Gravitational Waves @ KICC

Fundamental Physics and Astrophysics with Gravitational Waves

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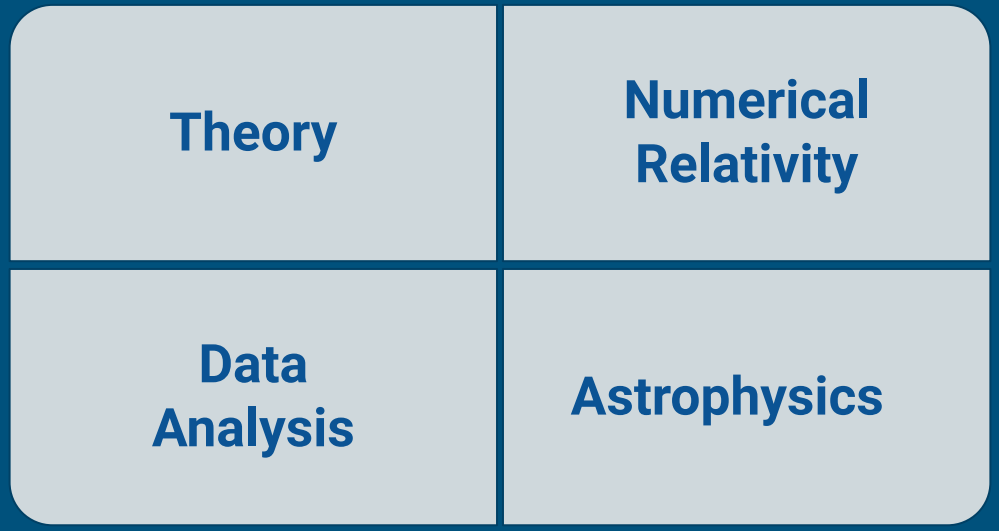
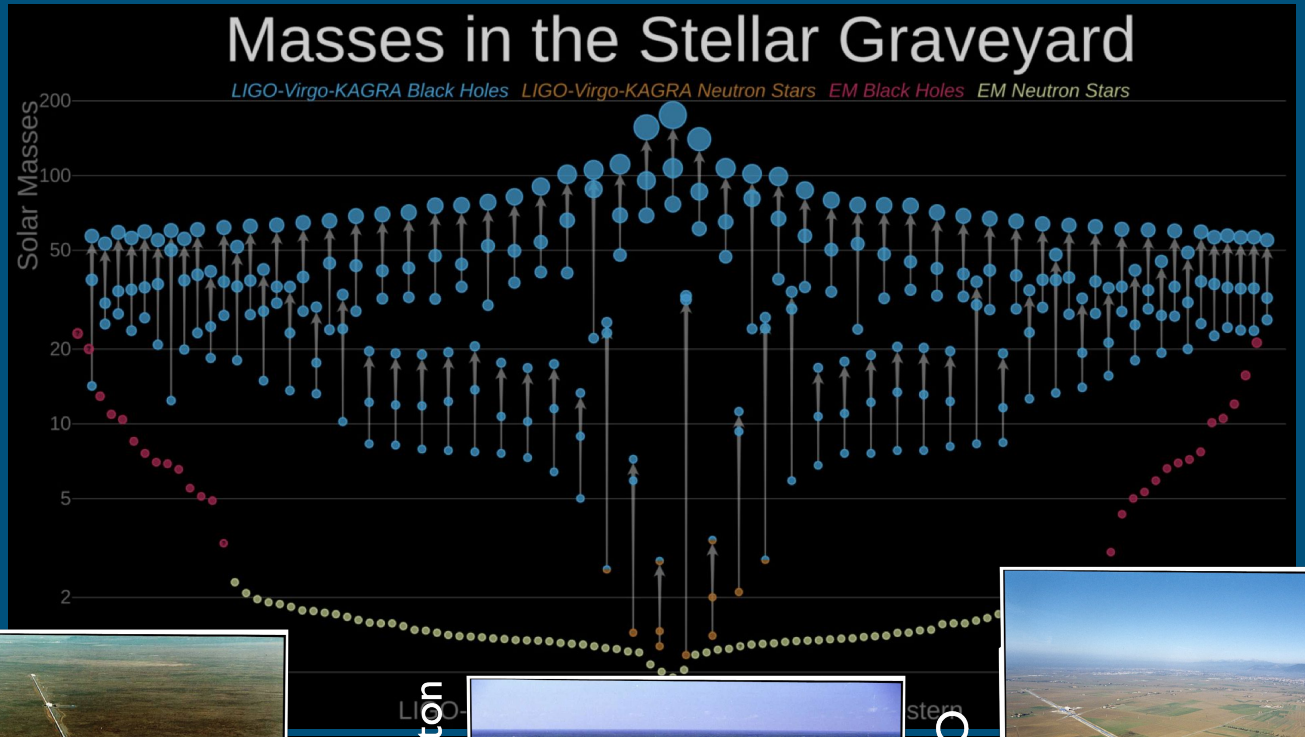
LIGO VIRGO KAGRA

