(Towards) a new gravitational wave plotter

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in collaboration with

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The aim:

Develop a **new gravitational wave plotter** that can cover the **ultra-high frequency range** and which adapts to the **needs of the community**

The plan:

Why do we need a new plotter?

Inspiration from the axion community

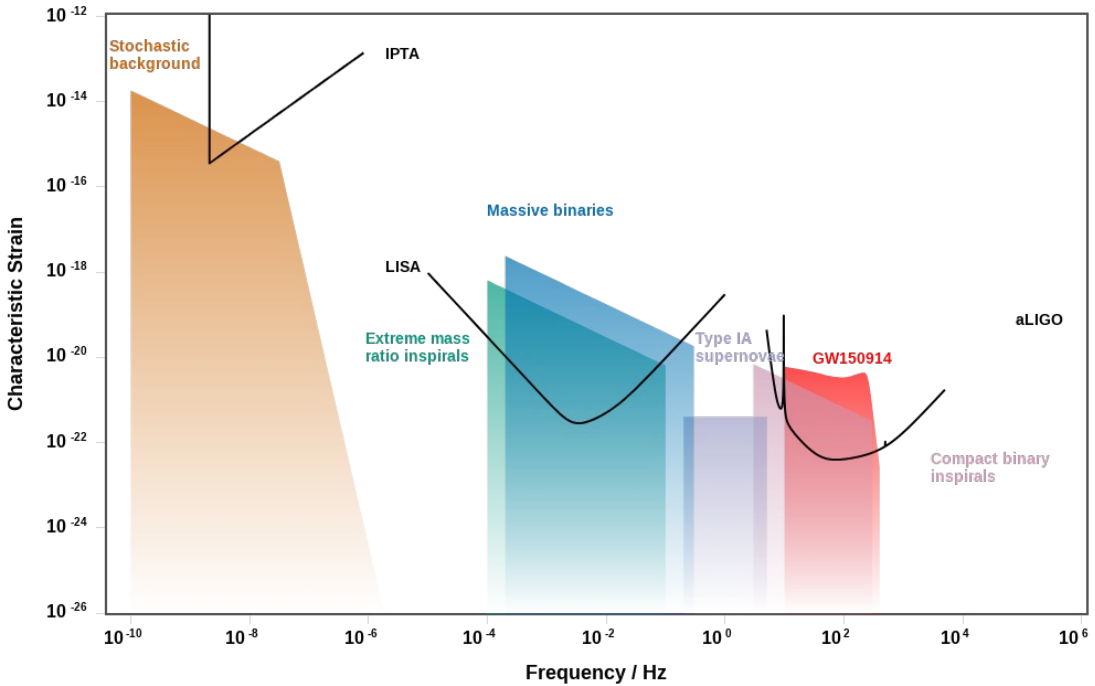
Basic features and community feedback

Current status

Why do we need a new plotter?

The classic GW plotter

[gwplotter.com, arXiv:1408.0740, Moore, Cole, Berry]



Can plot **strain, power spectral density**

Focused on **interferometers** and **astrophysical signals**

Missing cosmological signals, high frequencies

Minnesota GW plotter

[https://groups.spa.umn.edu/gwplotter/index.php, Mandic, Floden]

PLOT SPECIFICATIONS

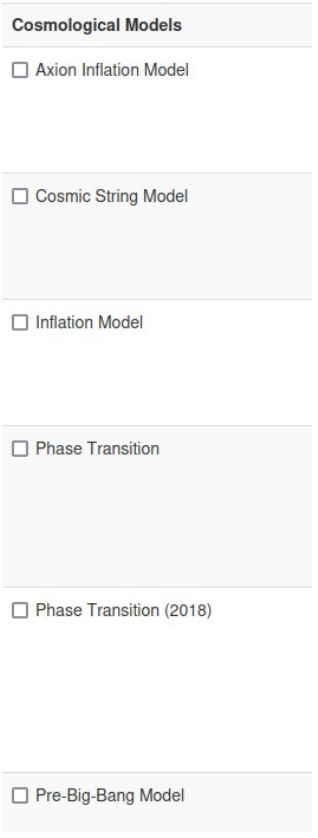
	Min	Max
X Axis (Frequency):	1.0E-18	1000
Y Axis (Energy Spectrum)	1.0E-16	0.1

Highly **customizable**

Can plot up to **high frequencies**

Minnesota GW plotter

[https://groups.spa.umn.edu/gwplotter/index.php, Mandic, Floden]



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Impressive array of **astro/cosmo signals**

