

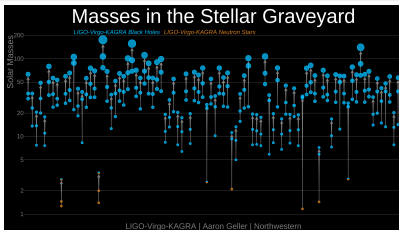
Gravitational Waves Science

Riccardo Sturani on behalf of R. Abramo, C. Frajuca, N.S.
Magalhaes ... (complete list here)

Latin American Strategic Forum 4 Research Infrastructure

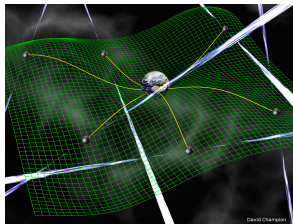
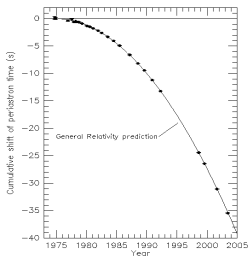
São Paulo @ Instituto Principia - August, 28th 2024

GW science with observations!



Large interferometers

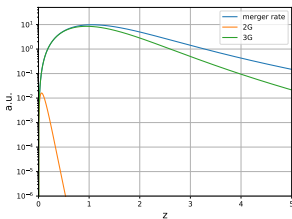
GWs emission and detections from astro/cosmo (?) sources



Pulsar timing

Scientific context

Binary coalescence distribution in redshift (adapted from Madau and Dickinson Ann.Rev.A.A., 1403.0007)



Scraping the surface! 2nd vs. 3rd generation

Expectation from star formation rate + ~ 100 Myr delay

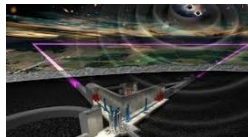
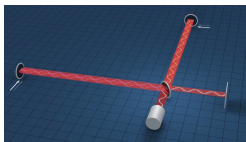
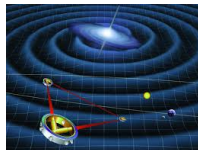
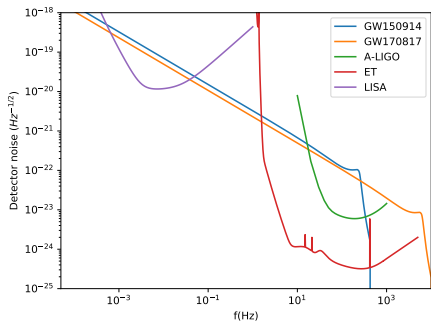
$$f_{max} = \frac{1}{2\pi M} \simeq 30 \text{kHz} \left(\frac{M}{M_{\odot}} \right)^{-1}$$

$$\Delta T = \frac{5}{256\pi\eta f} (\pi M f)^{-5/3} \simeq 2 \text{sec} \left(\frac{M_c}{1.2 M_{\odot}} \right)^{-5/3} \left(\frac{f}{100 \text{Hz}} \right)^{-8/3}$$

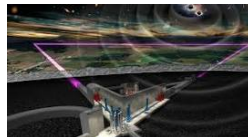
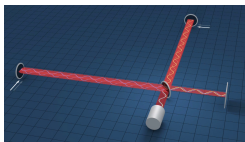
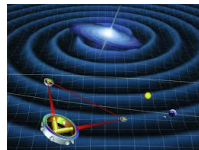
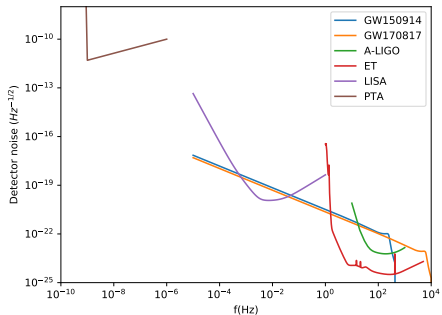
Typical strength of binary signal

$$\tilde{h}(f) \simeq \frac{M_c^{-5/6} f^{-7/6}}{d} e^{i\psi(f)}, \quad M_c \equiv \eta^{3/5} M, \quad \eta \equiv \frac{m_1 m_2}{M^2}$$

Comparison to noise

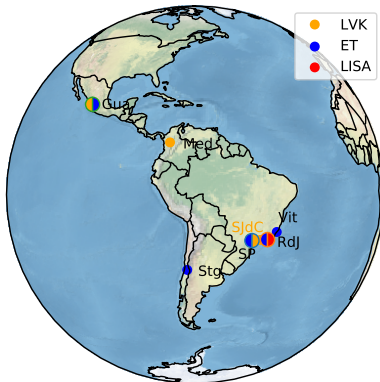


Comparison to noise



LATAM activities in GWs within large collaborations

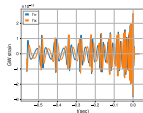
- Earth-based interferometric GW detectors
 - 2nd Generation (2G) $10 \lesssim f \lesssim 1\text{kHz}$
 - 3G $5\text{Hz} \lesssim f \lesssim 1\text{kHz}$
- Space detector: **LISA** $10^5\text{Hz} \lesssim f \lesssim 10^{-3}\text{Hz}$
- Nanograv $10^{-9}\text{Hz} \lesssim f \lesssim 10^{-7}\text{Hz}$ ($1/T_{\text{obs}}$)



What we do

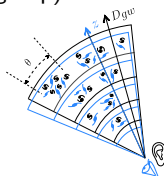
Waveform modeling/signal interpretation is crucial for maximizing the **physics/astrophysics/cosmology** detection output, beside **data analysis and instrument science**

- Improve **modeling** to (theory+ LVK collaboration, São Paulo)



- Developing method for **cosmology** $H_0 = z/d_L$, missing z from galaxy catalogs (within LVK collaboration, see Medellin group)

- **Cross correlating** with **large galaxy surveys** (see BETS ET group: Vitoria, Rio de Janeiro, São Paulo)



- Binary system **formation channels** (Santiago)
- **Detector characterization** (U. of Guadalajara), see previous talk
- **Instrument** work for LIGO (INPE São José dos Campos, BR, see previous talk) and by UoG (Fabian Peña Arellano, KAGRA member)
- LISA: **Primordial Universe**

What we will do - Goals

- **Build bridges** to existing astro/cosmo/particle communities already existent in LATAM
- Cosmology: Independent measure of background cosmological parameters (challenging to measure redshift) and primordial universe
- Astrophysics: relate detections of compact binary inspirals ($\sim 1 - 100M_{\odot}$) to binary system formation channels, and multi-messenger astronomy
- Fundamental Physics: recycle particle scattering physics methods to investigate the gravitational 2-body problem
- Hardware: seismic isolation mechanical systems