

Detection of Binary White Dwarf Populations with LISA

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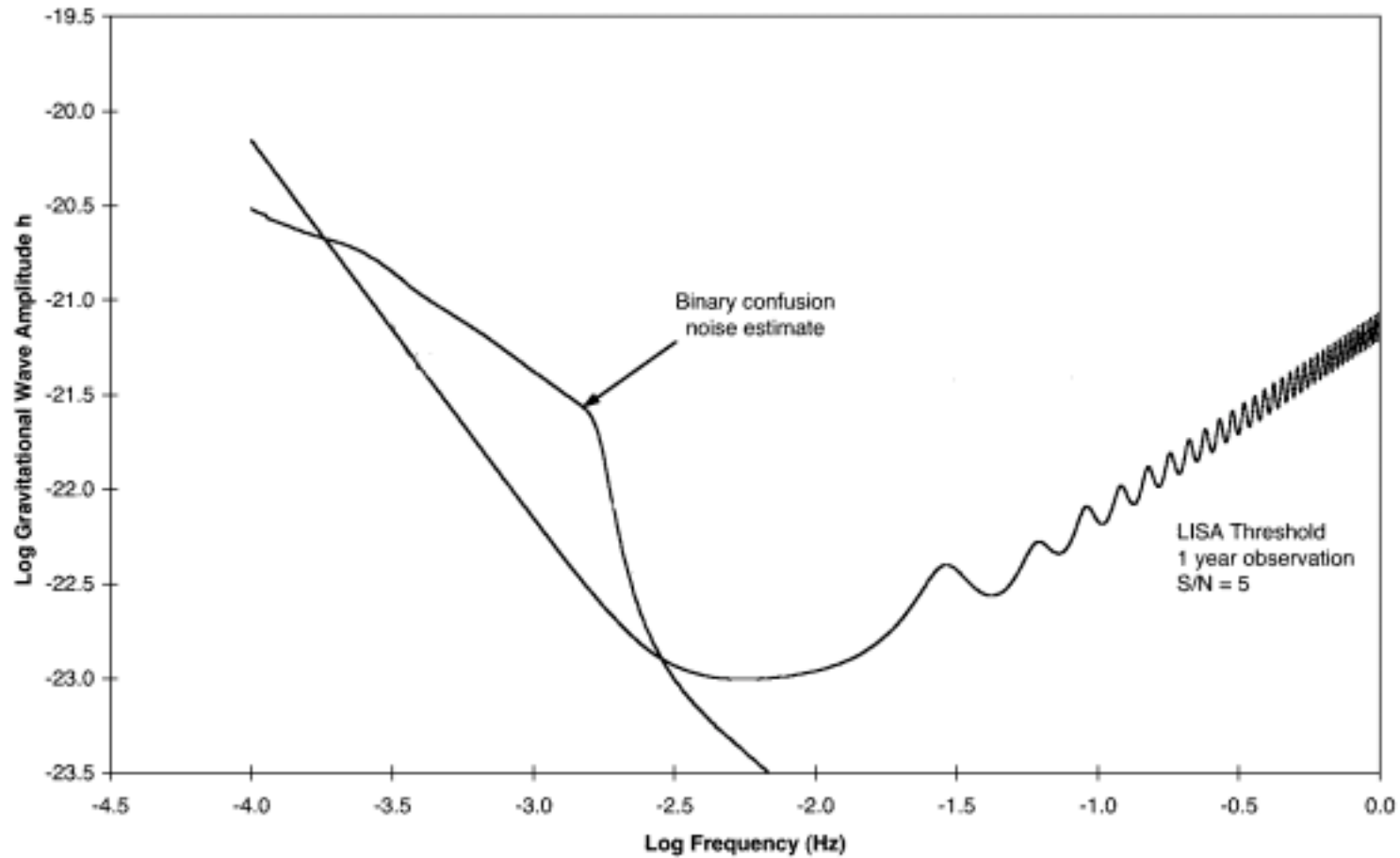
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Motivation and Focus

- The galactic population of close white dwarf binaries will produce a confusion-limited foreground in the LISA frequency band.
- Although considered “noise” if your interest lies in extra-galactic sources, it is signal if your interest is more local.
- Galactic globular cluster binaries will lie in the LISA band, but will compete with disk white dwarf binaries.
- Disk population of white dwarf binaries will be interesting in it’s own right.

