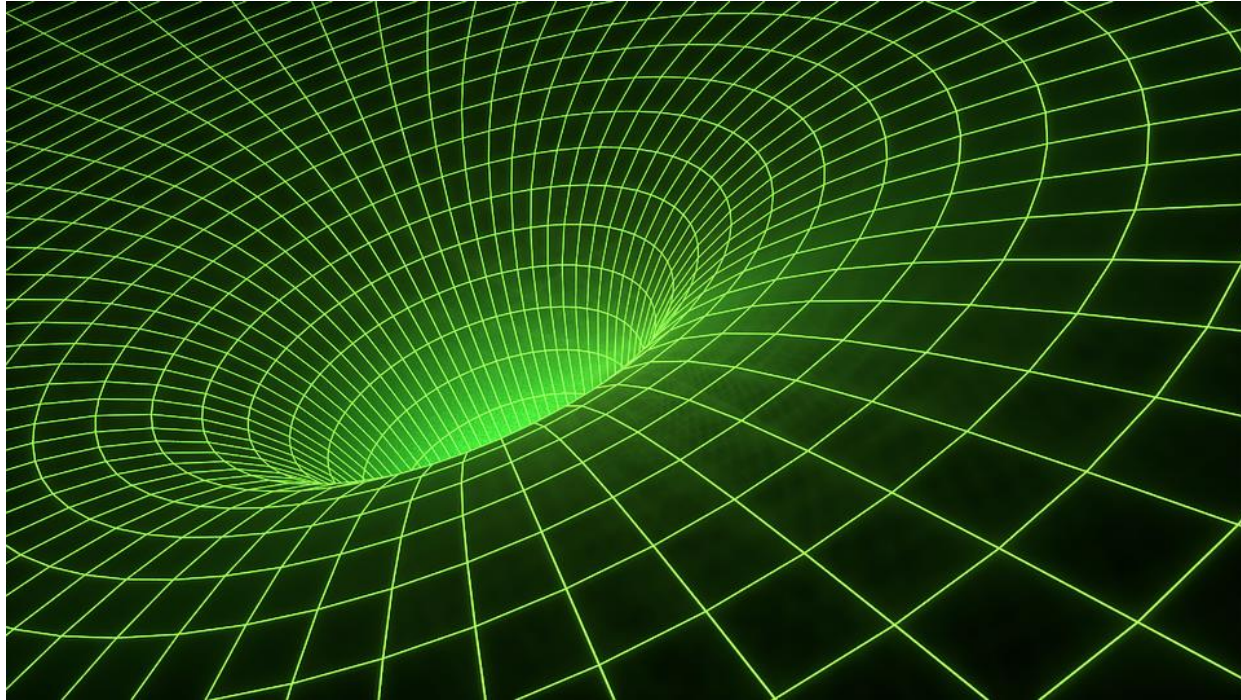
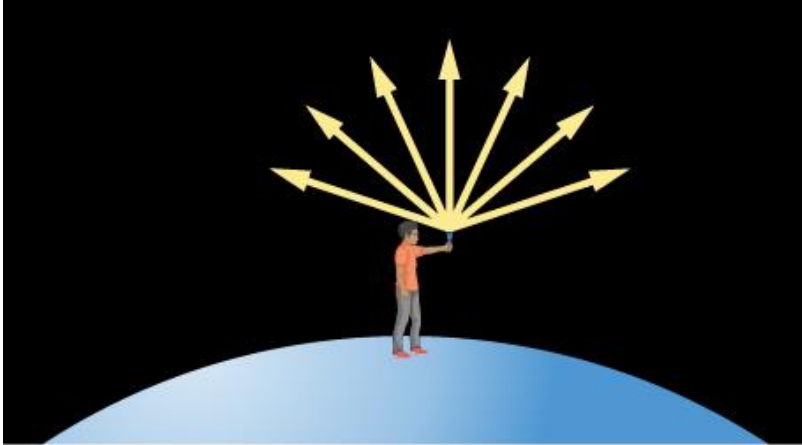