GRCHOMBO

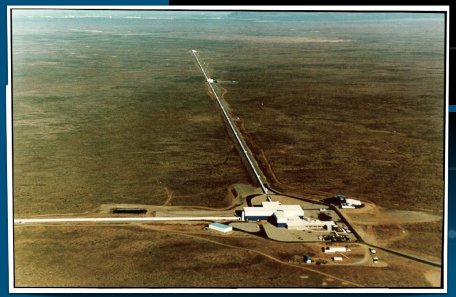
ET EINSTEIN TELESCOPE

GW Science @ KICC





LIGO Hanford

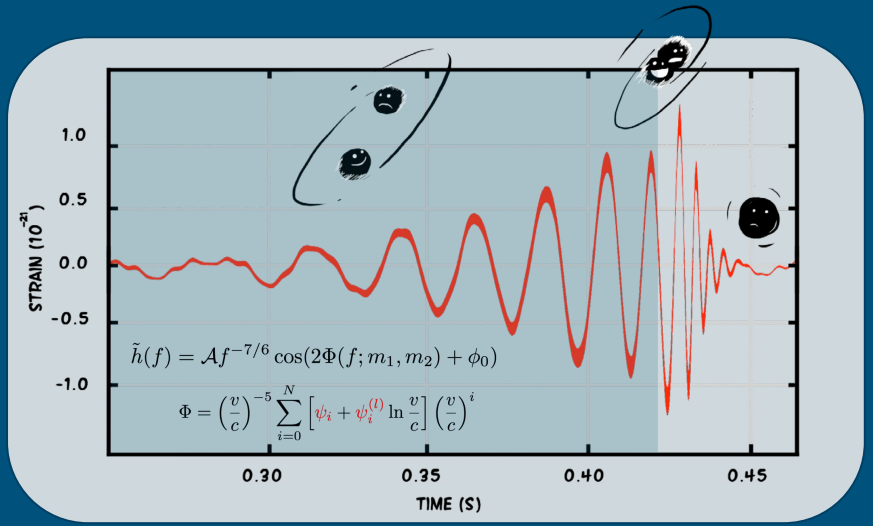


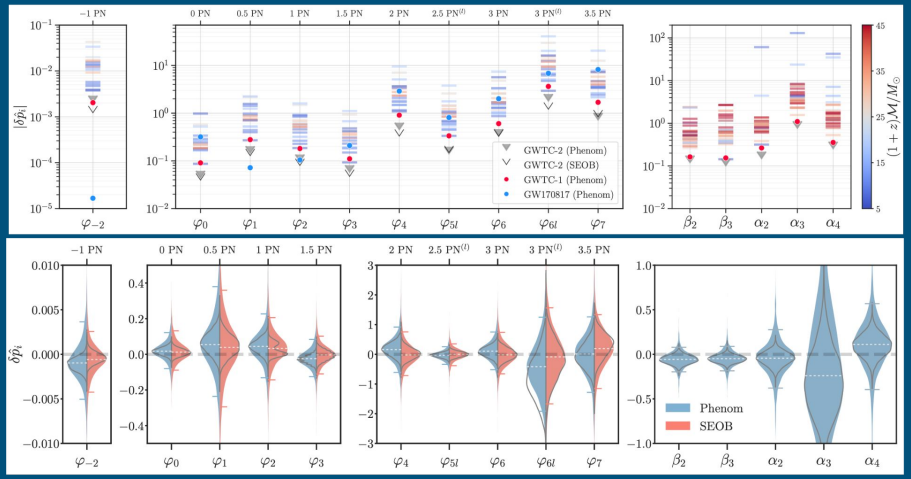
LIGO Livingston

VIRGO

Tests of GR @ LIGO-Virgo-KAGRA

- Look for **violations of GR** or signs of **modified gravity** in GW data
- Bayesian data analysis





	m_g $[10^{-23}$ eV$/c^2]$
GWTC-1	4.70
GWTC-2	1.76

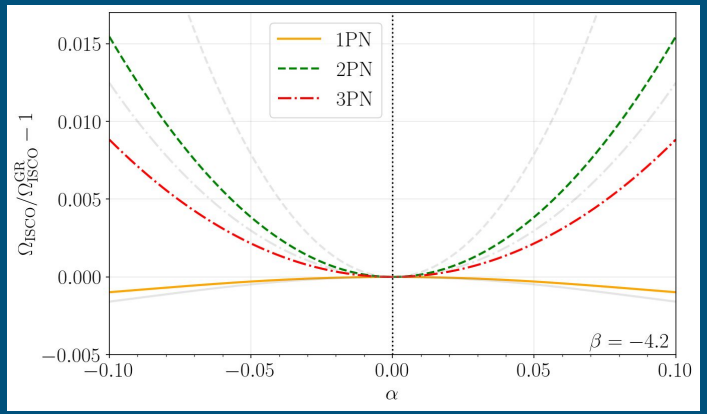