Model of the binary background



Bin-averaged, time-averaged, angle averaged

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Creating a model of the binary background

- Generate binaries
 - Initial Mass Function
 - Binary separation at formation
 - Dynamics of binary evolution
- Generate current period distribution
 - Star formation rate
- Generate population density
 - Spatial distribution of progenitors
 - Evolution of spatial distribution

Evolutionary effects on the background model

- Mass distribution
 - Low-mass components of the binary background merge at lower frequencies and drop out of the population if they coalesce or move back down to lower frequencies if they undergo stable mass transfer
 - Change the shape of the high frequency tail
- Star formation rate
 - If non-uniform, it results in population spikes which will disperse as high mass components evolve more quickly.

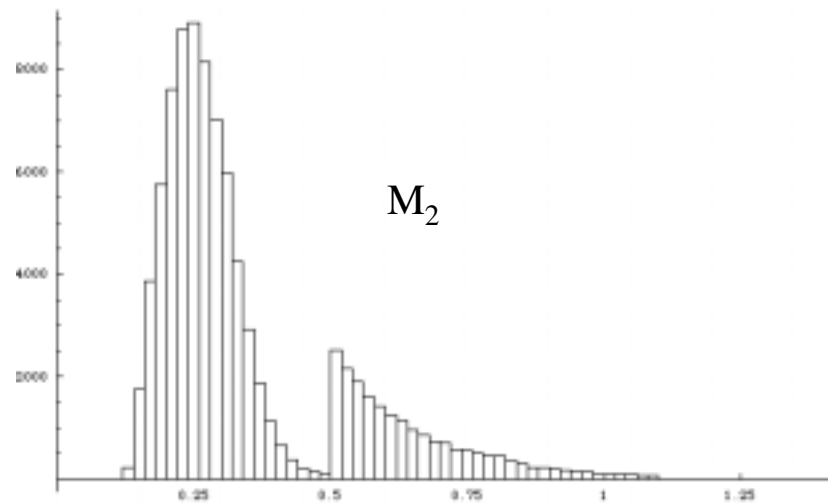
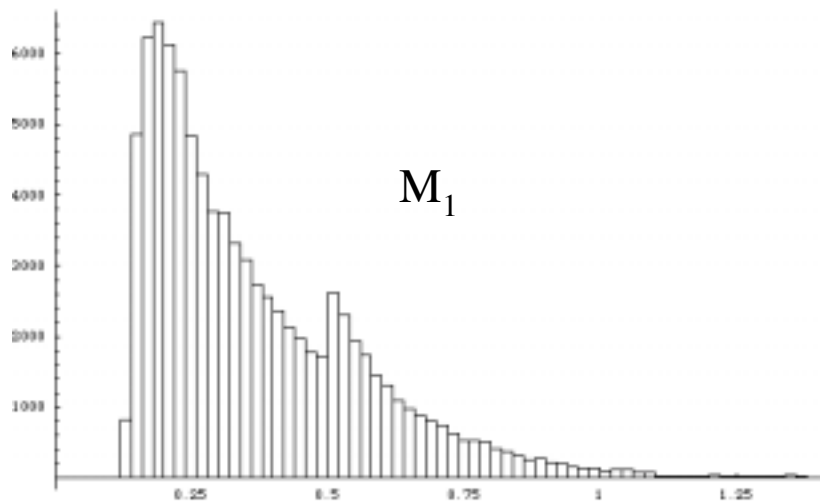
Spatial effects on the background model

- Population density
 - Confusion limit level is determined by the distance at which you have 100% probability of finding a binary in the frequency bin
- Scale height
 - If $r < r_0$ then the number of binaries grows as r^3
 - If $r > r_0$ then the number of binaries grows as r^2

Simulating the Binary Background

- Generating Binaries
 - Binary types from Nelemans et al. (2001)
 - White dwarf masses from Iben & Tutukov (1986)
 - Orbital period at birth from Nelemans et al. (2001)
- Generating current period distribution
 - Constant star formation rate
- Generating population density
 - Use local density of Hils, Bender, & Webbink (1990)
 - Use galactic spatial distribution of:
$$\rho = \rho_0 r^{-1} e^{-R/H} \operatorname{sech}^2(z/h)$$
with $H = 2500$ pc and $h = 200$ pc
- Create h_1 and h_2 of Cutler (1998)

