

LISA Data Analysis for All

Michael Katz+ on behalf of the organizers

Goals for this workshop



LEARN ABOUT LISA DATA
ANALYSIS THROUGH CODE!

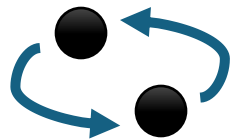
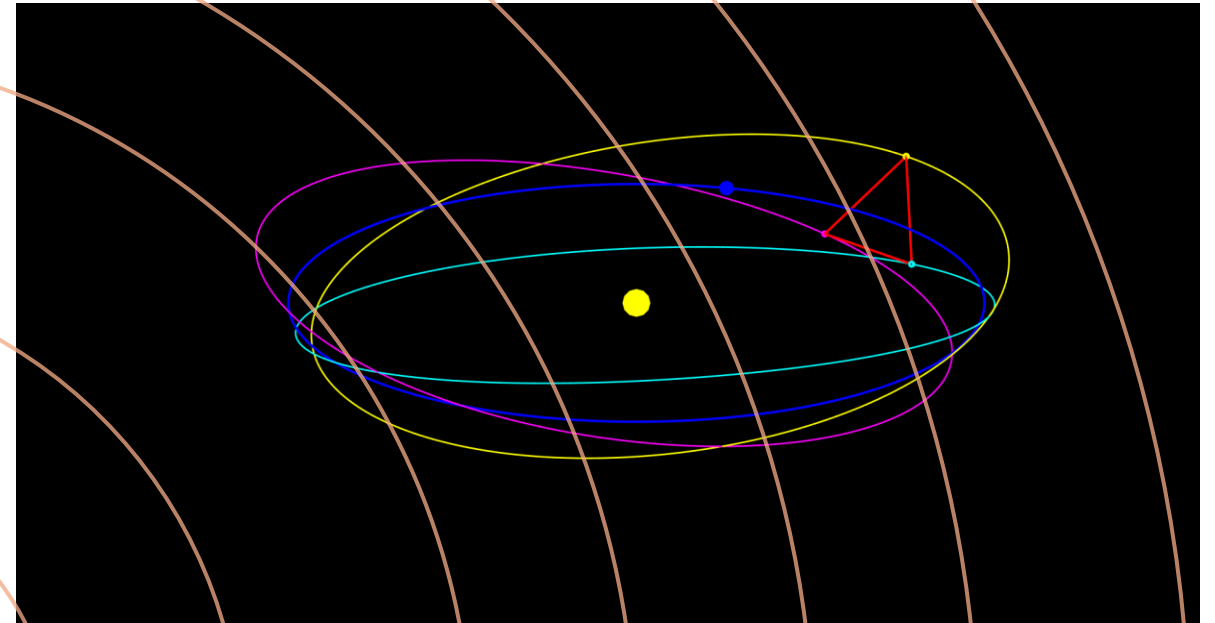
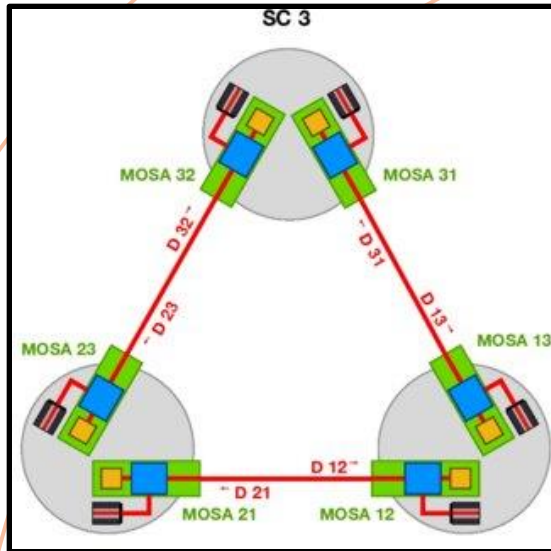


HEAR ABOUT THE LISA
MISSION!

