Characterization of the stochastic signal originating from compact binary populations as measured by LISA

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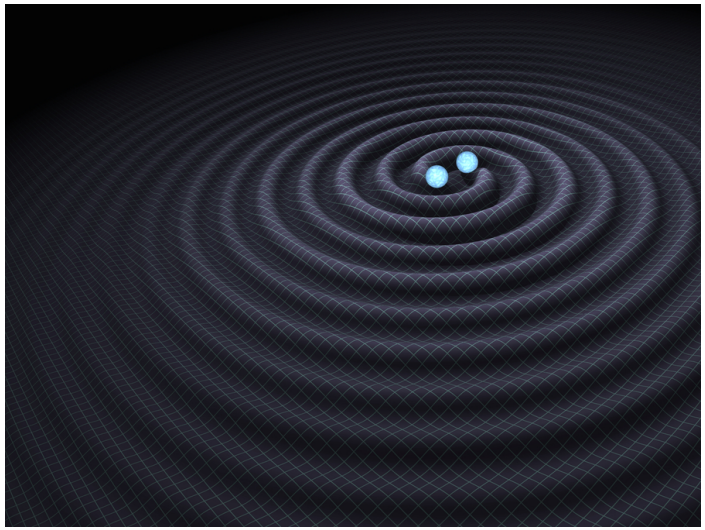
Gravitational waves

Ripples in space-time caused by accelerated masses.

Einstein field equations

$$G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$



Credit: R. Hurt (Caltech-IPAC)

$$g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu} \qquad |h| << 1$$

$$\bar{h}_{\mu\nu} = h_{\mu\nu} - \frac{1}{2}\eta_{\mu\nu} h$$

Gravitational waves

Lorenz gauge: $\partial_\mu \bar{h}^{\nu\mu} = 0$

$$16 \xrightarrow{symetry} 10 \xrightarrow[gauge]{Lorenz} 6 \xrightarrow[gauge]{TT} 2$$

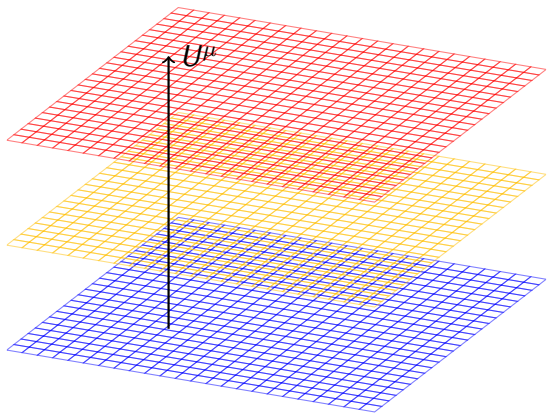
Wave equation

$$\Box \bar{h}_{\mu\nu} = 0$$

$$h_{\mu\nu} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & h_+ & h_\times & 0 \\ 0 & h_\times & -h_+ & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

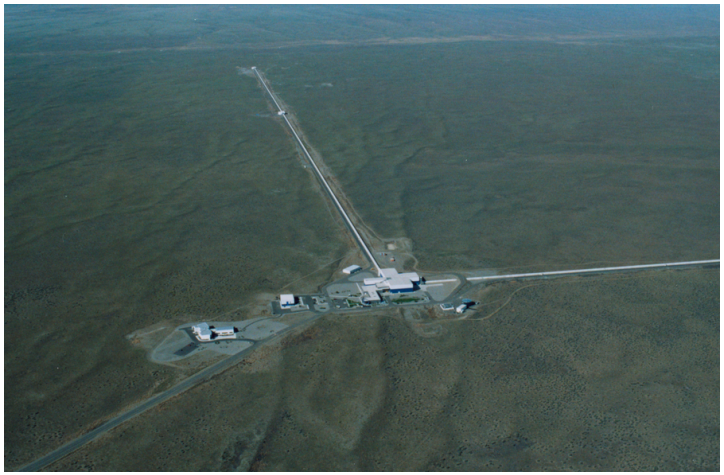
$$\bar{h}_{\mu\nu} = A_{\mu\nu} \exp\left(ik_\alpha x^\alpha\right)$$

Transverse traceless gauge:
$\bar{h}_{\mu\nu} U^\mu = 0$ and $\bar{h}_\mu{}^\mu = 0$