Binary Population Masses

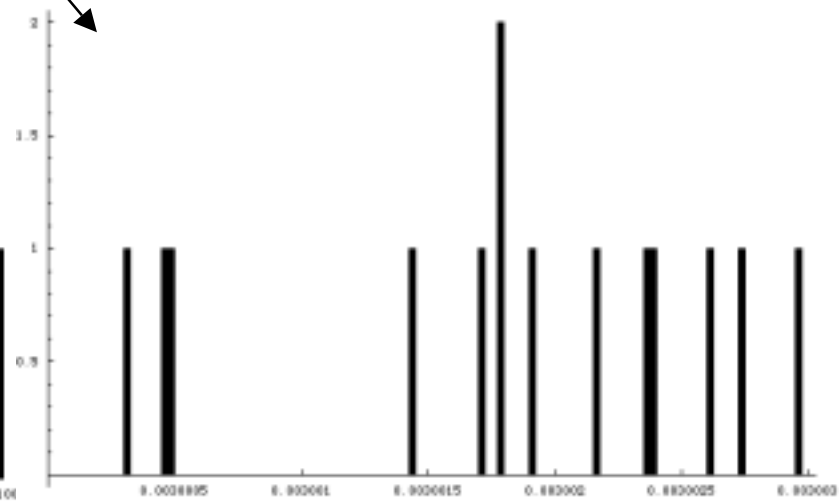
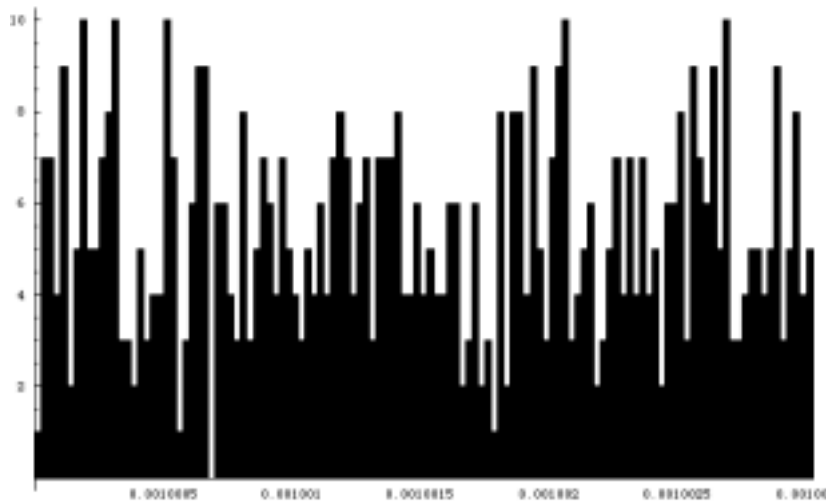
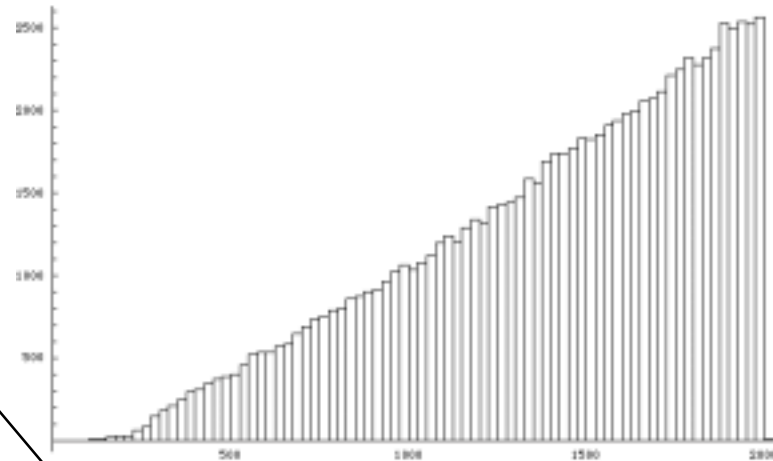