$$-3 \times 10^{-15} \leq \frac{\Delta v}{v_{\mathrm{EM}}} \leq +7 \times 10^{-16}$$

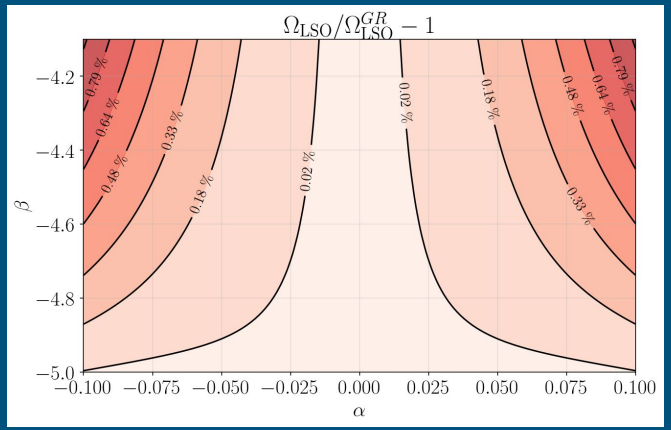
Compact Binaries in Scalar-Tensor gravity

$$S = \frac{c^4}{16\pi G_*}\int d^4x\sqrt{-g}(R - 2g^{\mu\nu}\partial_\mu\varphi\partial_\nu\varphi) + S_m[\Psi, \mathcal{A}(\varphi)^2 g_{\mu\nu}]$$

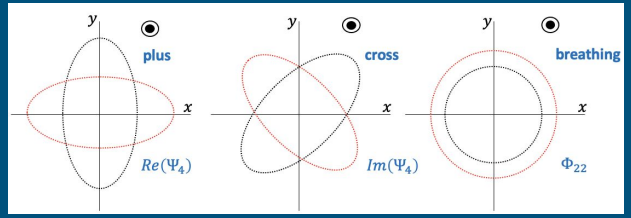
- Dynamics of compact binaries in **scalar-tensor** theory
- Waveforms need to be modelled to very high accuracy
- Hamiltonian @ **3pN** order

[Jain+, arXiv:2211.15580]



