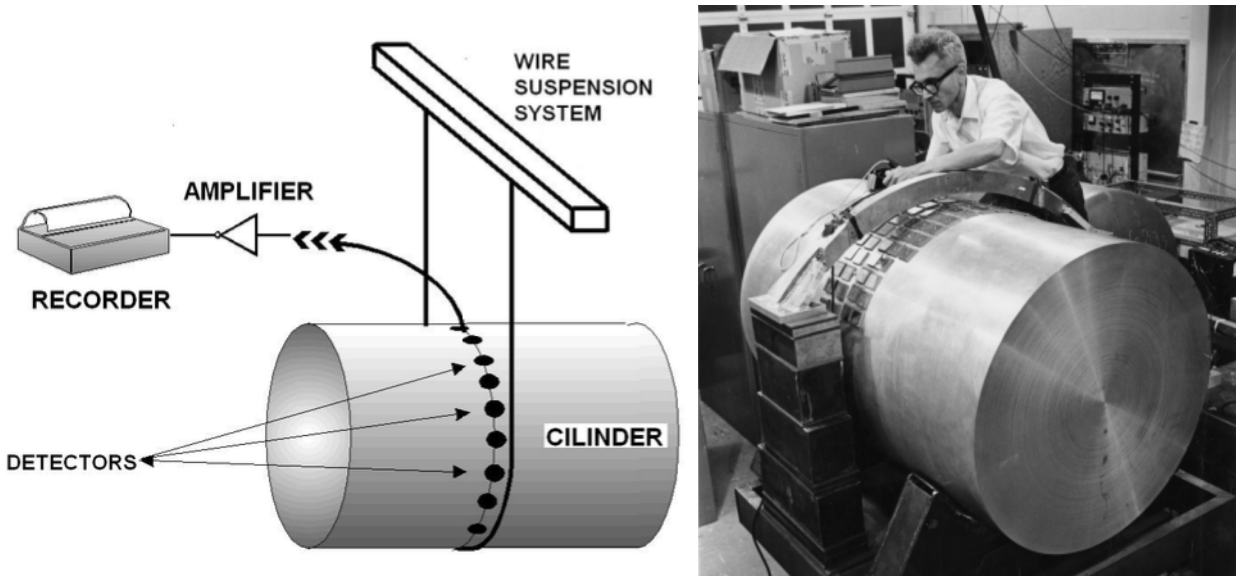

Figure 1: Sketch of Weber's cylinder detector and photo of Joseph Weber working at the antenna. Figures from Cervantes-Cota et al., Universe 2016, 2, 22 and arXiv:1609.09400

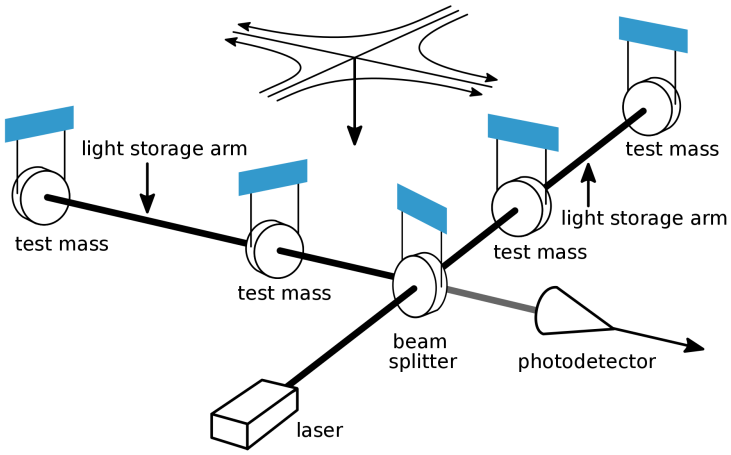

Figure 2: Schematics of an interferometer to measure gravitational waves. Figure from wikipedia.