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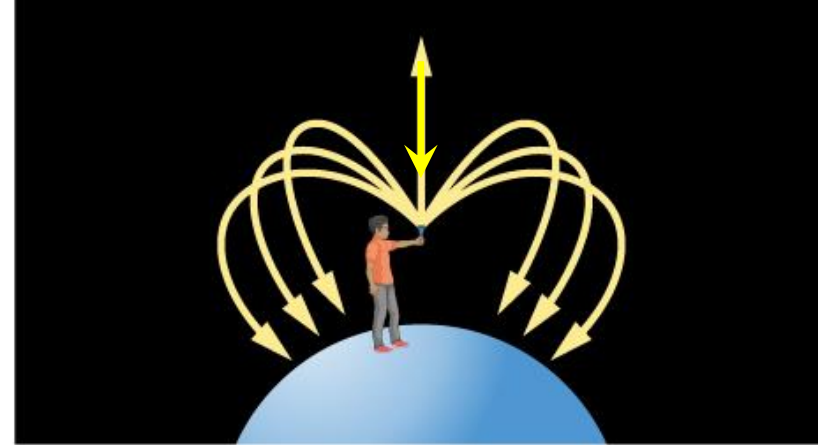


BLACK HOLES

GENERAL RELATIVITY 101: BLACK HOLES



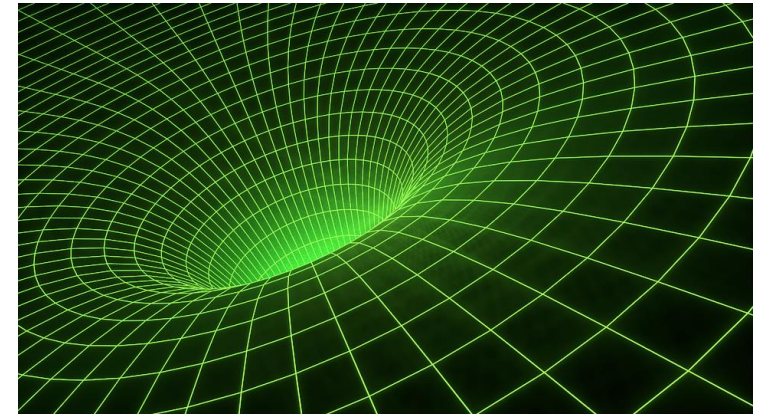
Low mass \rightarrow not enough gravity



High mass or compact \rightarrow strong gravity
 \rightarrow Light can't escape \rightarrow **Black Hole**

Newton's gravity: requires photons to have mass
But: **photons have zero mass**

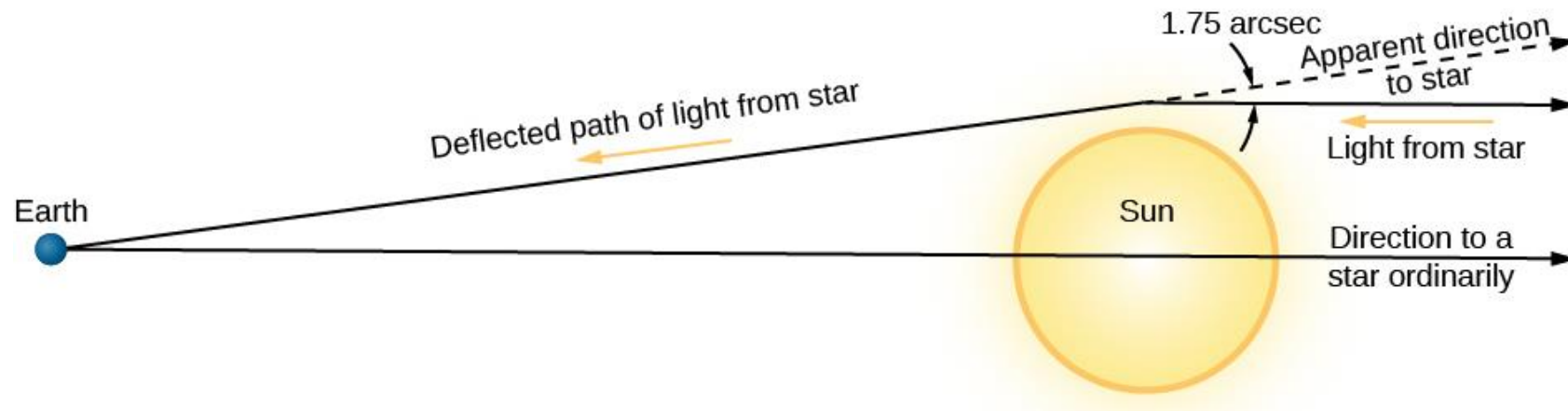
Einstein Theory of General Relativity: Gravity is not a force, but **a distortion of space-time**



