Gravitational wave echoes in multimetric gravity

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Centre of Excellence "The Dark Side of the Universe"

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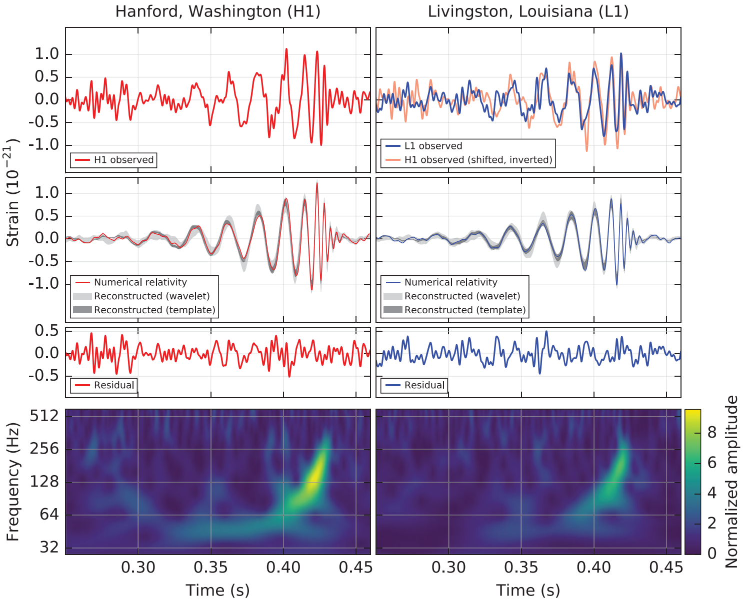
First observation of gravitational waves



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- Black hole merger:
  - Before merger: $36M_\odot$ and $29M_\odot$ black holes.
  - After merger: $62M_\odot$ black hole.
  - $\Rightarrow$ $3M_\odot$ radiated into gravitational waves.

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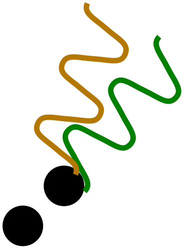
  - After merger: $62M_\odot$ black hole.
  - ⇒ $3M_\odot$ radiated into gravitational waves.

⇒ Distance reconstructed from observed amplitude: 410Mpc.

⇒ Signal travel time to Earth: 1.3Ga.

Idea of wave echoes

- Binary black hole emits different wave components.



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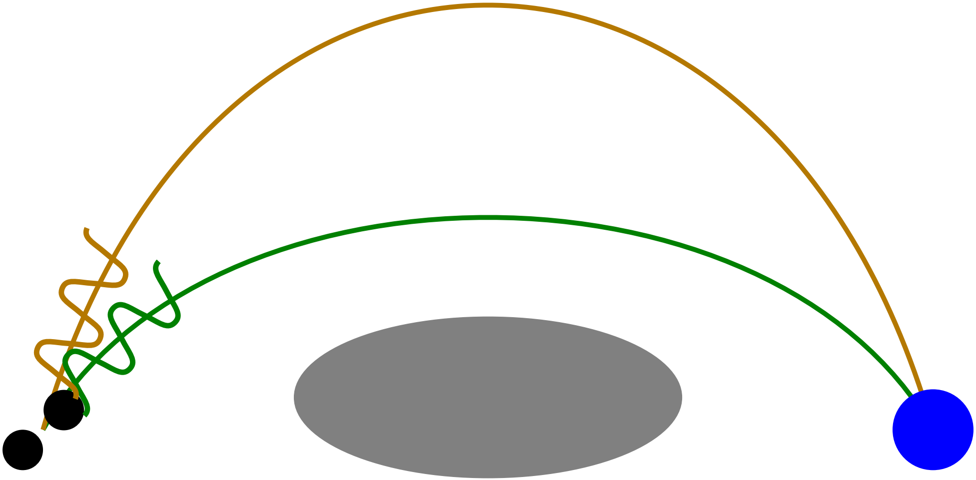

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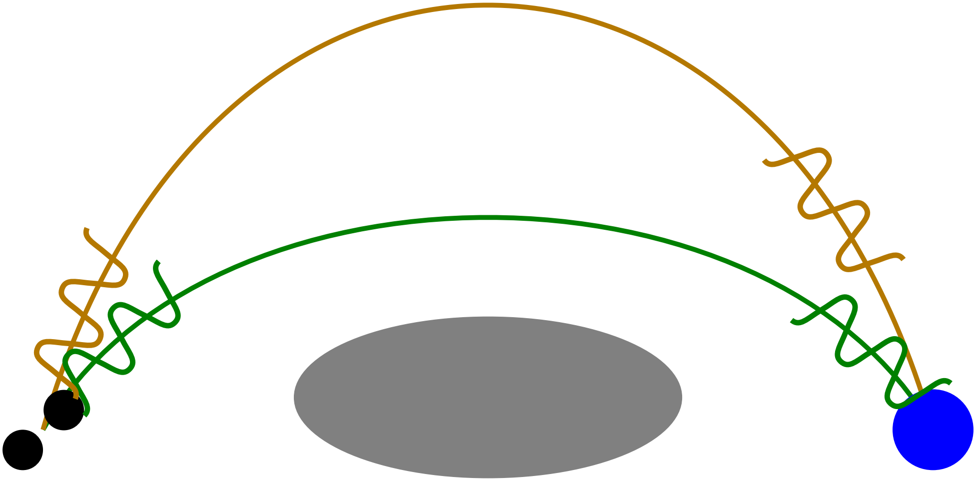

Simple bimetric model

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$\Rightarrow$ Both types of matter appear mutually dark.

$\Rightarrow$ Both metrics may carry gravitational waves.

$\Rightarrow$ Trajectories of gravitational waves depend on background metrics.

Weak field limit

- Metric $g^I_{\mu\nu}$ near point mass M of type J:

$$
\begin{aligned}
g^I_{00} &= -1 + 2G^{IJ}\frac{M}{r} + \mathcal{O}\left(\frac{M^2}{r^2}\right)\,,\\
g^I_{0i} &= 0\,,\\
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- Constants determined by the action:
  - Effective gravitational constants G^{IJ}.
  - Spatial curvature parameters γ^{IJ}.
- Different spacetime geometries seen by different sectors.

Wave propagation and Shapiro delay

- Assume massless gravitons (lightlike trajectories).

⇒ Shapiro delay from single deflecting point mass:

$$\delta t = G(1+\gamma)\,M \ln\left(\frac{(|\vec{x}_s| - \vec{x}_s\cdot\vec{n})(|\vec{x}_d| + \vec{x}_d\cdot\vec{n})}{d^2}\right)\,.$$

  - Effective gravitational constant G.
  - Spatial curvature parameter γ.
  - Source location $\vec{x}_s$.
  - Detector location $\vec{x}_d$.
  - Unit vector $\vec{n}$ from source to detector.
  - Shortest distance d between wave and deflecting mass.

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- Different parameters G and γ in different sectors.
- Different matter distributions in different sectors.

⇒ Waves will undergo different Shapiro delays.

Conclusion

- Gravitational wave echo:
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  - Realization possible via multimetric model.

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And I've seen so far into the night
And lingered in the land of no light.

(Uriah Heep, 1991)