Binary Population Period and Frequency

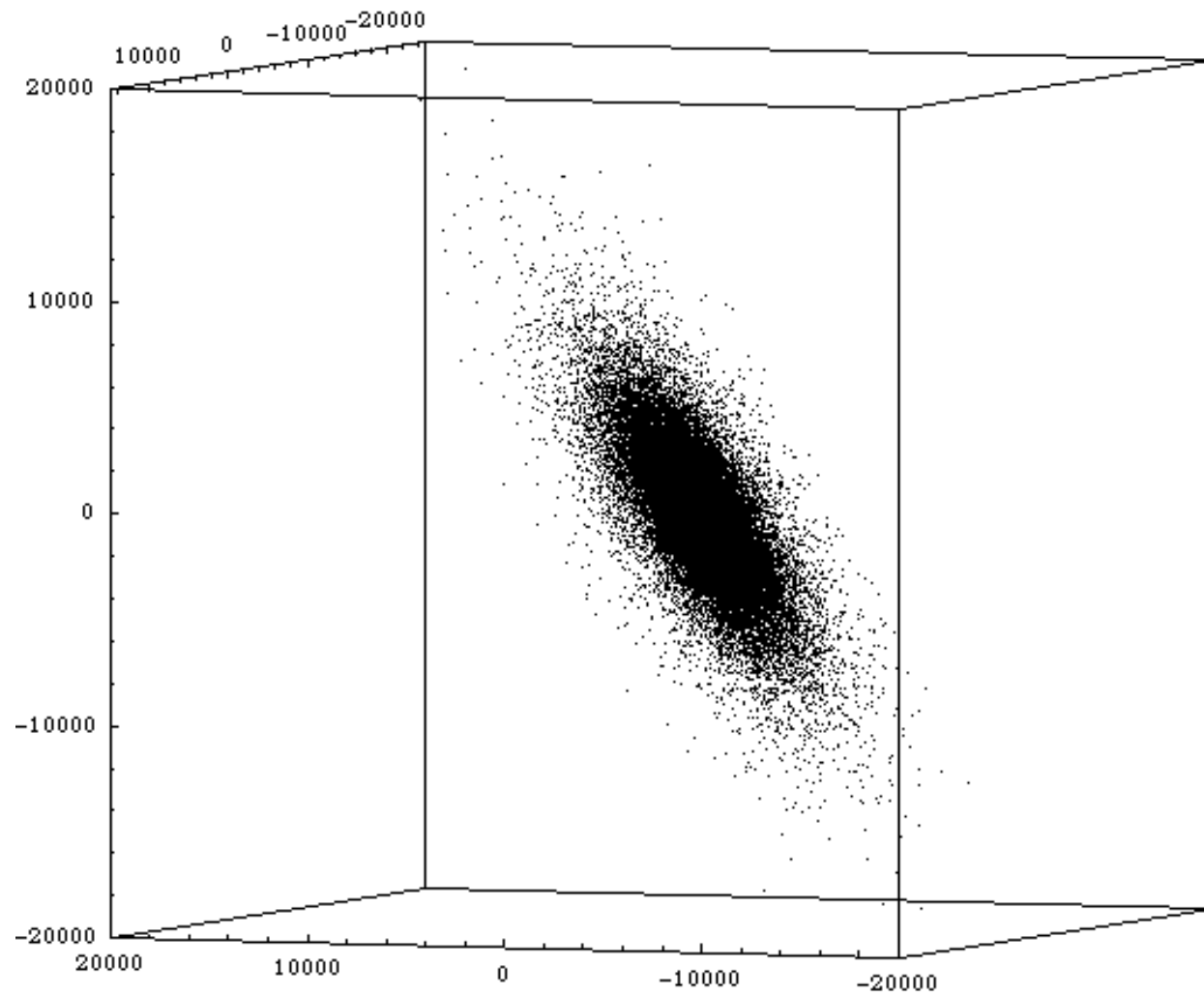
Orbital period \longrightarrow

100 bins above 3 mHz

100 bins above 1 mHz



