

Measuring matter distributions near binaries

Gravity and Cosmology 2018

January 29 - March 9, 2018

Yukawa Institute for Theoretical Physics, Kyoto University

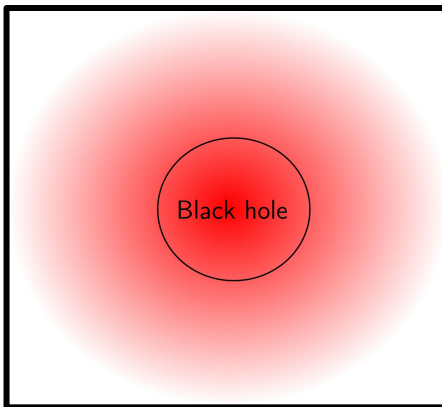


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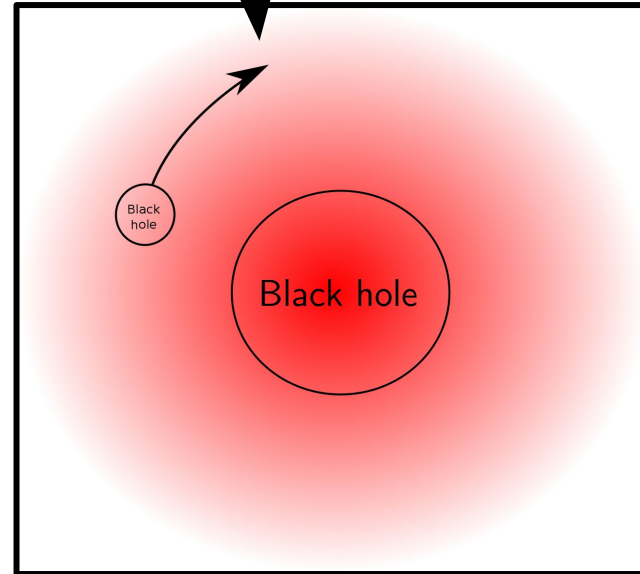
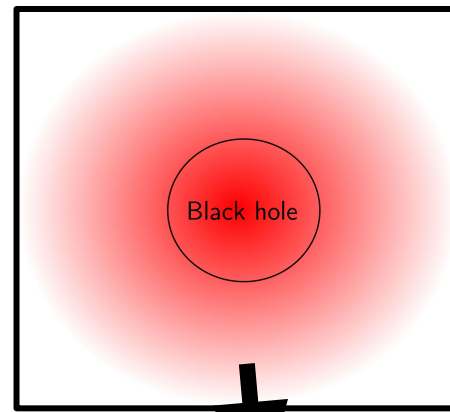
Black hole

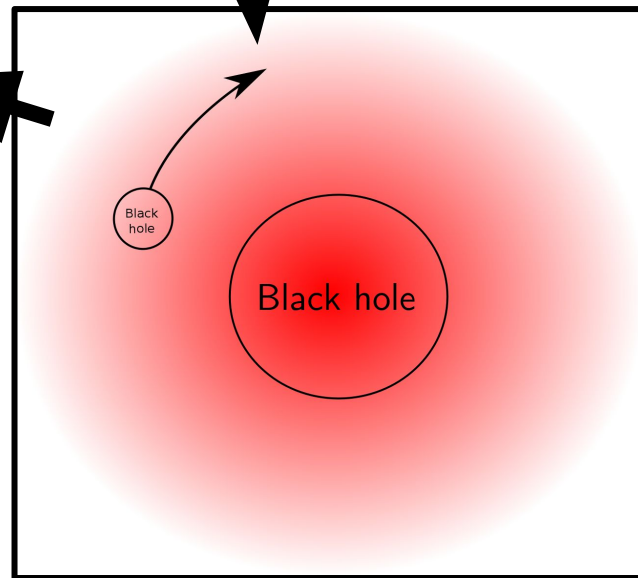
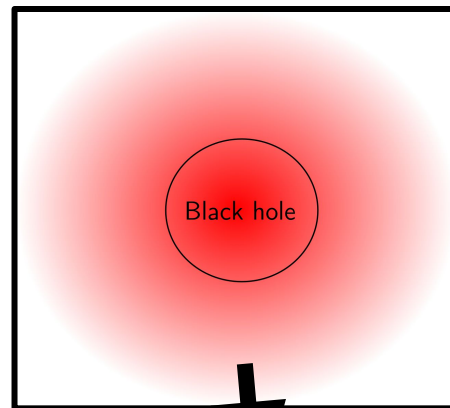
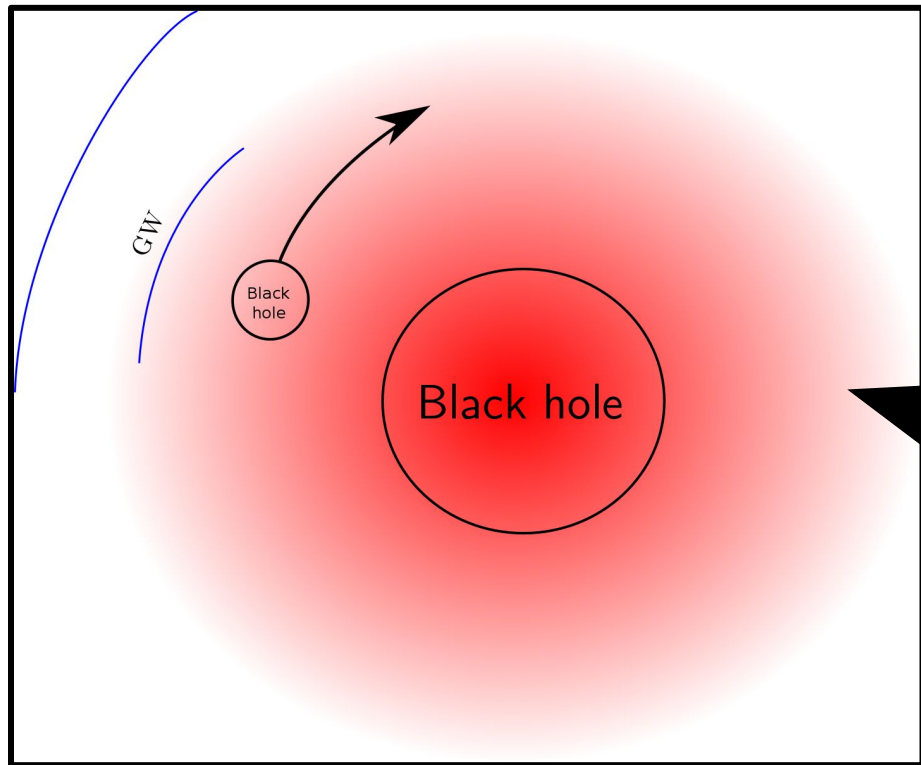
By The Hubble Heritage Team (AURA/STScI/NASA) NASA Headquarters - Greatest Images of NASA (NASA-HQ-GRIN) [Public domain], via Wikimedia Commons"