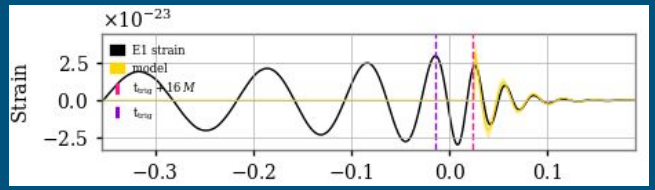


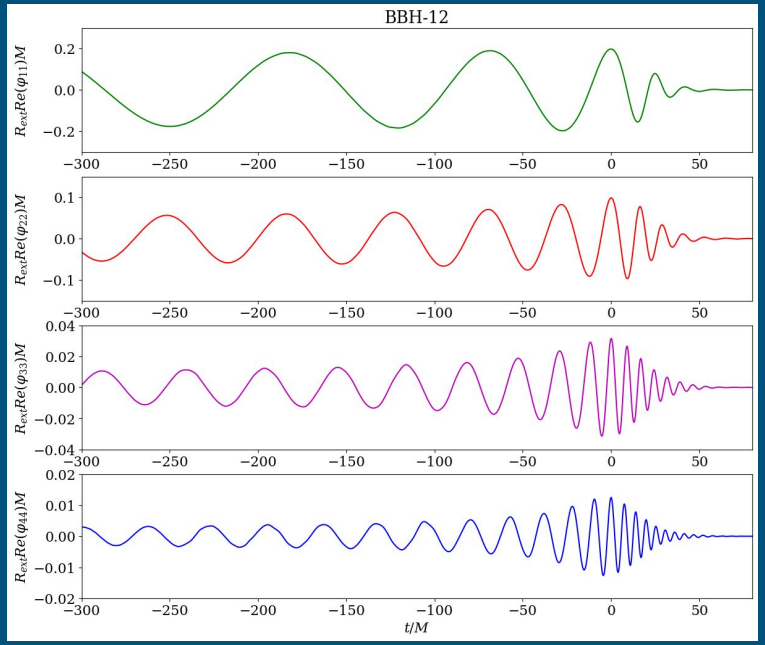
Scalar Ringdown in EsGB



- **Einstein-scalar-Gauss-Bonnet** is a promising alternative to GR
- **NR simulations** in EsGB (GRChombo)
- Remnant BH will <u>also</u> “ring” in **scalar QNMs**
- Signal will be weak, but potentially measurable with **next-gen detectors!**

[Evstafyeva+, in prep. 2022]

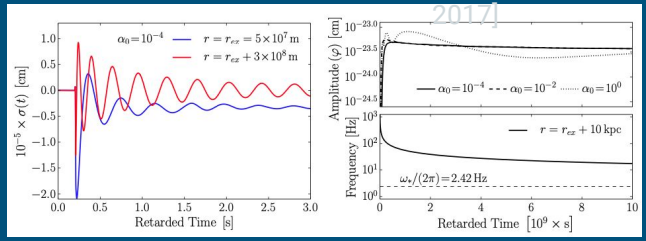




Core-Collapse in Massive Scalar-Tensor

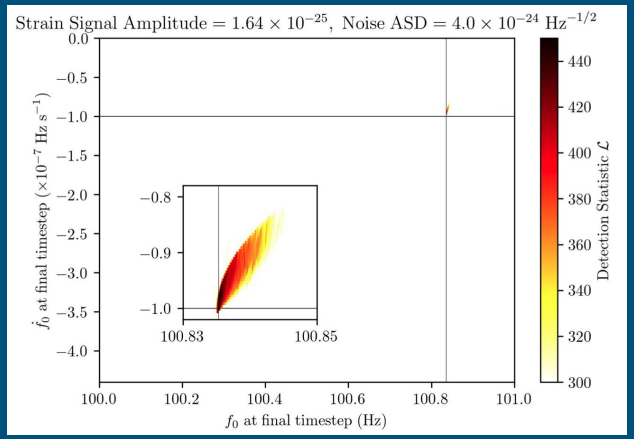
- Spherically symmetric **scalar GW** radiation
- Mass -> dispersion -> **inverse-chirp** signal
- Long-lived, quasi-monochromatic