Spatial distribution

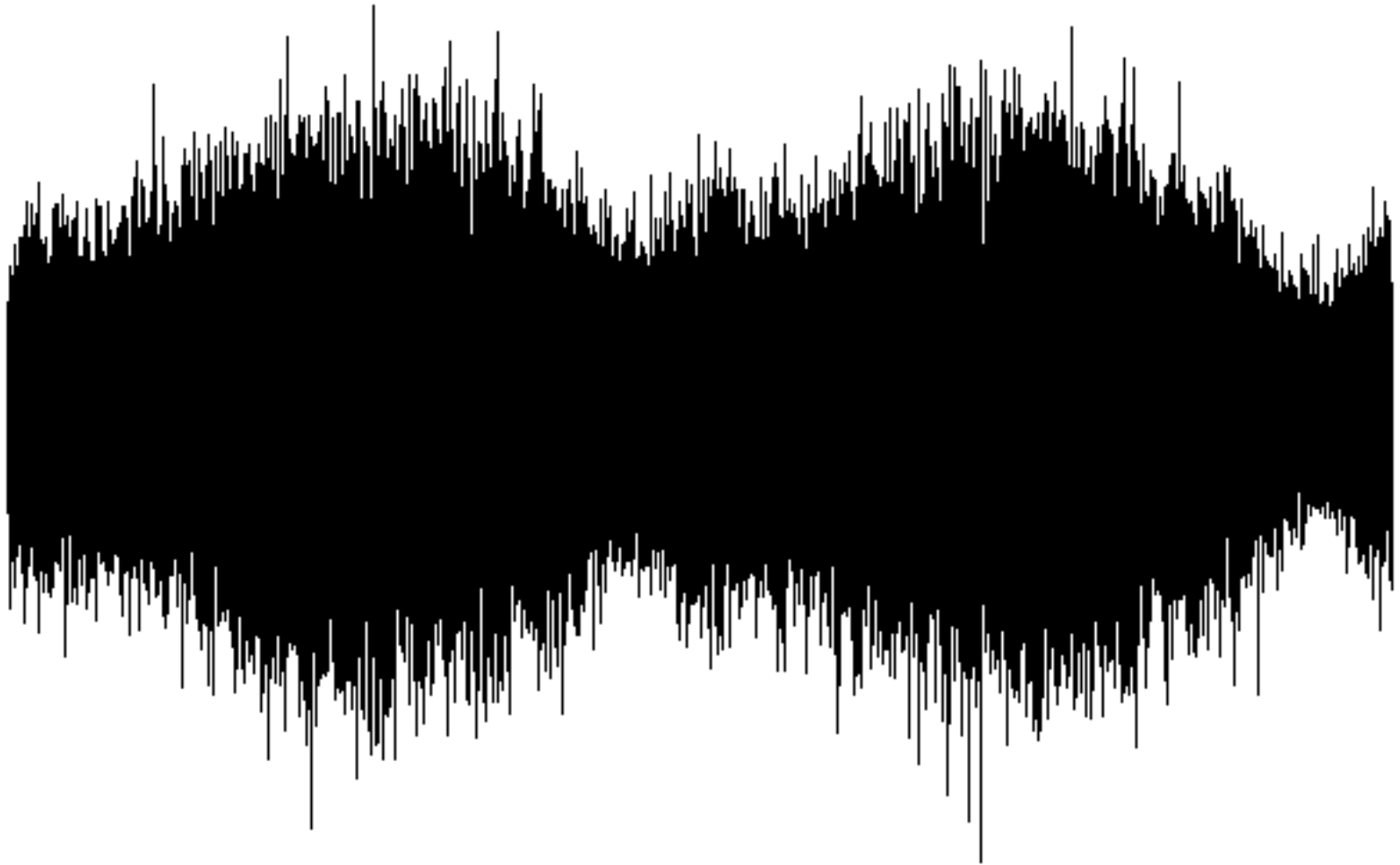


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