- BH+matter

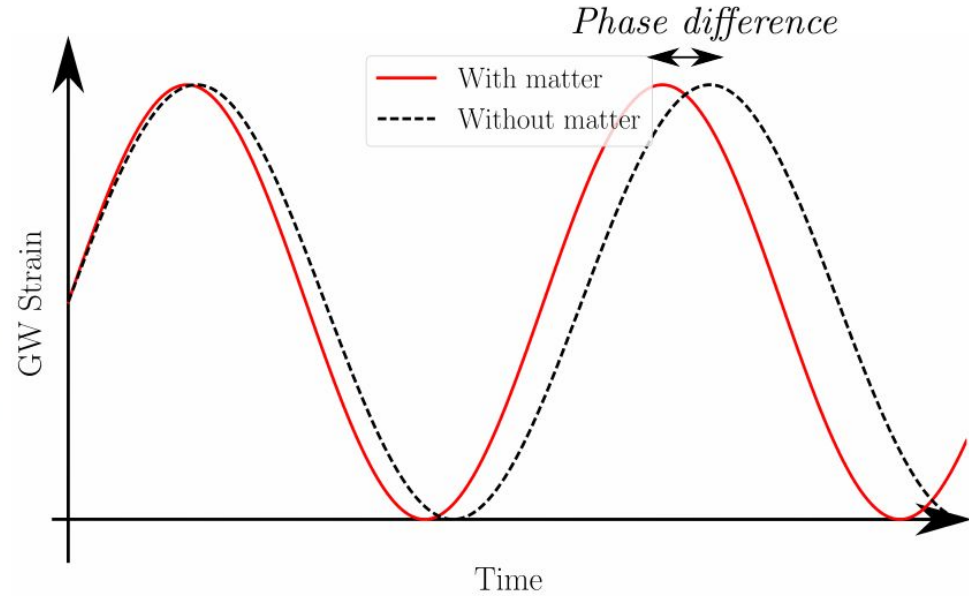
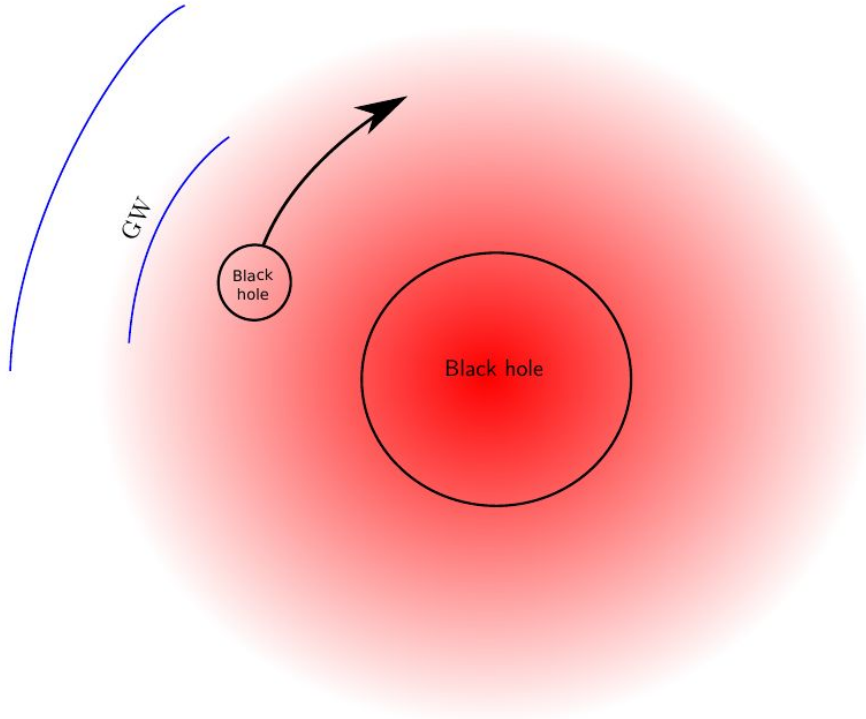
- BH+matter
- Binary plunges into the system