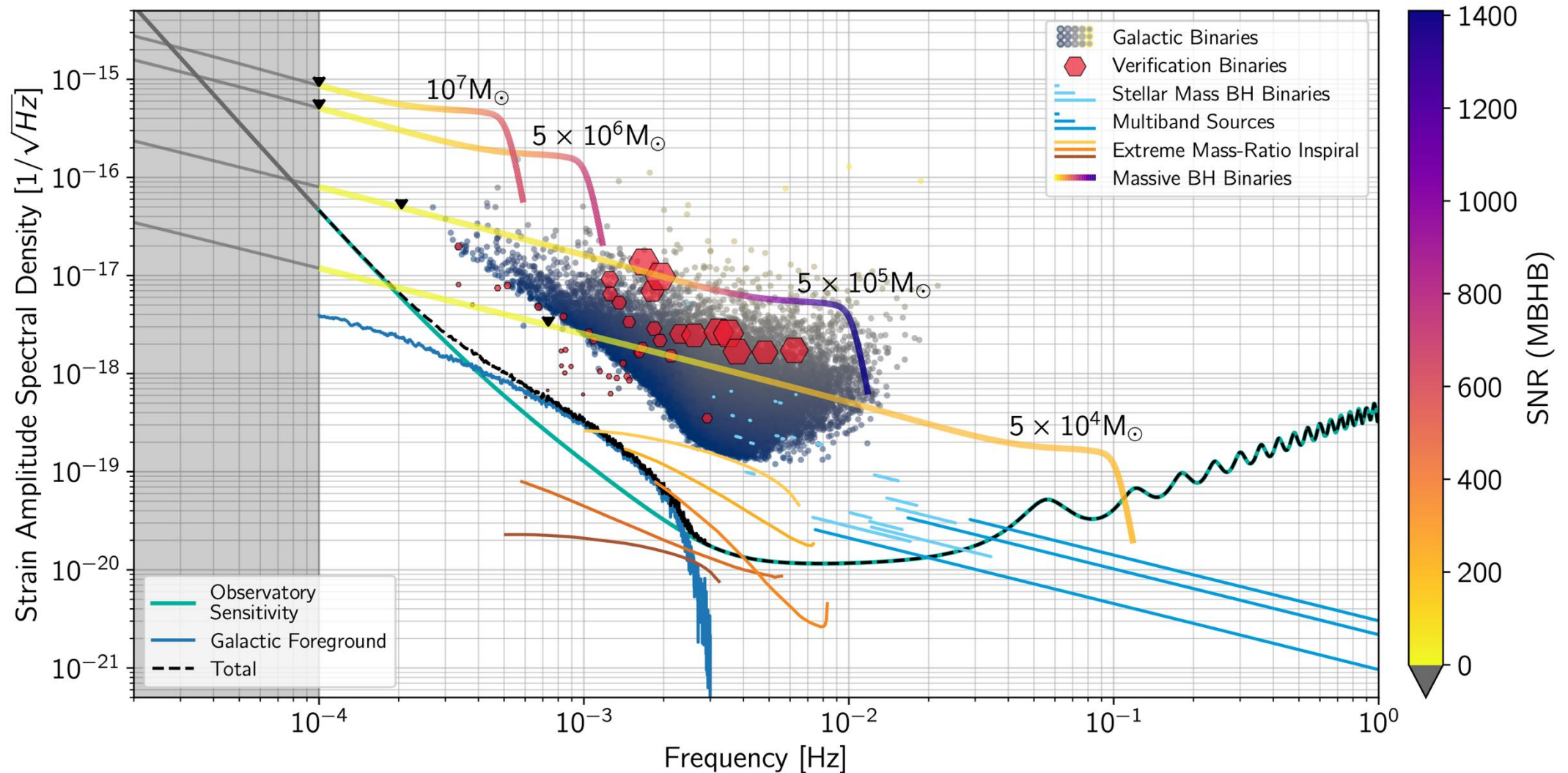


DISCUSS DEI IN
ASTRONOMY

Let's talk about the LISA Mission!



Let's talk about the LISA Mission!



Let's talk about the LISA Mission!

How does LISA measure things?
Ira Thorpe

LISA Science Objectives
Kelly Holley-Bockelmann

LISA Multiband and Multimessenger Science
Shane Larson

Diversity, Equity, and Inclusion in Astronomy

Short discussions
(~10-15min)

Pseudo-random timing
(like real life!)

Please be respectful of everyone

LISA Analysis Tools Library & Framework



LISA Analysis Tools Code (github.com/mikekatz04/LISAanalysistools)



Fast EMRI Waveforms (github.com/BlackHolePerturbationToolkit/FastEMRIWaveforms)



Eryn (MCMC + RJMCMC sampler; github.com/mikekatz04/Eryn)



BBHx (MBHB + SOBHB; github.com/mikekatz04/BBHx)






GBGPU (GBs+; github.com/mikekatz04/GBGPU)



Fast LISA Response (github.com/mikekatz04/lisa-on-gpu)

LISA Analysis Tools Workshop Tutorials

github.com/mikekatz04/LATW

 README  Code of conduct  Apache-2.0 license

LISA Analysis Tools Workshop (LATW)

This repo houses the tutorial codes for the LISA Analysis Tools Workshop. The tutorials are stored in the [tutorials](#) directory. In that same directory, you will find the answer keys. Introductory talk recordings can be found [here](#). PDF versions of the slides are in [intro_talks](#).

Question 2

We have asked you to compute the sky-averaged sensitivity curves. What does that mean? Can you determine, without looking at the documentation what the total sky-averaging factor is?

Links to
documentation

File display

Task 1: Plotting and comparing sensitivity curves.

Calculate and plot the **sky-averaged** LISA sensitivity function ([LISASens](#)) in the characteristic strain representation. Compare the **model** used for the LDC2A (or Sangria) dataset to the Science Requirements Document version for the sensitivity curves (`scirdv1`).