GENERAL RELATIVITY 101: CURVED SPACE-TIME

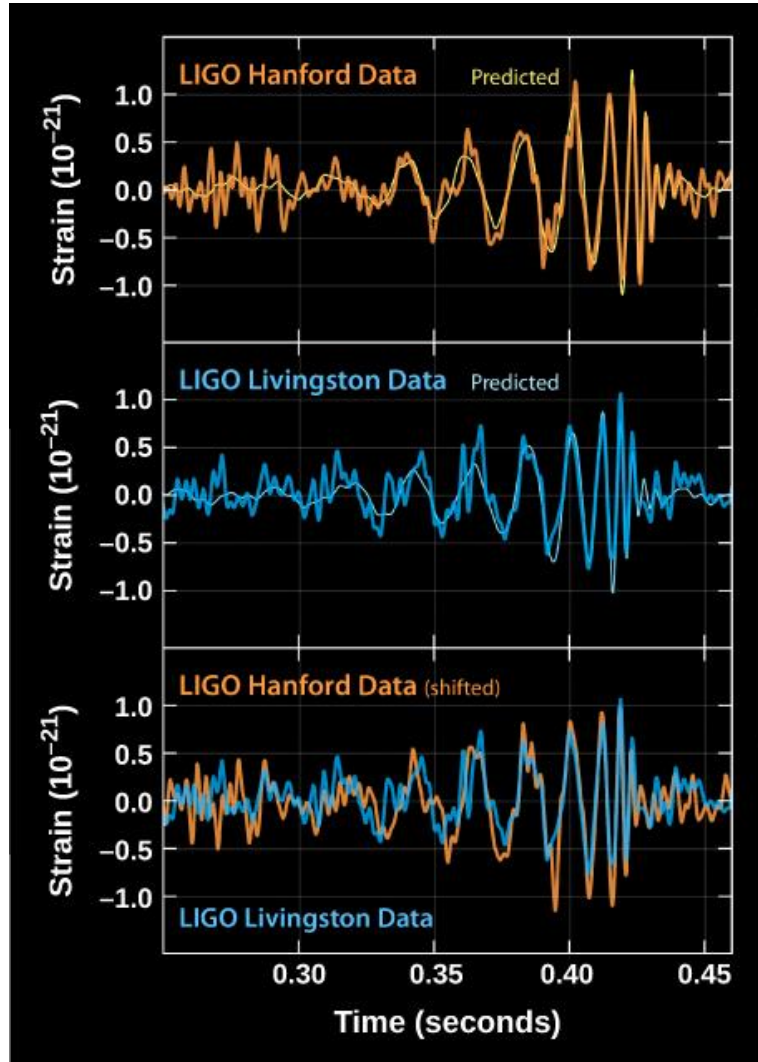
If Einstein's theory is right:

- Sun distorts space-time
- Light from stars behind the Sun bends towards Earth
- Stars behind the Sun should be visible during a solar eclipse



