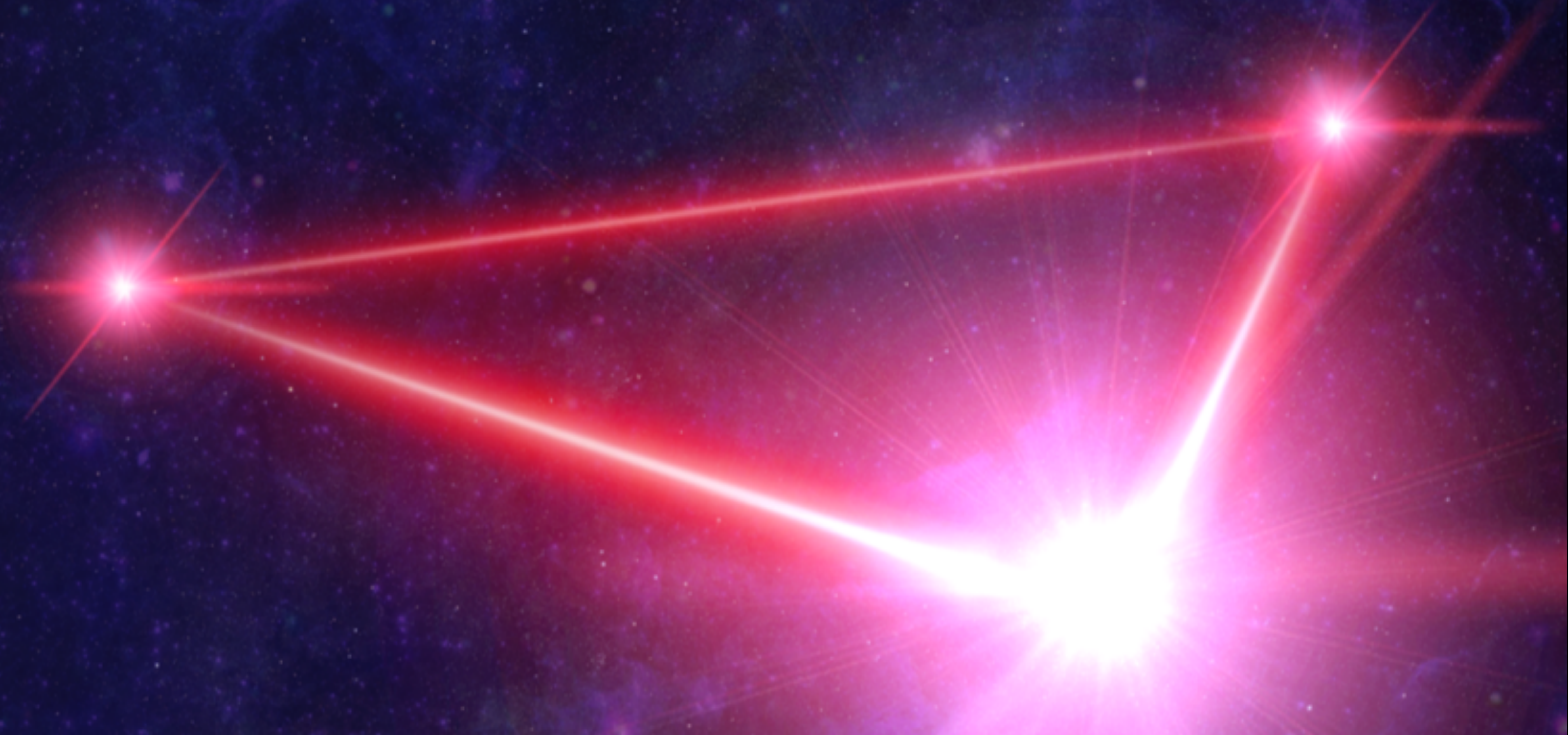