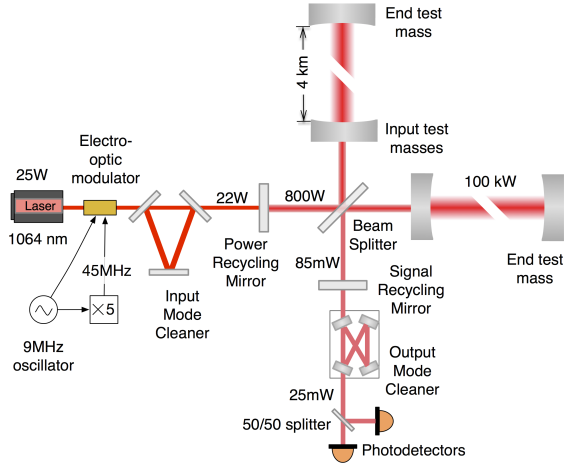


LIGO Structure

Giant Michelson interferometer



Credit: Caltech/MIT/LIGO Lab

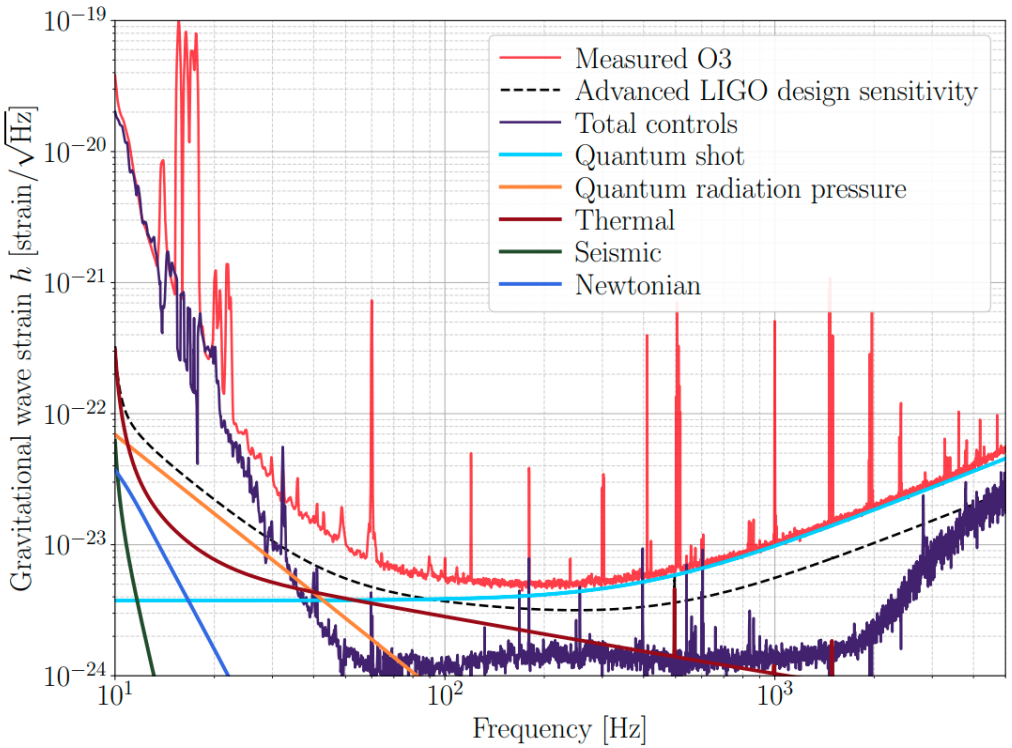


Credit: D. V. Martynov et all, 2018

$$S(t) = h(t) + n(t)$$

LIGO Noise budget

Hanford detector



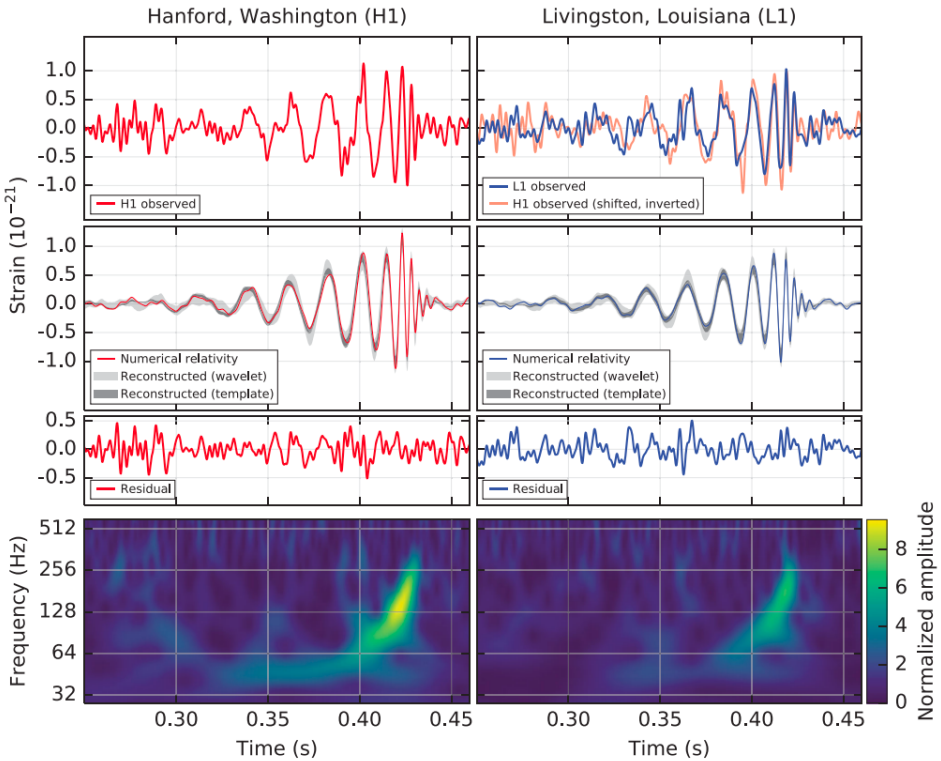
Credit: Craig Cahillane et all, 2022

Dominant noise:

