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motivation

By studying black hole mergers via gravitational waves, we can figure out the distance from Earth. Comparing this to the redshift of the light from these events allows us to better understand the universe's expansion.

methods

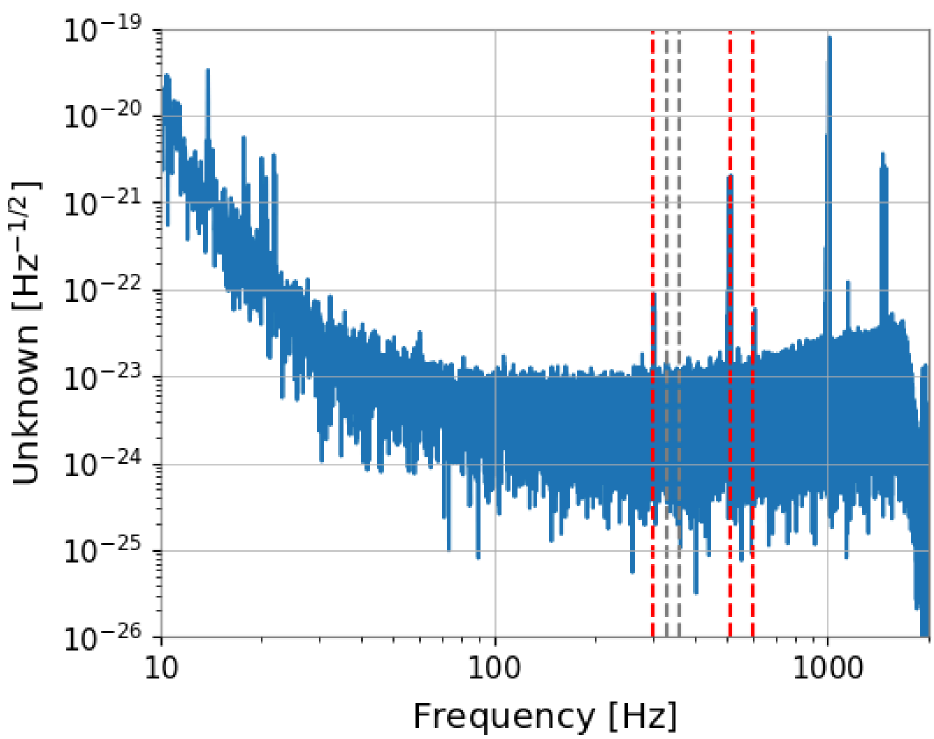
assumptions + calculations

M = $\frac{T * c^3}{16\pi G}$ $\quad R_{sch} = \frac{2GM}{c^2} \quad D = \frac{R_{sch}}{strain}$

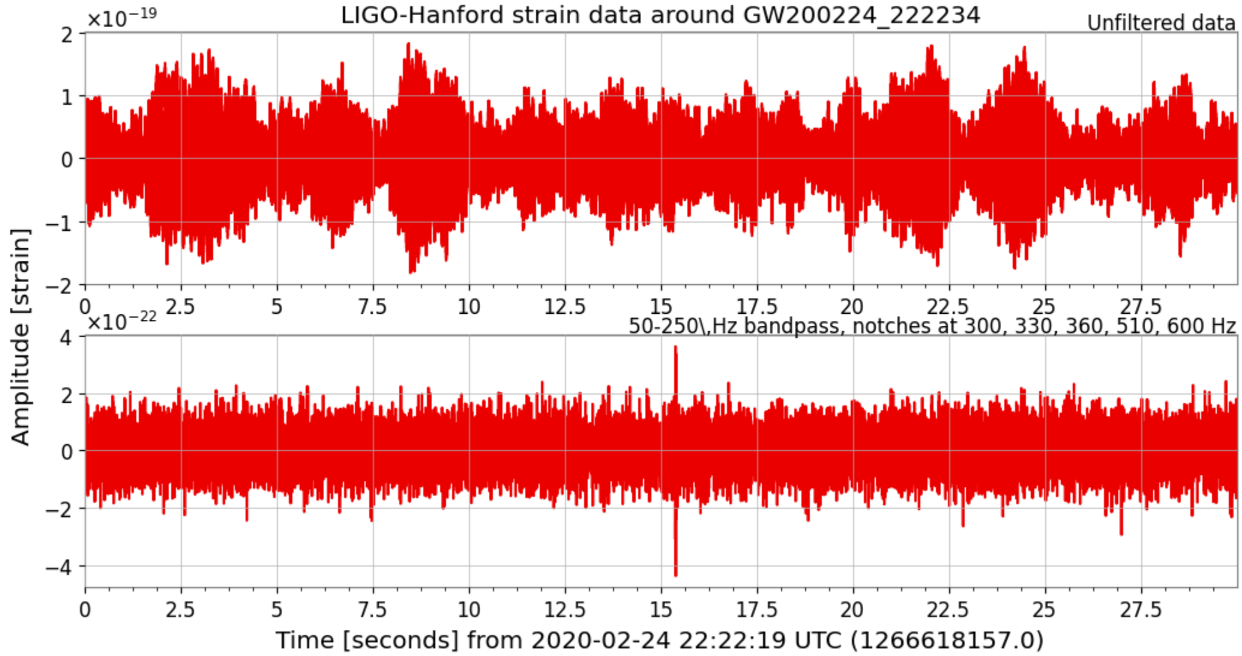
By using gravitational wave data collected from LIGO we should be able to calculate the masses of the two black holes that merged in order to cause the wave. Using data from the two different locations, we assume the Earth is round in order to account for their distance difference in order to line up the data.