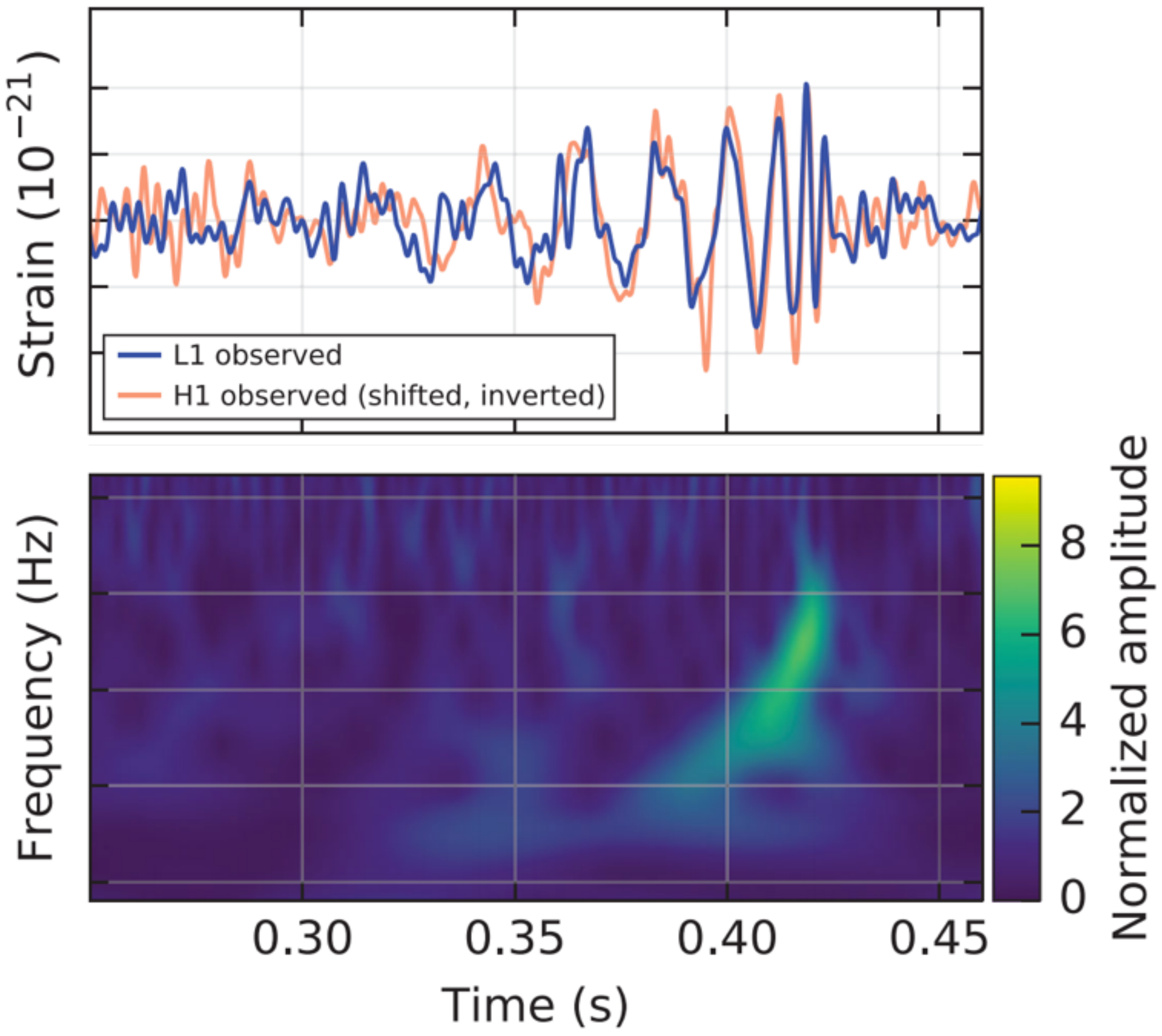
Laser Interferometer Space Antenna