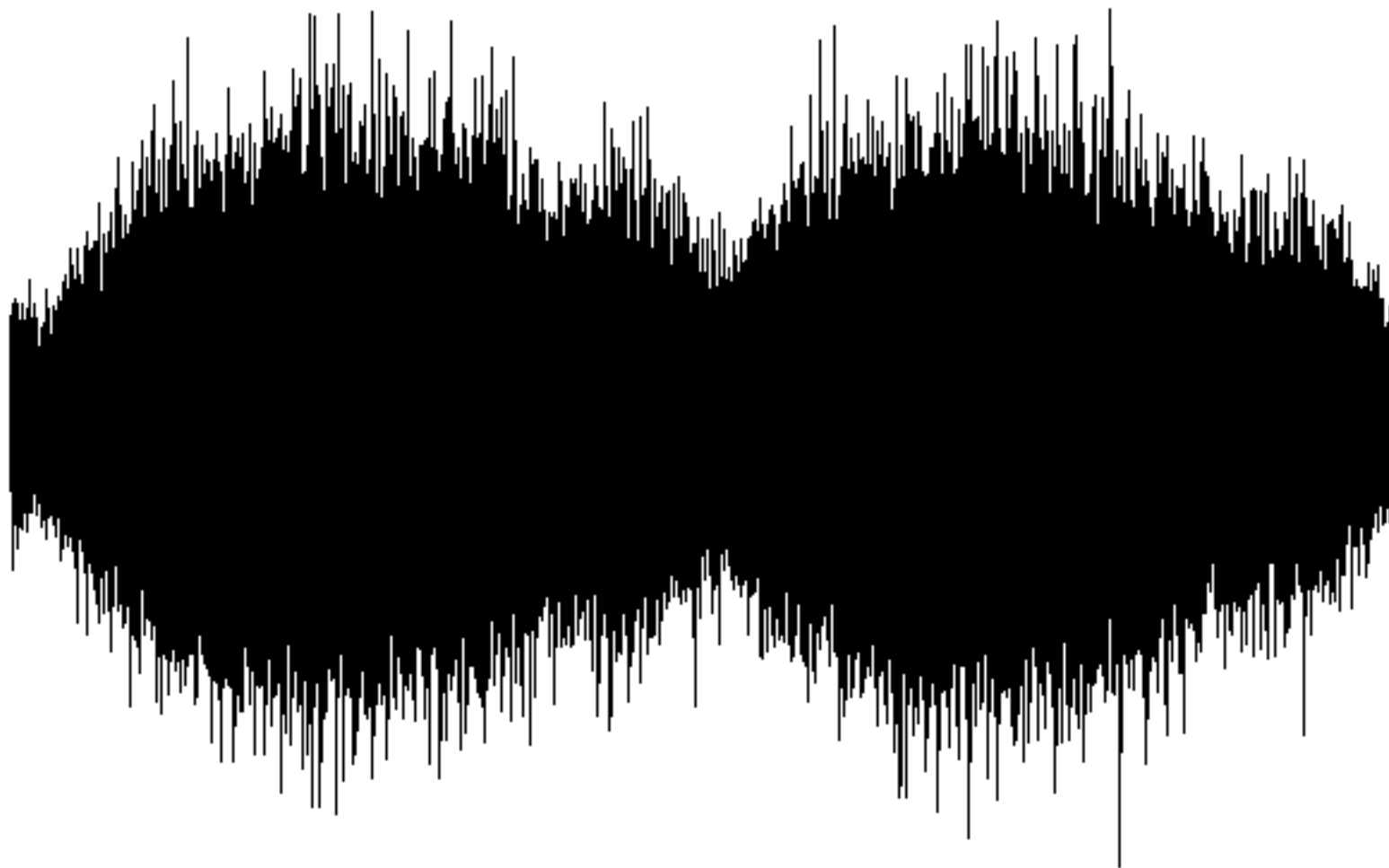
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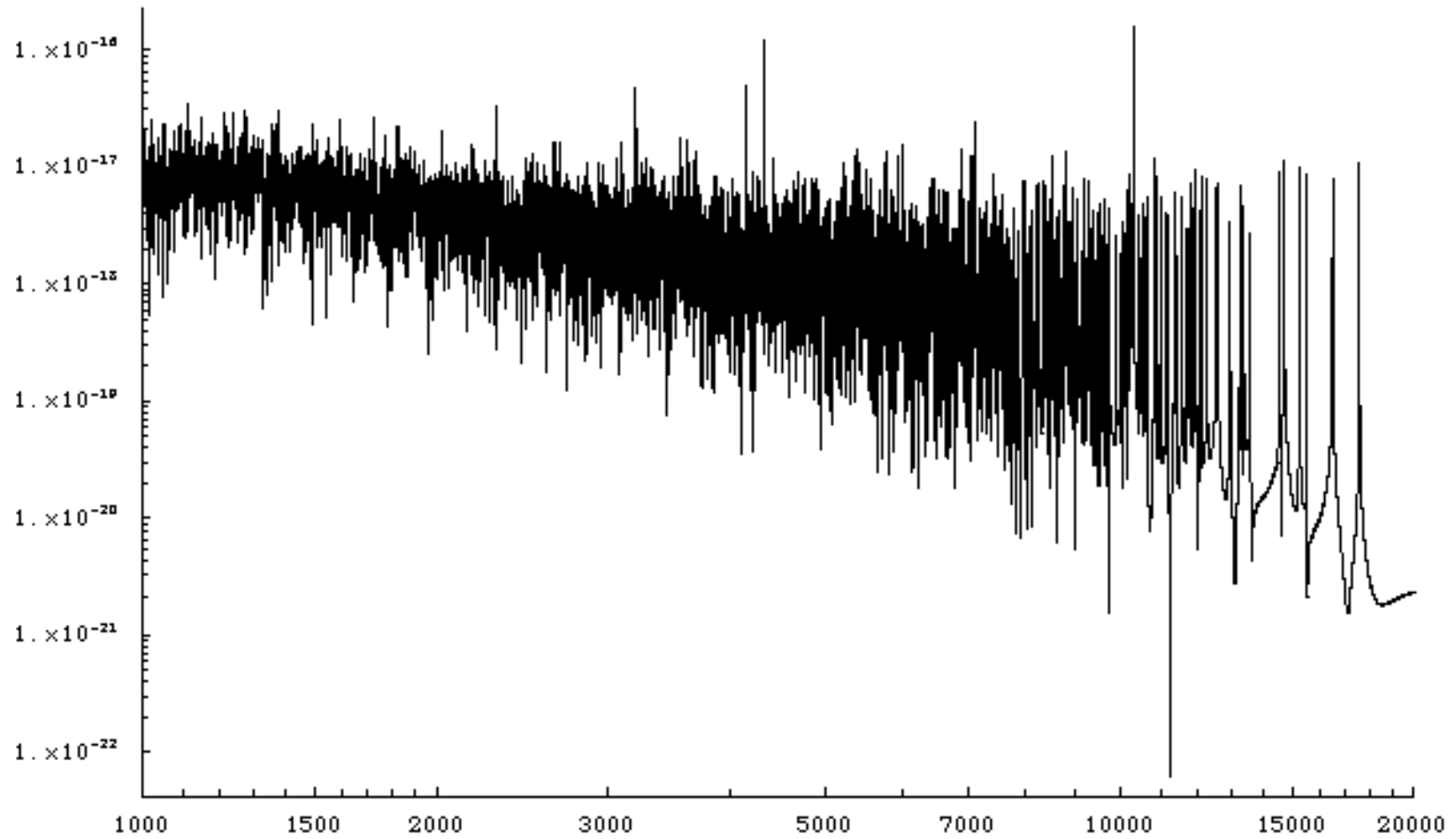
Time-domain simulation: h_1