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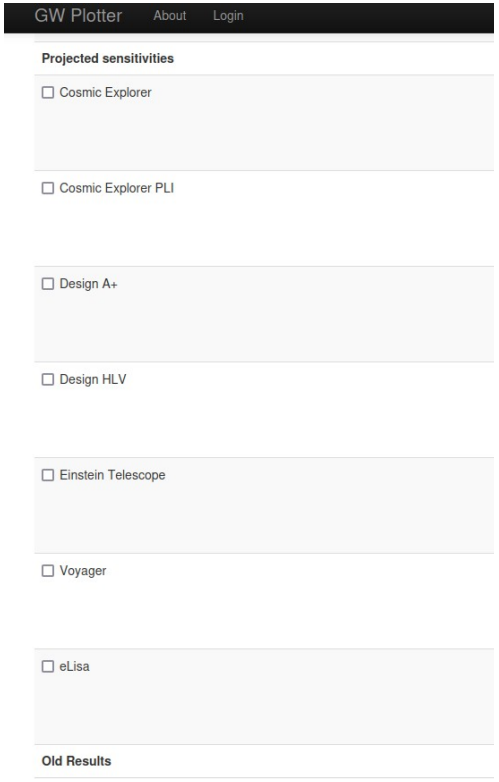


Highly **customizable**

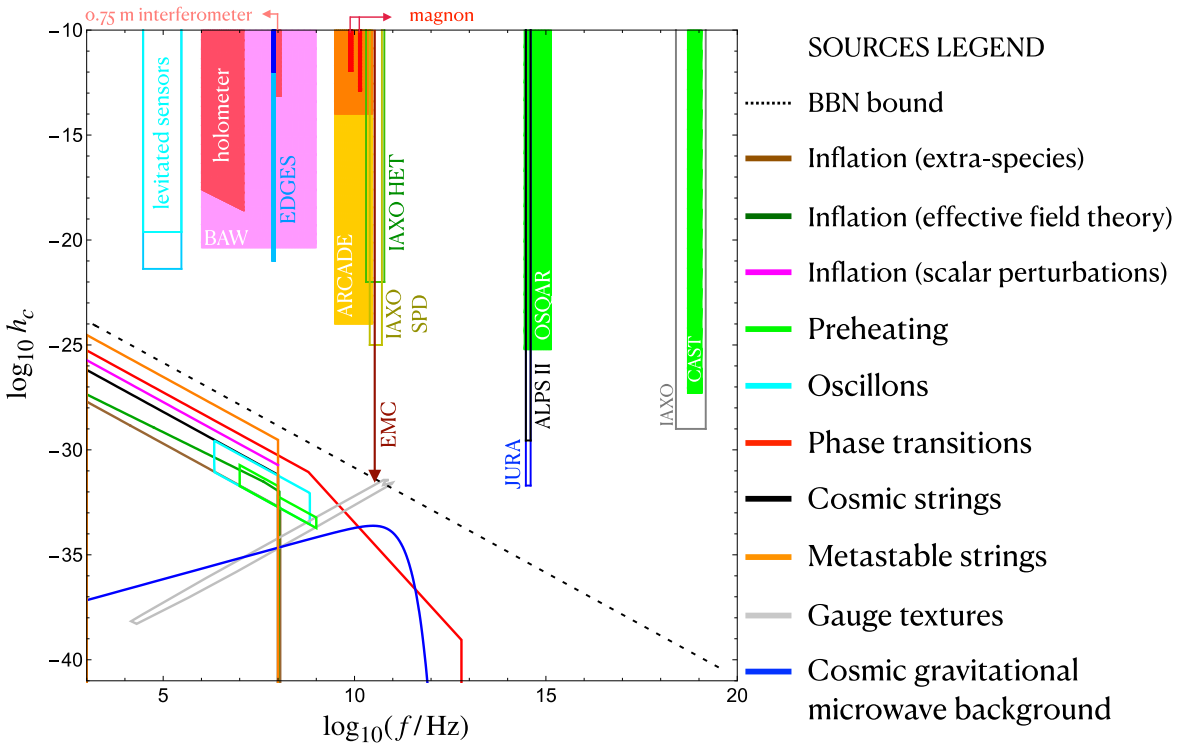
Can plot up to **high frequencies**

Impressive array of **astro/cosmo signals**

Misses high-f sensitivities and constraints

vs the living review

[2011.12414 [gr-qc], Aggarwal et al]



Our community would benefit from a **plotter with up-to-date experimental constraints, projected sensitivities and signals in the large frequency domain**

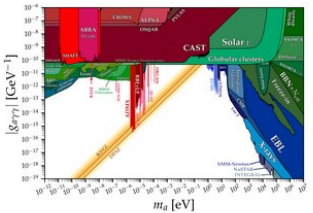
Inspiration from the axion community

Axion limits from Ciaran O'Hare

[https://cajohare.github.io/AxionLimits/, O'Hare]

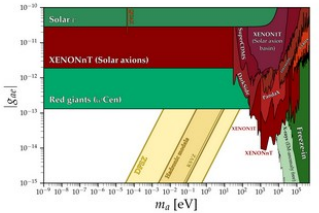
Axion-photon coupling

Data files
Plot (pdf, png)
Plot with projections (pdf, png)
Plot of dimensionless coupling (pdf, png)
Plot of dimensionless coupling with projections (pdf, png)



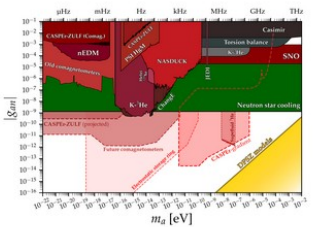
Axion-electron coupling

Data files
Plot (pdf, png)
Plot with projections (pdf, png)