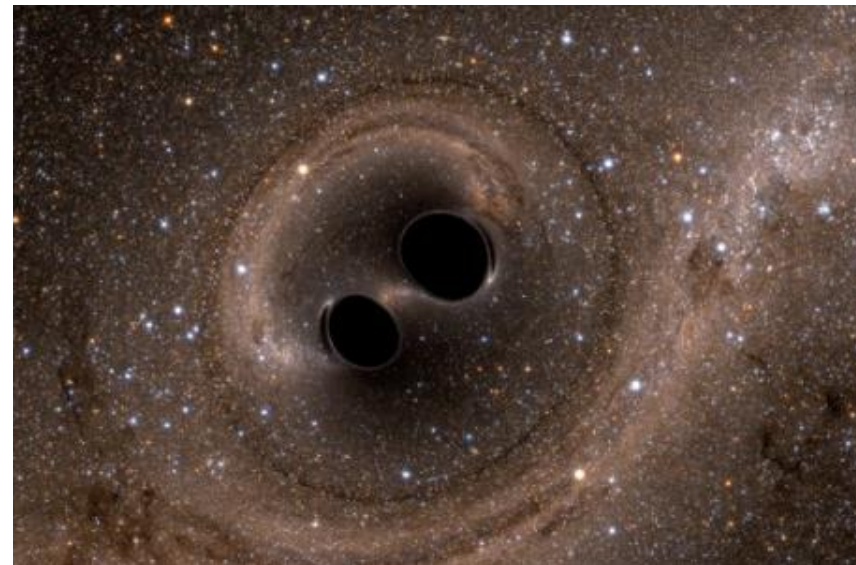
Confirmed in the solar eclipse of 1919 and ever since
→ Newton's theory of gravity is not 100% correct!

GENERAL RELATIVITY 101: GRAVITATIONAL WAVES

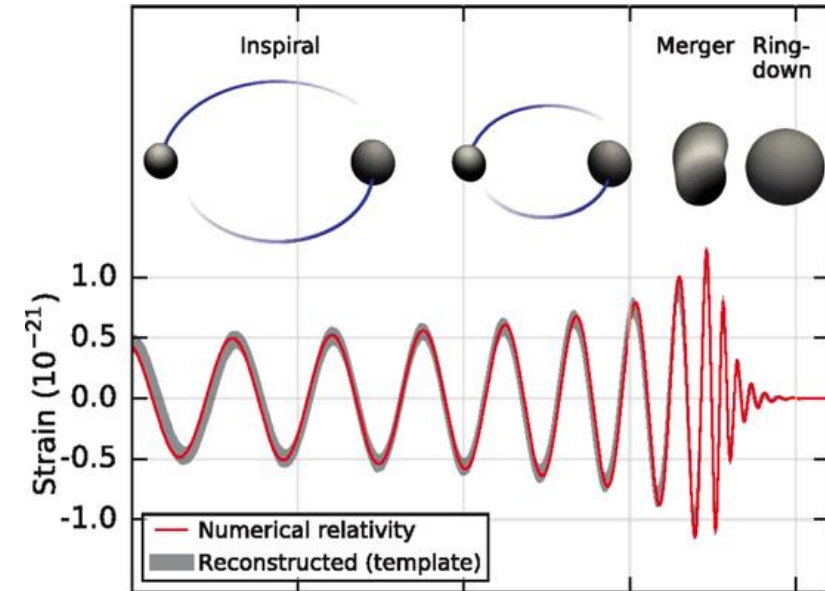


Space-time curvatures of two black holes interact to create gravitational waves:

- Wave? → energy is released
- Black holes spiral in
- Gravitational waves intensify
- Merge



DETECTING GRAVITATIONAL WAVES



[GW150914](#) by Abbott B. P., et al., [CC BY 3.0](#)