Time-domain simulation: h_2



Spectrum



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Compact Binaries in Globular Clusters

- Old populations
 - Lots of evolved objects (white dwarfs, neutron stars, black holes)
- Star formation rate is a spike
 - Current period distribution depends on dynamics of large N-body systems
- Population density is a ball
 - Localized to within LISA's angular resolution

NGC 104 (47 Tuc)

- Large, nearby globular cluster
- Dense core
- Binaries formed through dynamical encounters
- Lots of *Chandra* sources
- Large number of millisecond pulsars



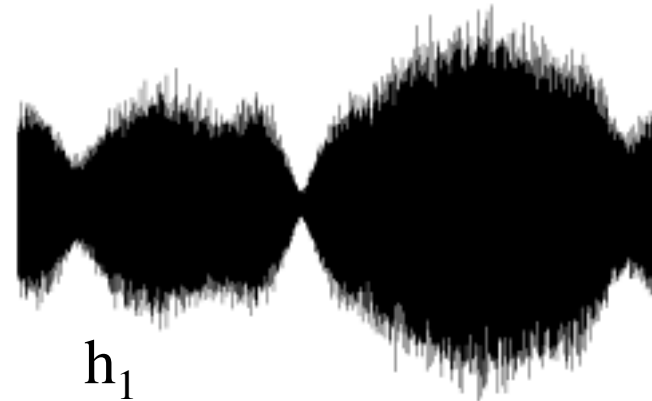
NGC 5139 (ω Cen)

- Largest galactic globular cluster
- Open core
- Binaries are primordial
- Has measurable rotation
- May be core of a dwarf spheroidal galaxy



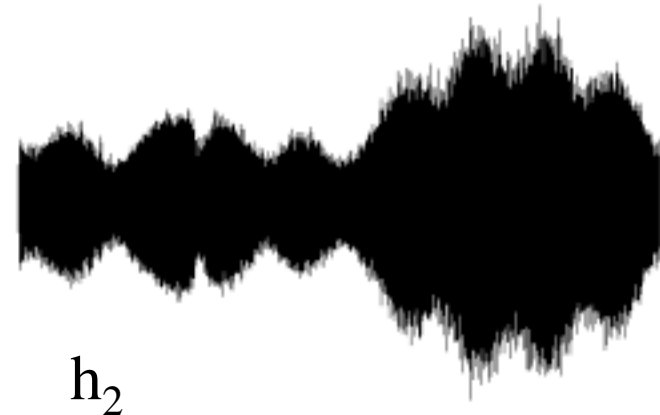
NGC 6397

- Nearest galactic globular cluster
- Probably core collapsed
- ~ 20 X-ray sources
- Evidence of mass segregation
- Binaries formed through dynamical encounters



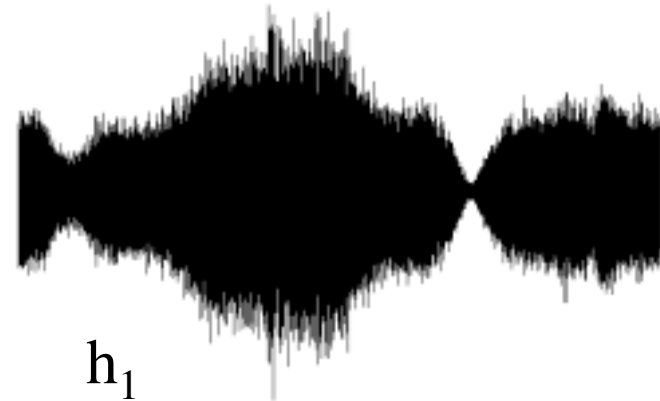
NGC 6752

- Nearby galactic globular cluster
- Core collapsed
- ~ 20 X-ray sources
- 15%-38% binary fraction in the core
- 5 millisecond pulsars
- Binaries formed through dynamical encounters