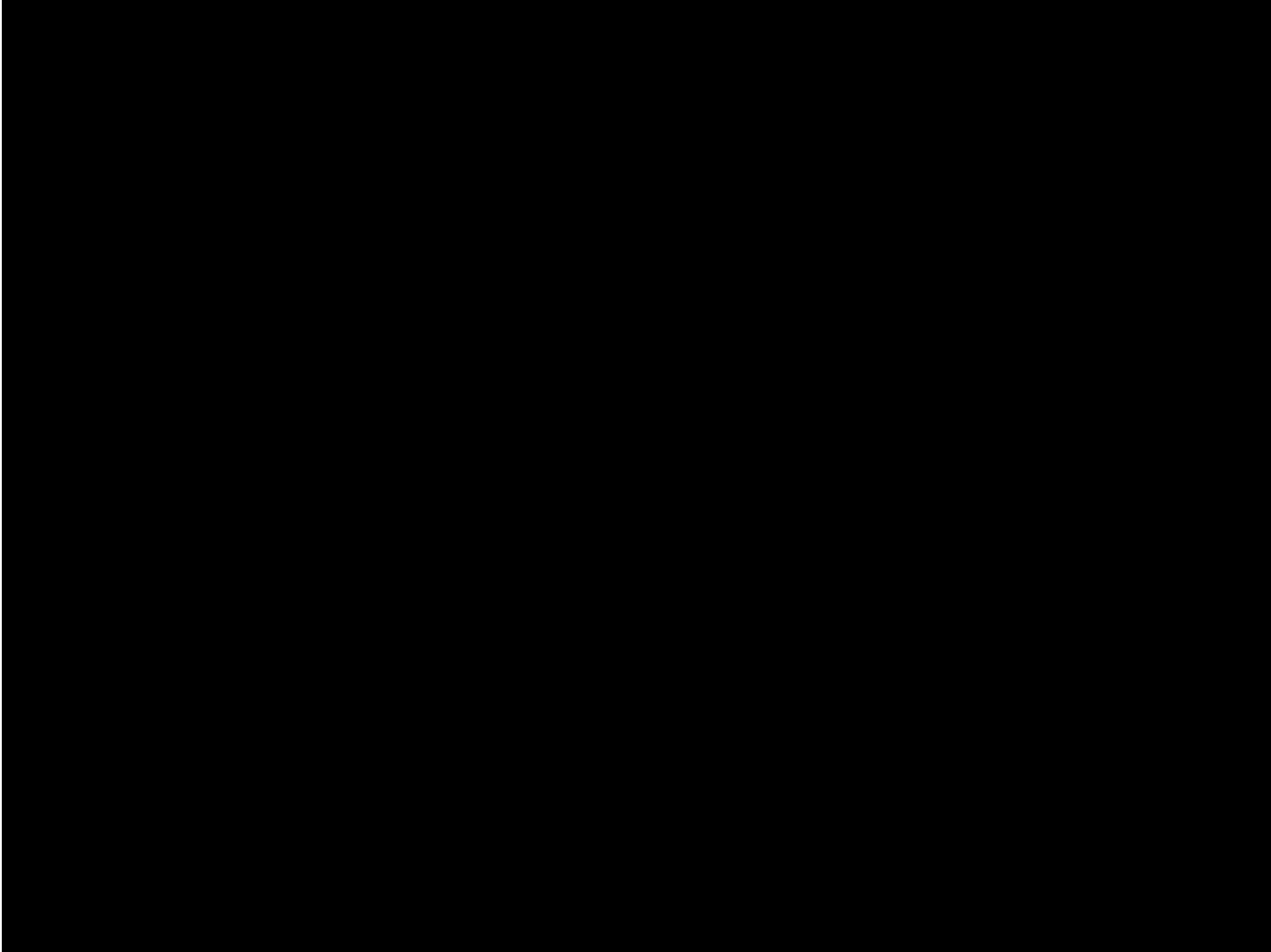


- BH+matter
- Binary plunges into the system
- Emits GWs

Mass screening and dynamical friction cause energy loss



Demo



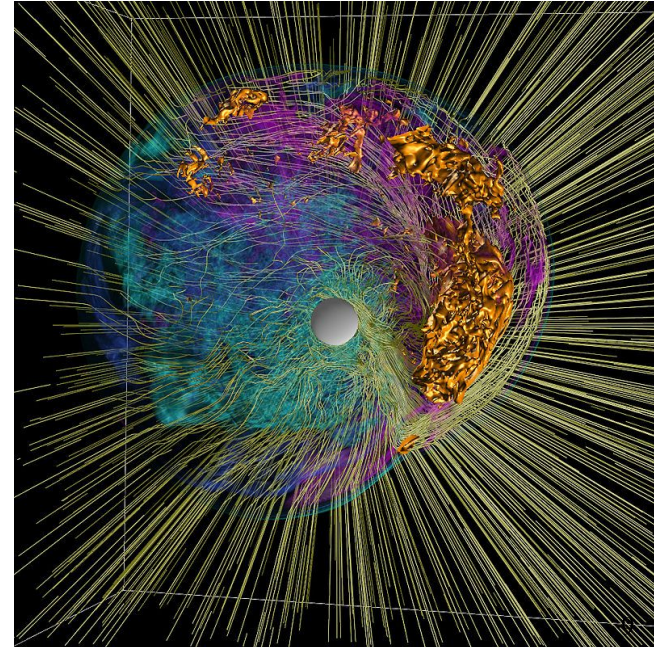
1. Matter influence resolved via astrophysics

$$\frac{dE_{\text{orbit}}}{dt} + \frac{dE_{\text{GW}}}{dt} + \frac{dE_{\text{DF}}}{dt} = 0,$$

Image credits: Blondin and Mezzacappa

1. Matter influence resolved via astrophysics