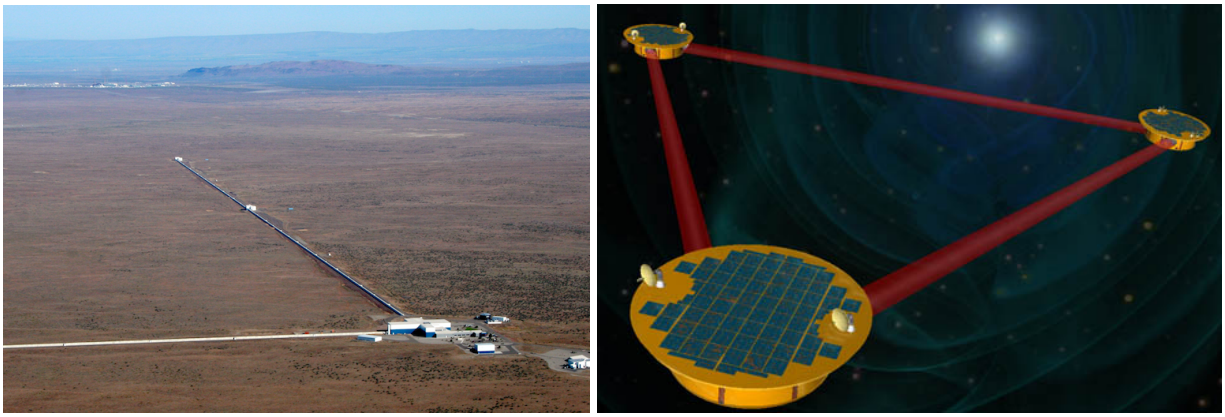

Figure 3: Left: aerial view of the LIGO Hanford Observatory. Figure from the LIGO homepage. Right: artistic design of the future LISA spacecrafts which will fly in a triangular formation to detect gravitational waves. Figure from NASA.

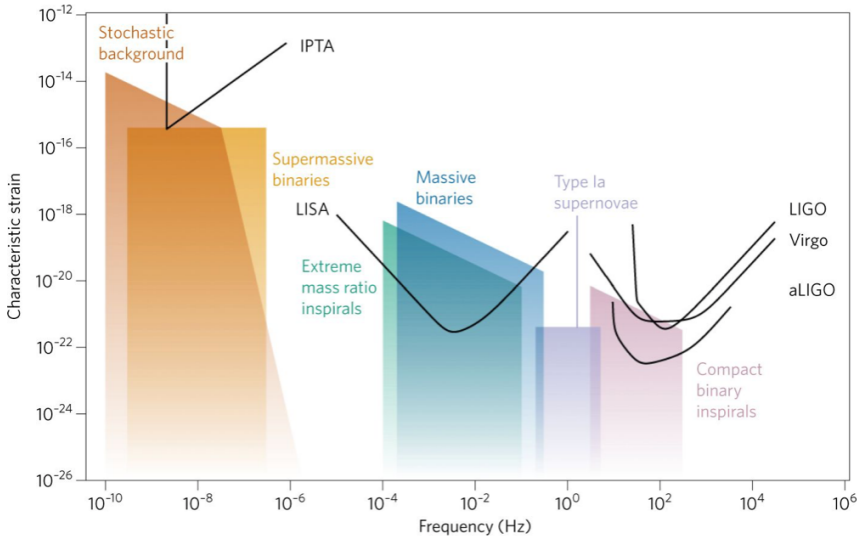

Figure 4: Sensitivity of gravitational wave experiments (in black) to different sources of gravitational waves (coloured blocks). Figure from Lommen, Nature Astron. 1 (2017) 809.