- Quantum shot in high frequency
- seismic noise in low frequency

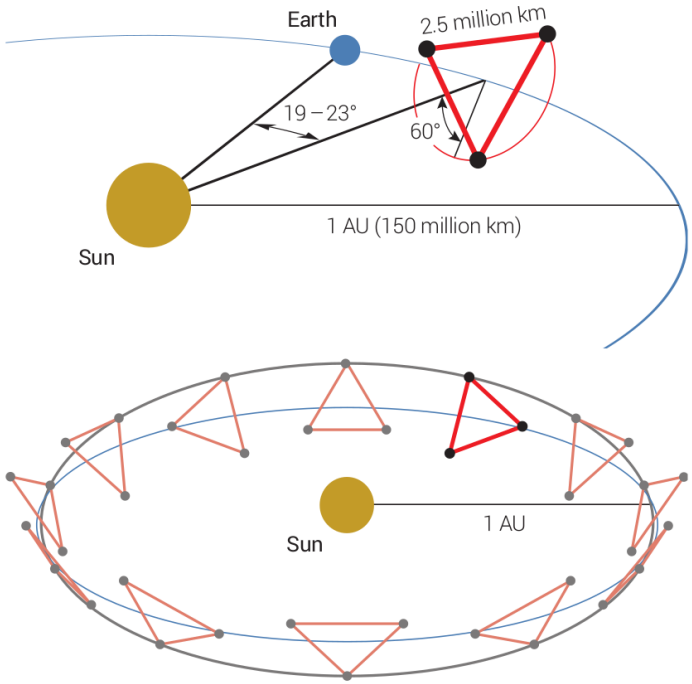
First detection

GW150914

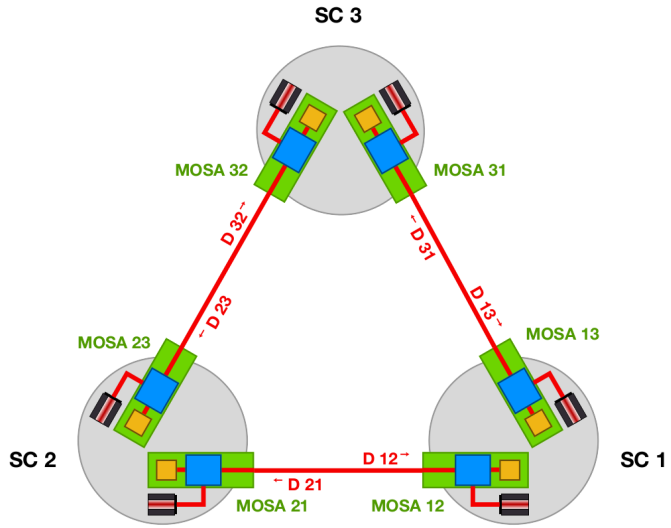


Credit: B. P. Abbott et al., 2016

Laiser Interferometer Space Antenna

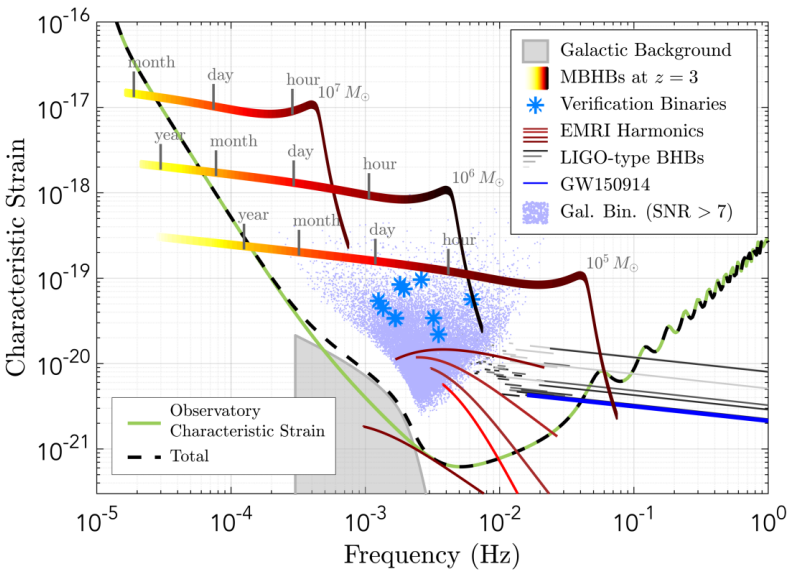


Credit: Karsten Danzmann et al., 2017



Credit: Jean-Baptiste Bayle et al., 2021

LISA Band



Credit: Karsten Danzmann et al., 2017

GW sources in LISA band

- Supermassive black hole binaries (SMBHBs)
- Stellar-mass black hole binaries (SBBHs)
- Ultracompact galactic binaries (CGBs)
- extreme mass ratio inspiral (EMRIs)
- stochastic GW background

Gravitational waves

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Our Group

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Reference

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Thank you!