

Key points from Lecture 22 of ASTR 350

1. Gravitational waves are ripples in spacetime produced by the accelerated motion of matter and energy.
2. Gravitational waves have no analog in Newtonian gravity.
3. At Earth they are weak even in the best circumstances. When they pass by, distances between objects change by minute amounts. Those minute changes are only detectable when large masses move fast, e.g., black holes and neutron stars orbiting each other.
4. However, gravitational waves carry tremendous amounts of energy, in ways we couldn't see before. For example, when two black holes of comparable mass merge with each other, during that brief time of merger the luminosity in gravitational waves is tens of times larger than the combined luminosity of every star in the visible universe! But this energy is invisible in other forms, so gravitational waves carry unique information.
5. Even before the direct detection of gravitational waves, we knew that they existed, and that at high precision they followed Einstein's equations, because binary pulsar systems (in which two neutron stars orbit each other and at least one appears as a pulsar to us) were seen to spiral together slowly, at the predicted rate to within 0.1%.
6. Binary pulsars thus show that gravitational waves exist, and they also helped constrain various types of deviations from general relativity.