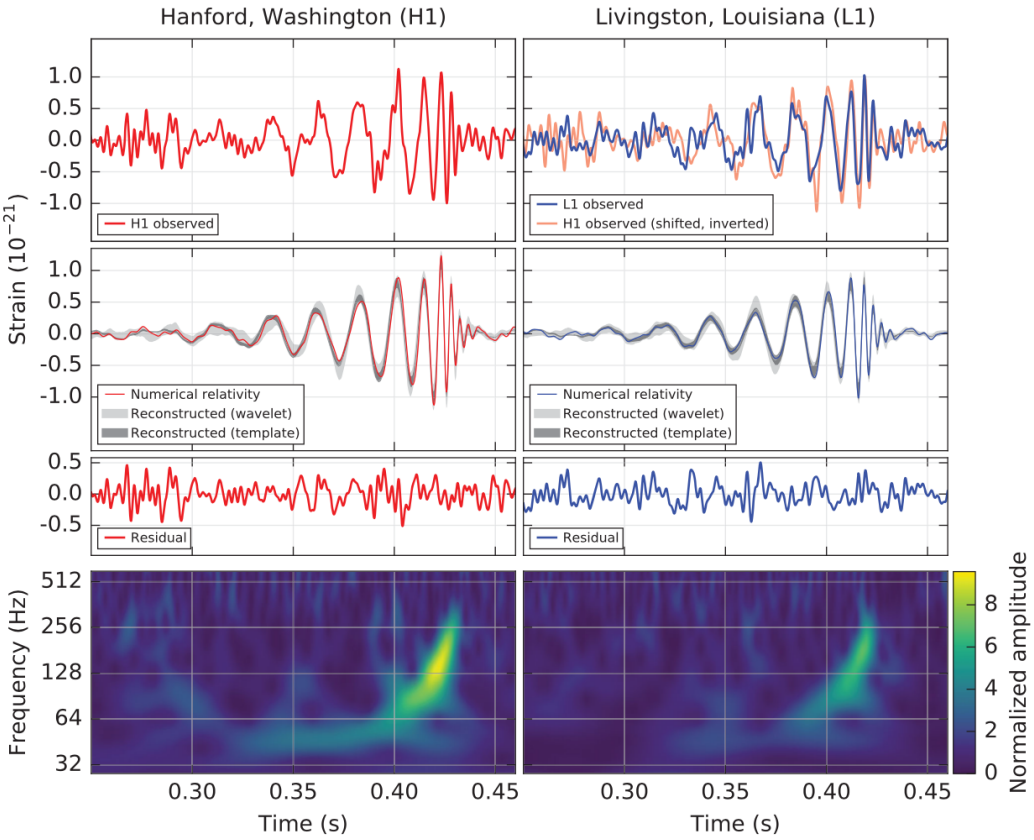

Figure 5: The gravitational-wave event GW150914 observed by the LIGO Hanford (H1, left column panels) and Livingston (L1, right column panels) detectors. Figure from the LIGO and Virgo collaborations, PRL 116, 061102 (2016).

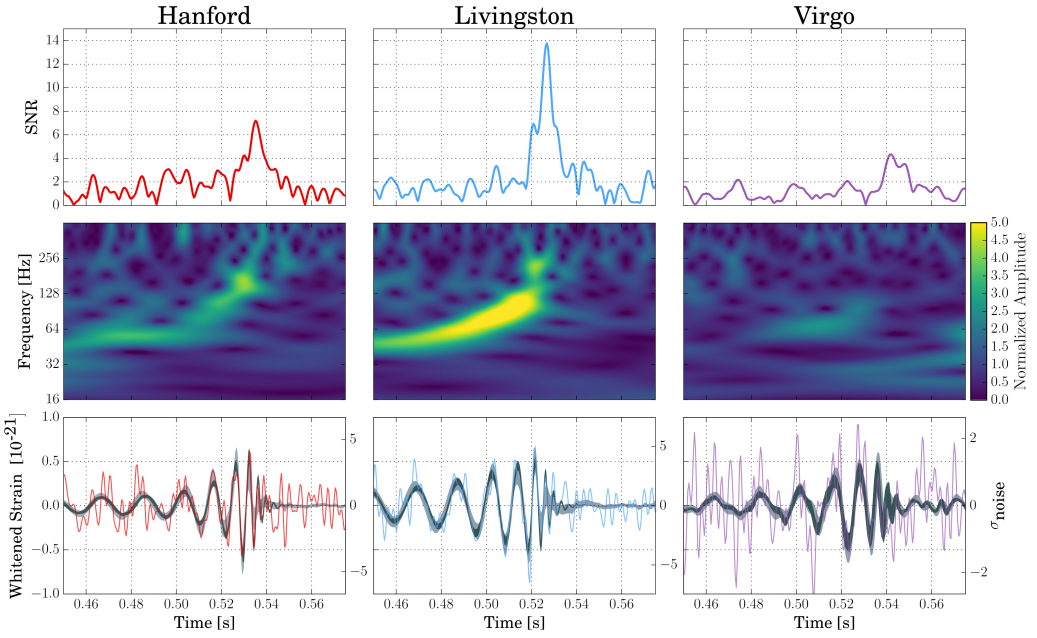

Figure 6: The gravitational-wave event GW170814 observed by the LIGO Hanford, LIGO Livingston and Virgo detectors. Figure from the LIGO and Virgo collaborations, Phys. Rev. Lett. 119, 141101 (2017).