Axion-neutron coupling

Data files
Plot (pdf, png)
Plot with projections (pdf, png)



Exhaustive repository of plots with **current limits** and **projections**

Reactive to feedback from community

Has become a **reference** for axion enthusiasts

Basic features and community feedback

What we envision

A tool that brings together:

the **ease-of-use** of a **web plotter**

downloadable python code

the **completeness** and **community awareness** of [O'Hare]'s axion plotter

We can think of the following types of plots:

strain vs frequency

energy fraction vs frequency

power spectral density vs frequency

Feedback

What would you like to see and have? Keep sending us feedback in the survey:

https://forms.gle/Vw28pmgyLaMmgunb8

Thank you to all who contributed so far. Some feature requests:

- PSDs
- Bare vs power-law-integrated sensitivities
- Noise sources
- SNR computations
- N_{eff} bound in real time
- dynamical parameters
- python compatibility

Feedback

Some signal / constraints requests

PBH mergers

stochastic backgrounds from astrometry

cosmic strings

effects of modified cosmology

audible axions

axion haloscopes

...

Current status

Current (very preliminary) status

https://github.com/fmuia/GWplots

Current test code uses **Bokeh**, a **python** library for interactive visualizations in browsers

We are starting with a plot of strain vs frequency analogous to Fig. 2 of living review for stochastic backgrounds

Plot has:

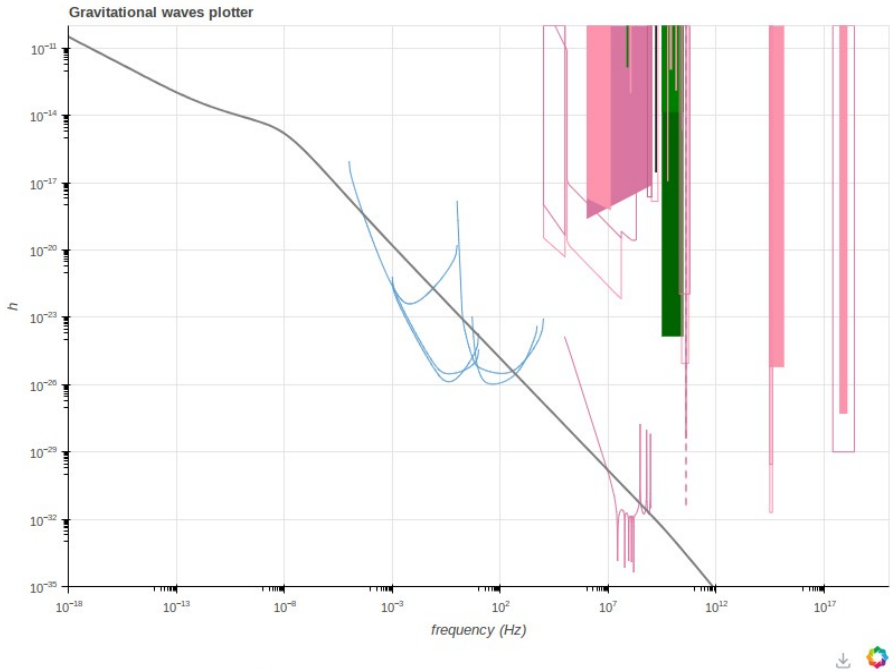
customizable ranges and **aspect ratio**

dynamic selection of signals/bounds

can be **saved in vector format**

Gravitational Waves Plotter

Edited and maintained by Francesco Muia, Andreas Ringwald, and Carlos Tamarit



Adjust frequency range: **1e-18 .. 1e+20**

Adjust strain range: **1e-35 .. 1e-10**

Adjust plot width: **800**

Adjust plot height: **600**

Experimental Bounds

Direct Bounds	Indirect Bounds	Projected Bounds
☑ BAW	☑ ARCADEstrong	☑ LSDweak
☑ OSQAR	☑ ARCADEweak	☑ LSDstrong
☑ CAST	☐ EDGESstrong	☑ IAXOSPD
☑ HOL	☑ EDGESweak	☑ IAXOHET
☑ Akutsu		☑ IAXO
☑ MagnonLow		☑ ALPSII
☑ MagnonHigh		☑ JURA
		☑ ADMX
		☑ HAYSTAC
		☑ CAPP
		☑ SQMS
		☑ GaussianBeamWeak
		☑ GaussianBeamStrong
		☑ ORGAN
		☑ Resonant Antennas
		☑ DMR 8
		☑ DMR 100
		☑ BBO
		☑ CE
		☑ DECIGO
		☑ ET
		☑ LISA

Potential Signals

- ☑ Global string Gmu=1E-11
- ☐ Global string Gmu=1E-12
- ☐ Global string Gmu=1E-13
- ☐ Global string Gmu=1E-14
- ☐ Global string Gmu=1E-15
- ☐ Global string Gmu=1E-16

Merci!