2. However, astrophysical modeling complicated

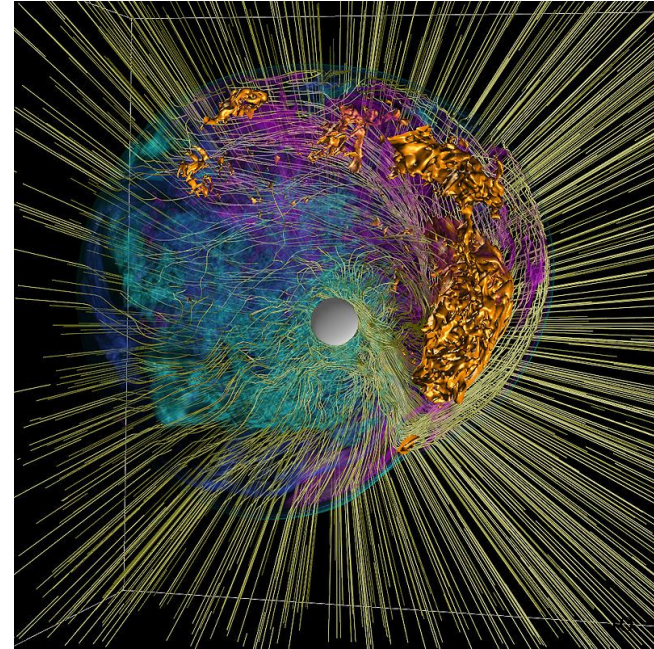
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$$\frac{dE_{\text{orbit}}}{dt} + \frac{dE_{\text{GW}}}{dt} + \frac{dE_{\text{DF}}}{dt} = 0,$$

$$\frac{dE'}{dt} \rightarrow \frac{dE}{dt} + \delta F(r)$$

1. Matter influence resolved via astrophysics
2. However, astrophysical modeling complicated
3. To fix the situation: Use a perturbative approach that does not rely on astrophysics