[Sperhake+, 2017]



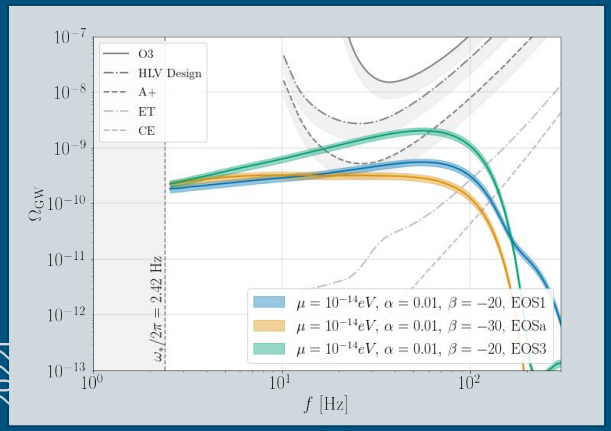
Continuous Waves

[Kwok+, in prep. 2022]



Stochastic Background

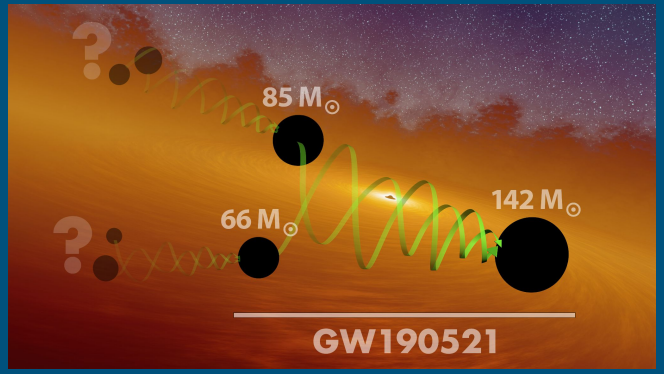
[Rosca-Mead, MA+ in prep. 2022]

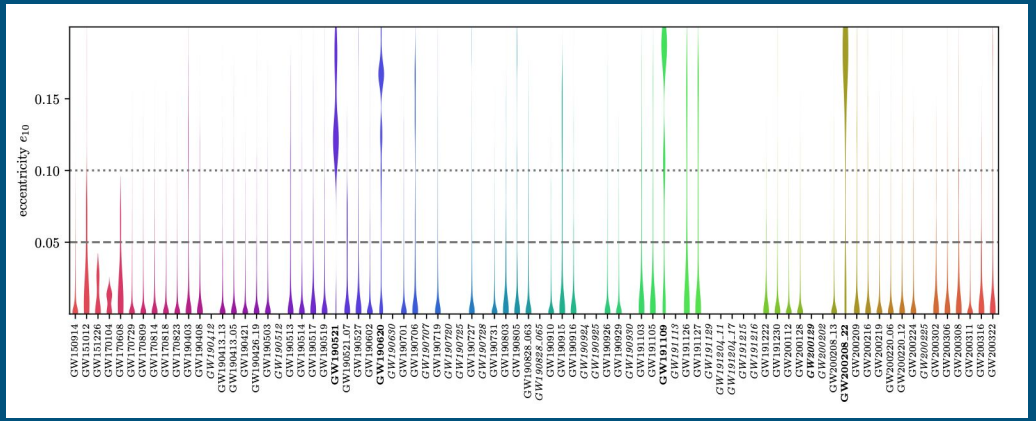


Eccentricity in compact binaries

[Romero-Shaw et al, 2021,2022]

- There can be **residual eccentricity** when binaries merge
- Population statistics depend on formation mechanism
- Have we seen eccentric binaries?
- What is their **origin**?





More GW Science

- Neutron star matter properties with multi-messenger signals
- Machine Learning methods for GW data analysis
- Numerical simulations of boson star binaries
- Echoes from exotic binaries
- Cosmology with NS binaries
- BH superradiance and axion clouds
- BBH simulations in higher dimensional spacetimes
- Cosmic strings
- GW cosmography in modified gravity
- GW science with **Einstein Telescope** and Cosmic Explorer