(it’s really happening)

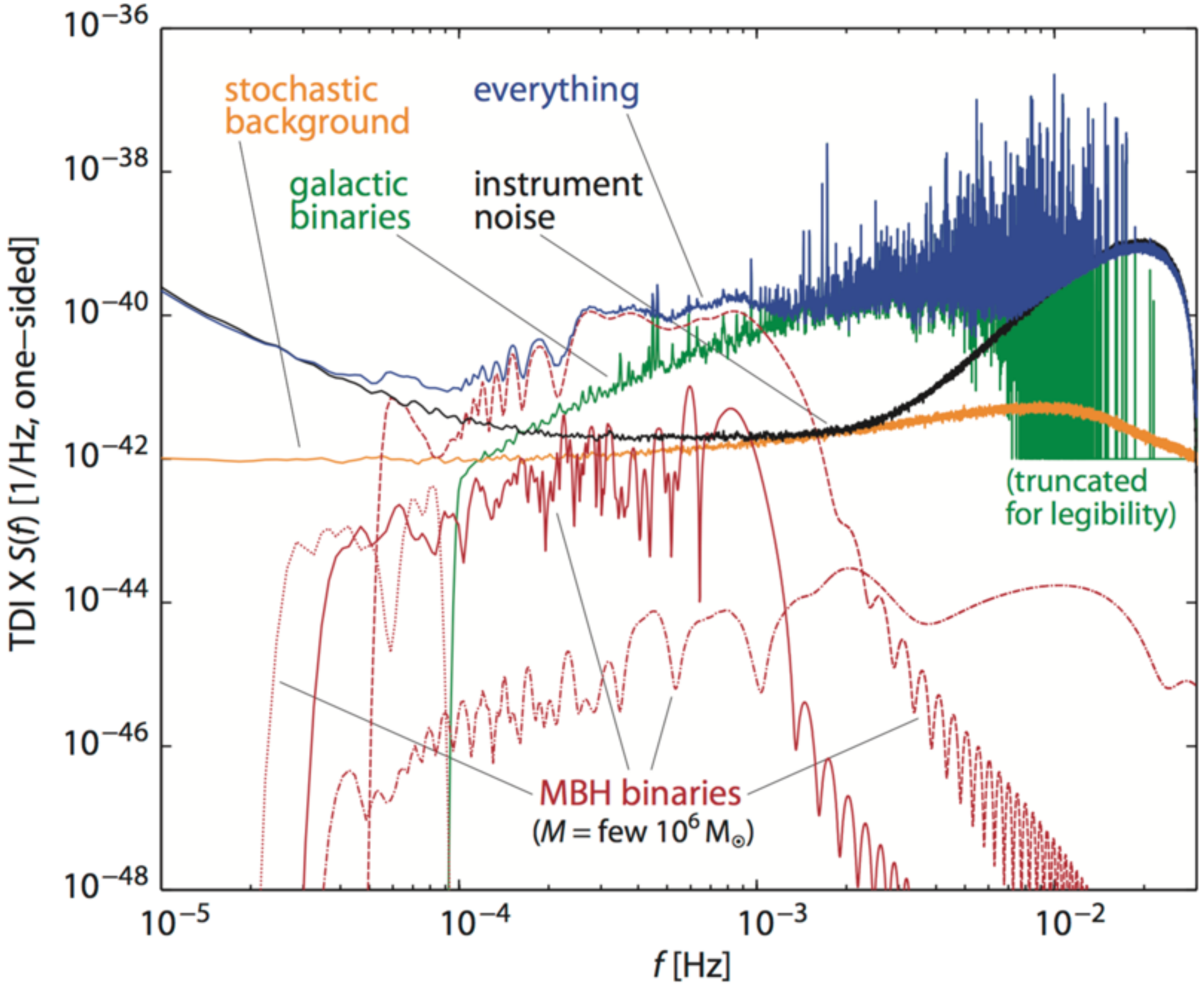


The LISA science analysis: a solved problem?

GW150914: LIGO could do it



MLDC4: we could do it (sort of)



It’s not like LIGO’s joking re computing!

The new supercomputer “Minerva” at the
Max Planck Institute for Gravitational Physics
in Potsdam. Credit: A. Okulla/MPI

But: a bigger problem…
(for waveform generation)

- Not one, but many thousands superimposed signals
- A thousand times longer
- A thousand times more accurate

…and a deeper problem
(for data analysis)

- Very large source parameter spaces
- Complex parameter/waveform posteriors
- Iterative, highly correlated search for multiple source species
- LISA catalog must enable diverse types of inference

LISA sources

Some Source Modeling Issues

- Modeling many LISA sources requires PDEs
  - Hydrodynamics
  - MHD
  - Gravity (Newton; Einstein)
  - ...
- Dominant algorithm is still finite differencing, after 50 years!
- Dominant parallelization is via MPI

Is It Time for a Change?

- LISA SN for BBH $\sim 10,000$
- So need $\delta\phi \lesssim 10^{-4}$ after many orbits
- Can current codes achieve this on future computers?
- Tentative answer: Methods do not scale to extreme-scale machines

Is It Time for a Change?

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- So need $\delta\phi \lesssim 10^{-4}$ after many orbits
- Can current codes achieve this on future computers?
- Tentative answer: Methods do not scale to extreme-scale machines
- What about hydro/MHD?

What Are Some Options?

- Finite differencing $\rightarrow$ Discontinuous Galerkin or similar
- MPI $\rightarrow$ task-based parallelism
- ...

Contents

“We should not make the mistake of looking at computing in astronomy as simply an applied form of computer science. That would imply the existence of a toolbox containing suitable techniques that can easily be adapted to work in astronomy. Experience shows, however, that these tools either do not match our needs or have yet to be created; computer science [faces] unique challenges in the context of actual astronomical research questions, technical requirements, and real-world big data and data science.”

[Pankratius and Mattmann 2014]

New tools, new directions

- Task-intensive parallelism
- Data intensive architectures
- Big-data Monte Carlo, approximate inference
- Deep learning

New tools, new directions

- HW accelerators: GPUs, special purpose processors
- Visualization: interactivity, virtual reality
- Open science: reproducibility, workflows

Overall

- Meta: what are the right questions to ask about the computational design of the analysis?
- Beyond: what are currently intractable problems that we can imagine solving in the 2030s?
- Our report: indicate directions, formulate projects