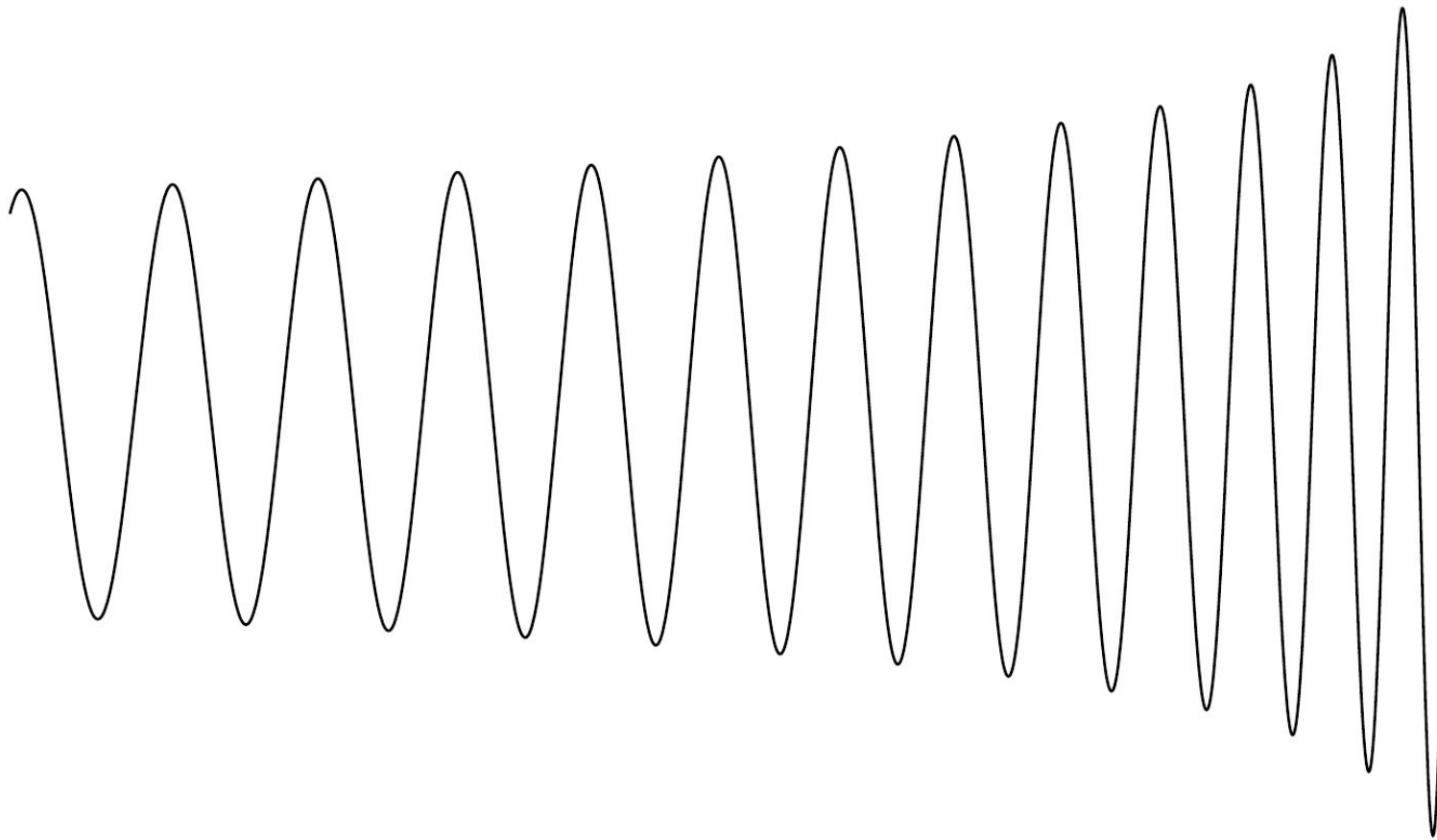


Idea: Search for the astrophysical waveform using perturbative waveform template