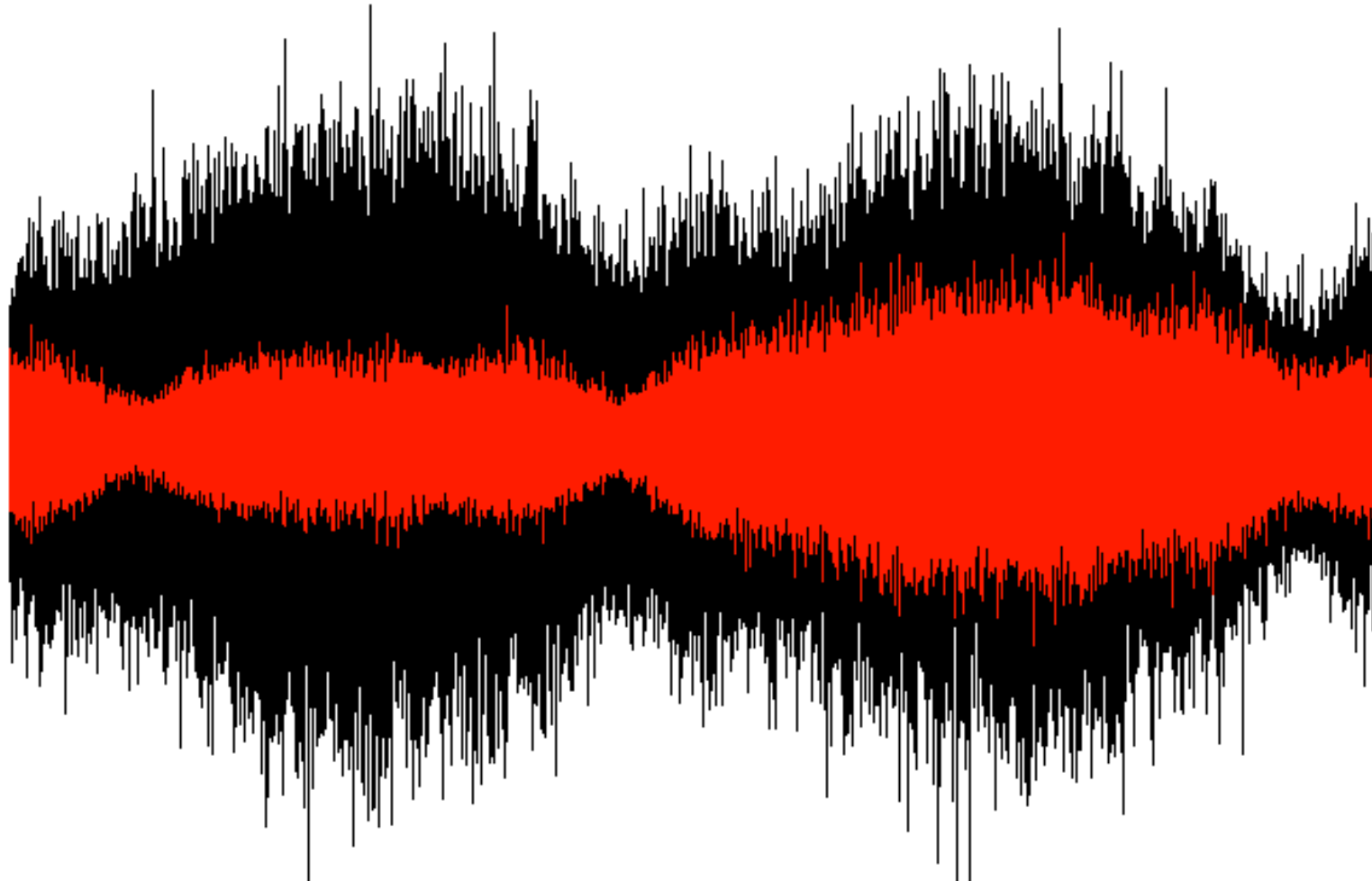


NGC 7078 (M 15)

- Distant galactic globular cluster
- May harbor an intermediate mass black hole (Gerssen et al.)
- May harbor a large number of compact objects (Baumgardt et al.)



Globular Cluster and Disk



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Questions

- To what extent can the galactic binary background be identified and characterized?
- How well can the nature of the population of galactic white dwarf binaries be determined from the confusion limited background?
- Can the signal from globular cluster populations be distinguished from the confusion limited background?
- How can the dynamics of globular cluster evolution be determined from gravitational radiation?