results

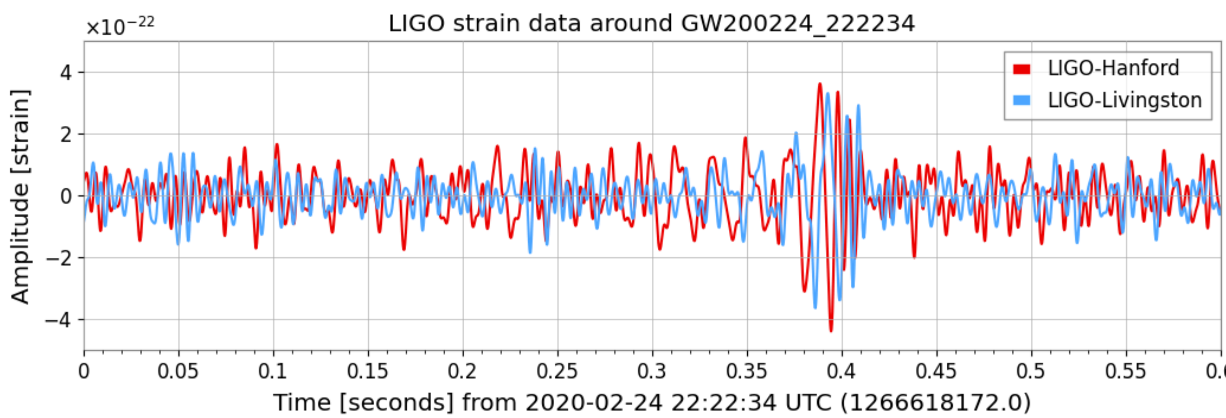
By applying a fast fourier transform on the data we get this graph which represents which frequencies are dominant in the wave.



We can also process the data to reduce noise, which gives us a better picture of the gravitational wave. Here is the before and after.



After that, we can use the data from Livingston as well as Hanford, and after shifting the data to account for a round Earth's location differences, we can overlay them to see the differences and similarities. Measuring strain is like measuring the tiny bit of change in distance that the gravitational wave causes. LIGO measures this by splitting a laser in half that bounce between mirrors in each arm of the observatory. The gravitational wave changes the distance between these two mirrors, which is how the wave is measured.



Using our assumptions and code, as well as T = 1/f, we find that the mass of the two black holes are 7 solar Masses, which might be too small as for some reason my strain seems to be an order of magnitude smaller than usual, but with a distance of 1588 Mpc from Earth and released energy of 1.3 * 10^47 J the rest of it seems to line up relatively well.

conclusions

Black holes are big. Gravitational waves tell us a lot about the universe, such as how far things can be. Measuring the distance of objects in the universe, combined with redshift data, could also help us get a handle on the age of the universe.

AI acknowledgement

I used AI to generate the code for the peak frequency, and max strain.