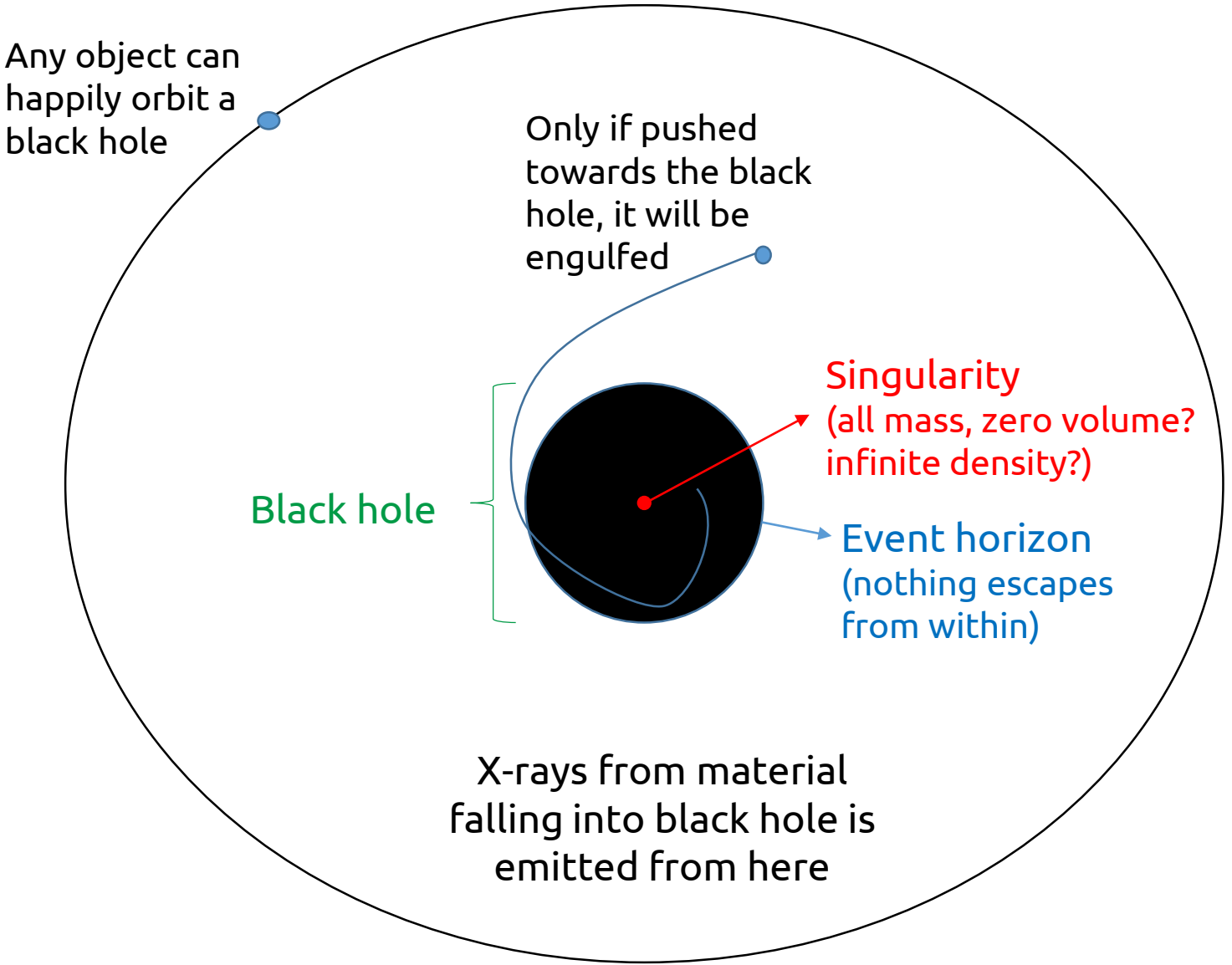
Gravitational wave telescope (LIGO in Livingston LA; a second one is in Hanford, WA)

Space-time around Earth stretches out and expands everything when a pulse arrives

Ways to study the distant universe:

- Light (electromagnetic waves)
- Neutrinos
- Gravitational waves

BLACK HOLES: SINGULARITY AND EVENT HORIZON



RANKING TASK

Star Evolution (Ex. 3)