Useful documentation:

- [get_available_default_lisa_models](#)
- [get_stock_sensitivity_options](#)
- [get_sensitivity](#)
- [LISASens](#)

```
In [2]: # useful imports
from lisatools.sensitivity import LISASens, get_sensitivity, get_stock_sensitivity_options
import lisatools.detector as lisa_models

In [ ]: get_stock_sensitivity_options()

In [ ]:
```


LISA Analysis Tools Workshop Tutorials

github.com/mikekatz04/LATW

0. Python basics needed for LATW

1. Introduction to LISA Analysis Tools

Our goal for the workshop!

2. EMRIs and LISA Response

3. Fixed-dimensional MCMC

4. MBHBs + MCMC

Rest is optional.
You can decide after tutorial 1!

5. RJMCMC (trans-dimensional sampling)

6. GBs + MCMC + RJMCMC

*All tutorials have answer keys (in the tutorials/tutorial_answers/ folder).
They can be helpful if you are stuck.

LISA Data Analysis Basics

Our goal is to calculate the signal-to-noise ratio (SNR) and Likelihood for a source in LISA data. Key mathematics terms we will see in this lesson:

Data array $\rightarrow d(t) \rightarrow$ Fourier Transform $\rightarrow \tilde{d}(f)$

Template array $\rightarrow h(t) \rightarrow$ Fourier Transform $\rightarrow \tilde{h}(f)$

Sine wave in our example case.

Noise Power Spectral Density $\rightarrow S_n(f)$

Inner Product $\rightarrow \langle a(t)|b(t) \rangle = 4\Re \left[\int_{-\infty}^{\infty} \frac{\tilde{a}(f)^* \tilde{b}(f)}{S_n(f)} df \right]$

Trapezoidal or rectangular summation numerically.

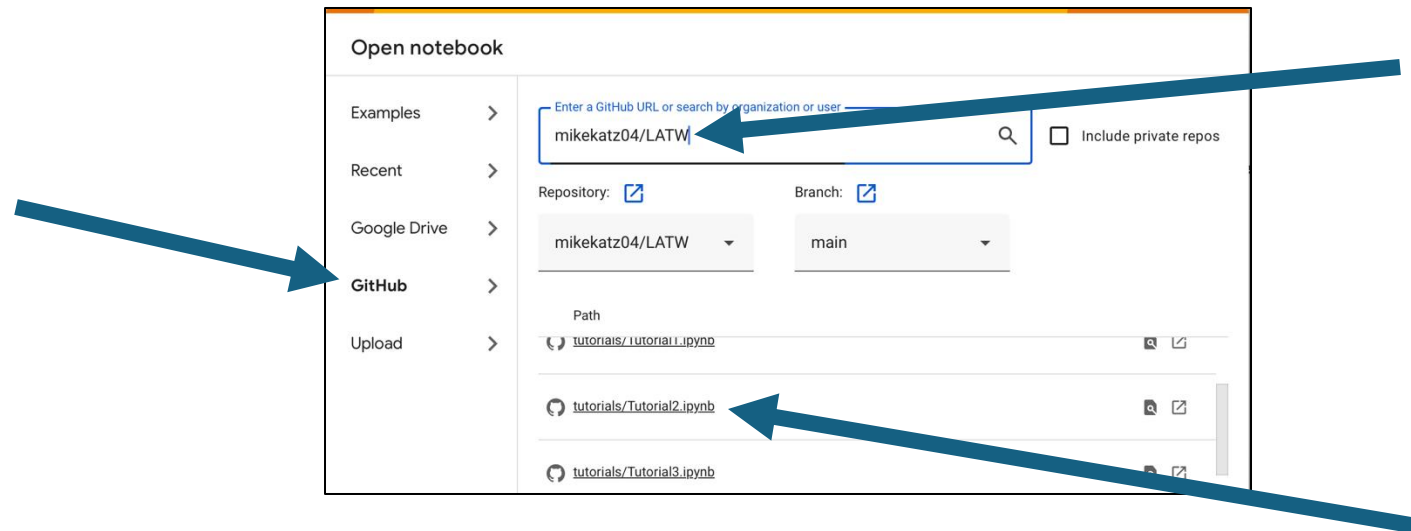
SNR (Optimal) $\rightarrow \sqrt{\langle h|h \rangle}$

log Likelihood ($\ln \mathcal{L}$) $\rightarrow -\frac{1}{2} \langle d - h | d - h \rangle = -\frac{1}{2} [\langle d|d \rangle + \langle h|h \rangle - 2\langle d|h \rangle]$

Google Colab Instructions for LATW

github.com/mikekatz04/LATW

1) “File”. “Open Notebook”. “Github”. Type “mikekatz04/LATW” in the search bar. Hit Enter. Click the link for “tutorials/Tutorial#.ipynb”.



2) Click “Copy to Drive”. Then start working!