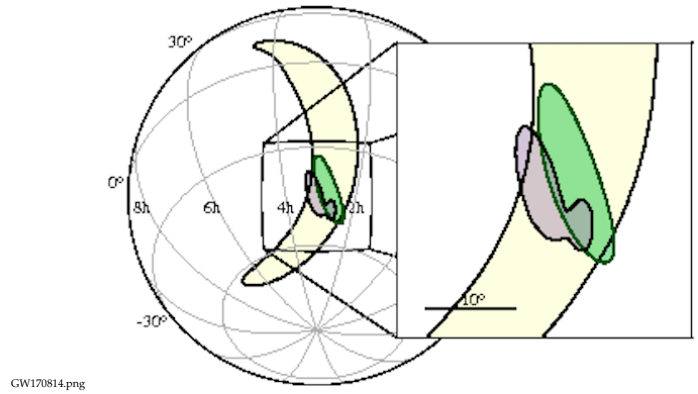

Figure 7: Localization of event coordinates using data from the two LIGO sites (yellow) with the inclusion of data from Virgo (green). The full Bayesian localization is shown in purple (contours are the 90% credible regions). The left panel is an orthographic projection and the inset in the center is a gnomonic projection; both are in equatorial coordinates. Figure from the LIGO and Virgo collaborations, Phys. Rev. Lett. 119, 141101 (2017).

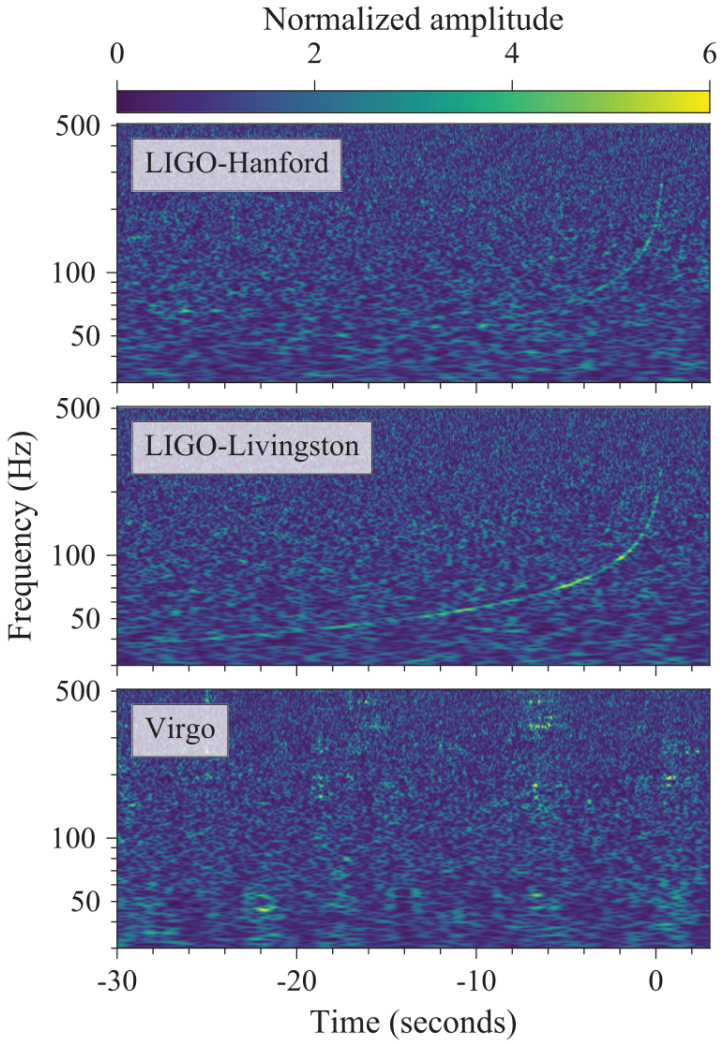

Figure 8: Time-frequency representation of data containing the gravitational wave event GW170817. Figure from the LIGO and Virgo collaborations, Phys. Rev. Lett. 119, 161101 (2017)