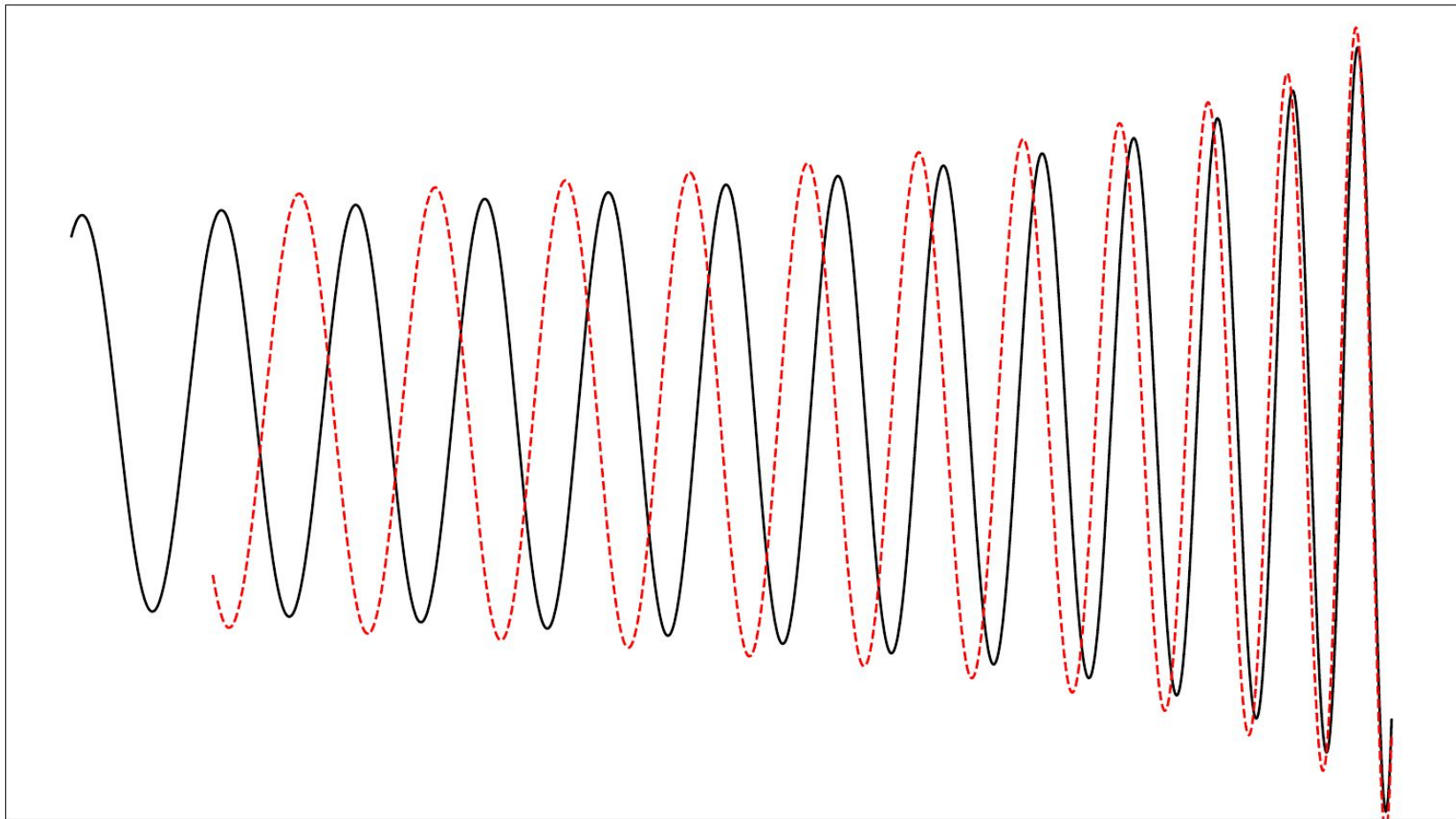
Search using “nested sampling”, a markov-chain monte-carlo algorithm

Strain

Time



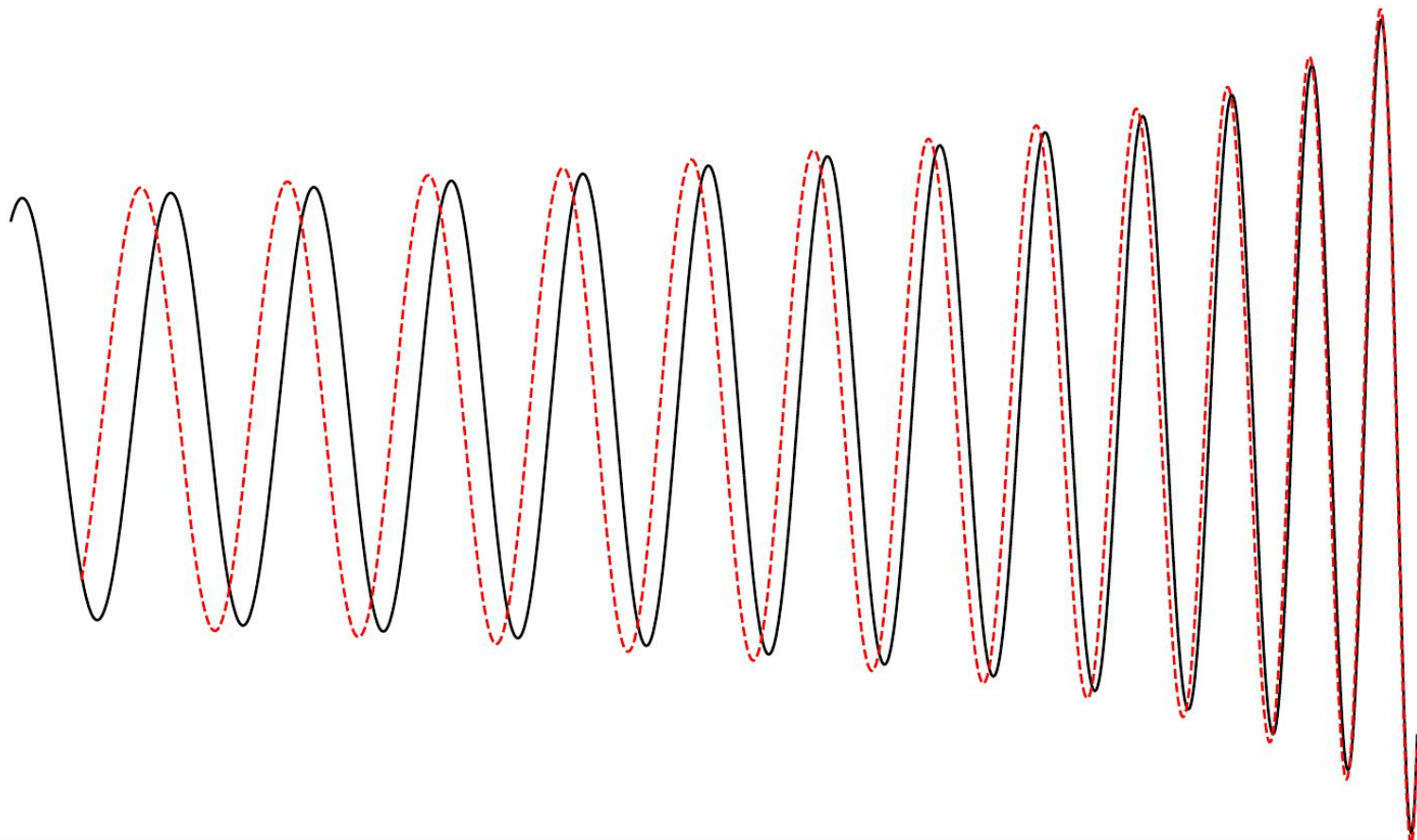
Strain

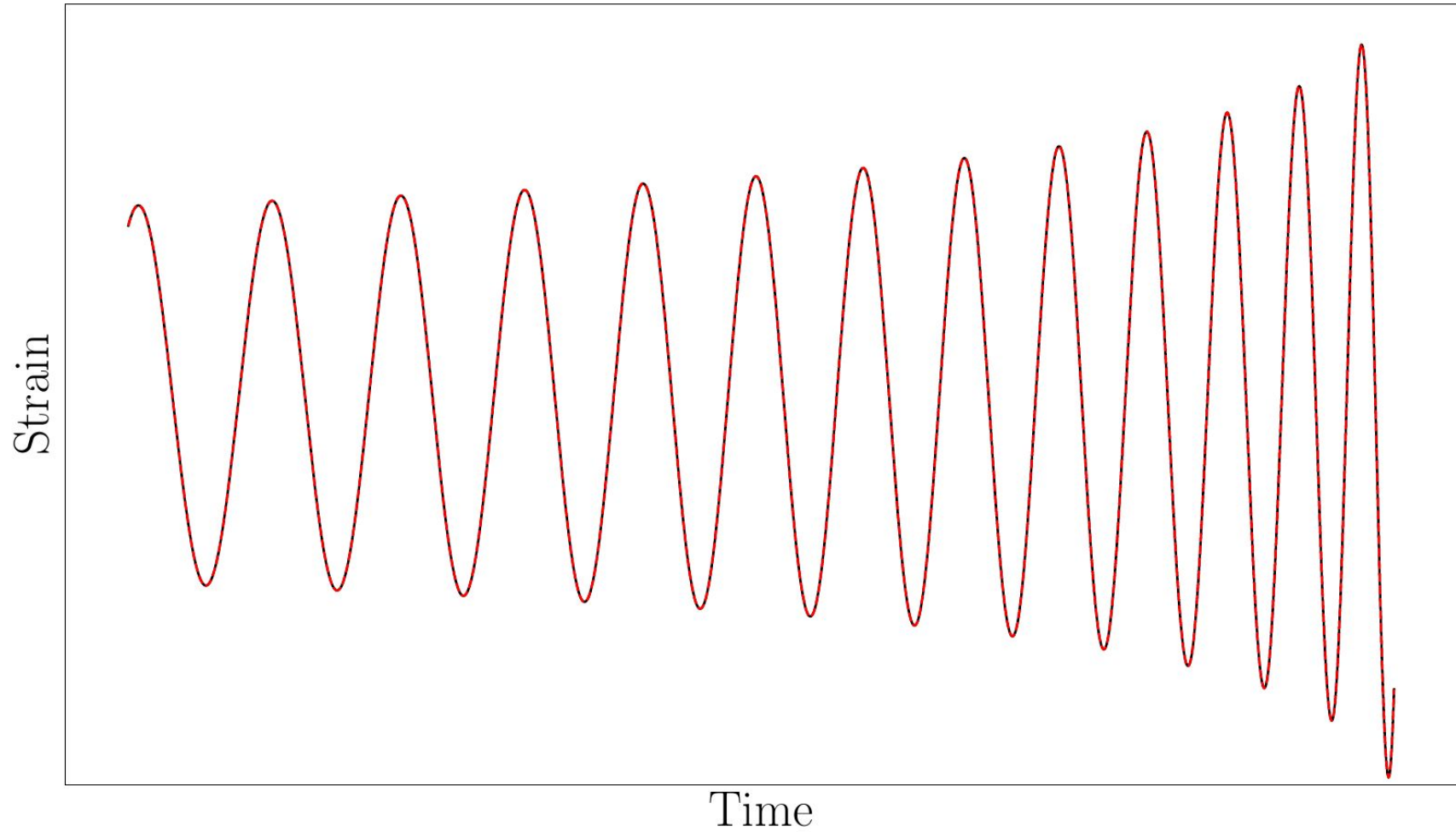


Time

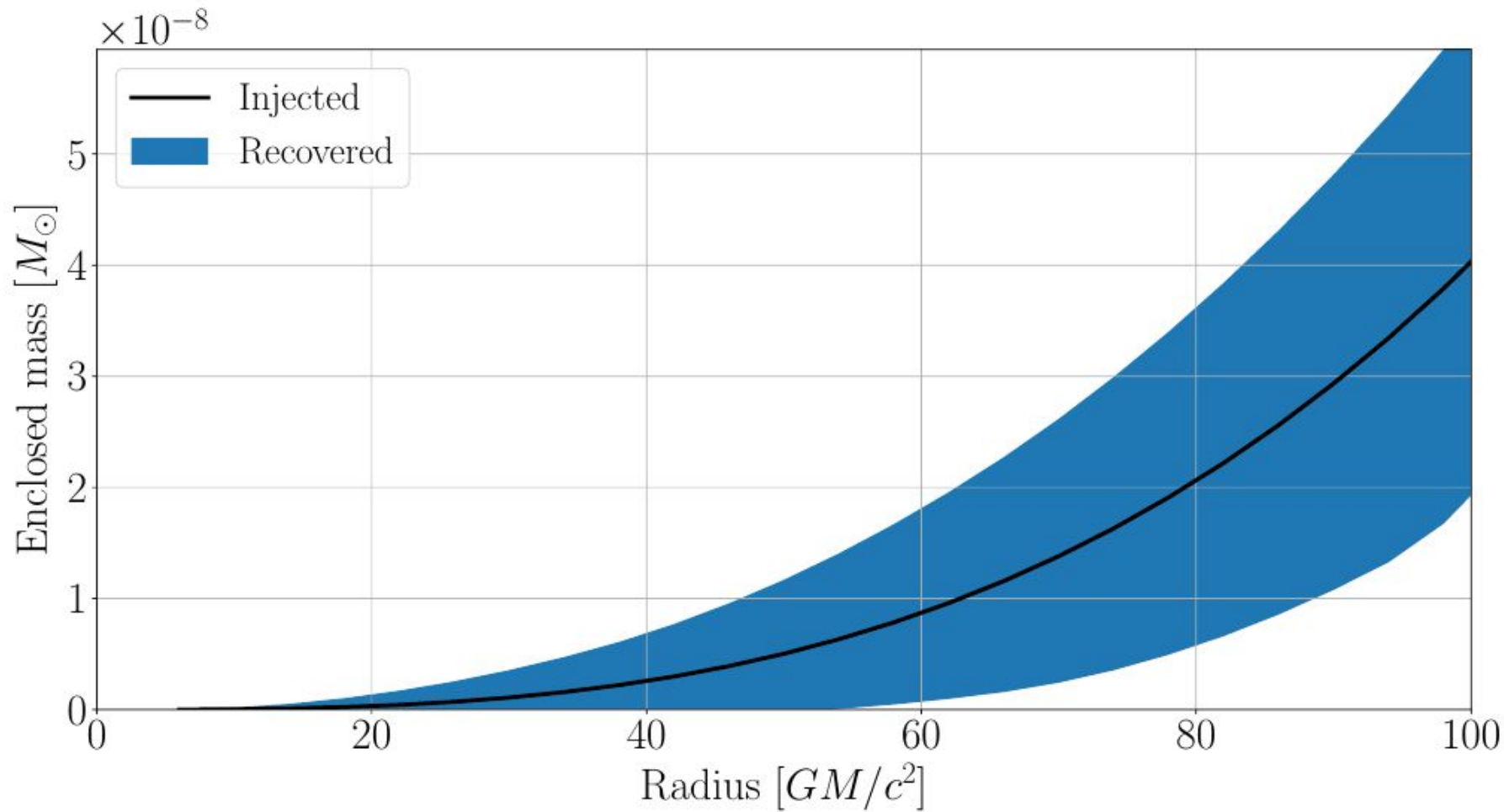
Strain

Time





Recovery



What we expect to see is unknown:

- Astrophysics largely not understood in the galactic center & near black holes
- To understand what is out there, we would need to measure it



Conclusions

- We use `general` waveform to capture astrophysical waveform
- The resulting waveform inference record matter information
- Higher masses correspond to higher event rates, but less sensitivity to matter
- What we would see in the future is largely unknown