

# Waveforms for LISA

Wav Working Group chairs:

Deirdre Shoemaker, Maarten van de Meent, Niels Warburton, Helvi Witek

Wav Work-Package Group chairs:

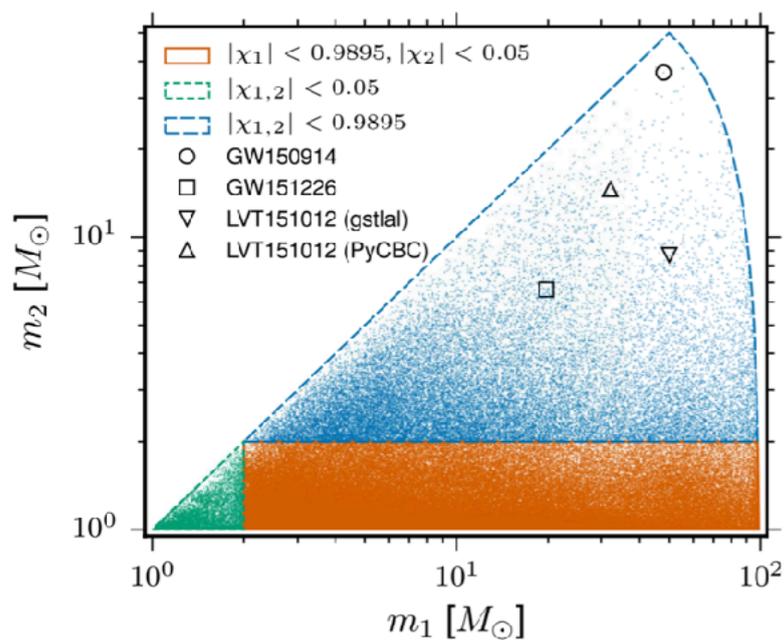
Leor Barack & **Harald Pfeiffer** (Albert-Einstein-Institute, Potsdam)

LISA Canada Workshop (virtual), April 28, 2021

# Motivation

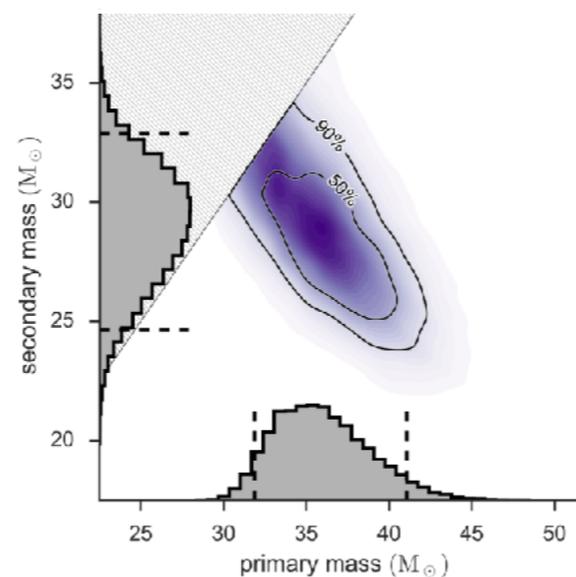
- Waveforms underpin the extraction of all science from LISA
- similar to LIGO/Virgo

## Detection



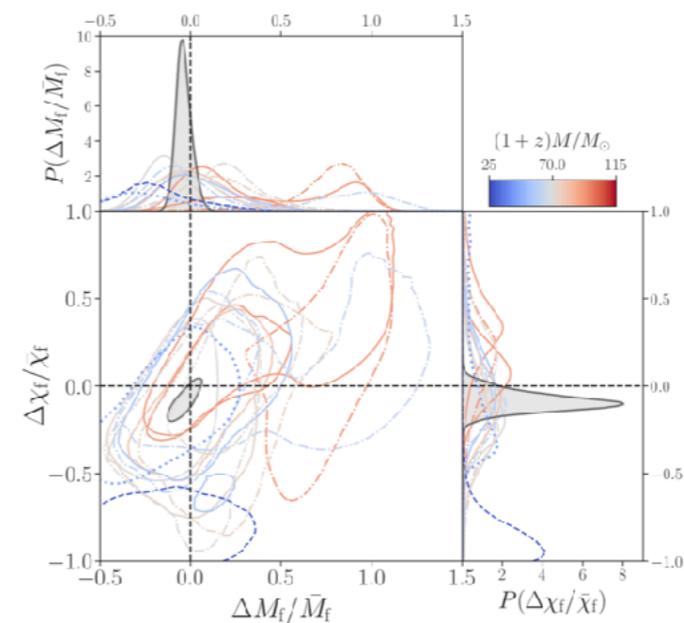
LIGO+Virgo, PRX 2016 (1606.04856)

## Parameter estimation



"GW150914" Abbott+ PRL 12016

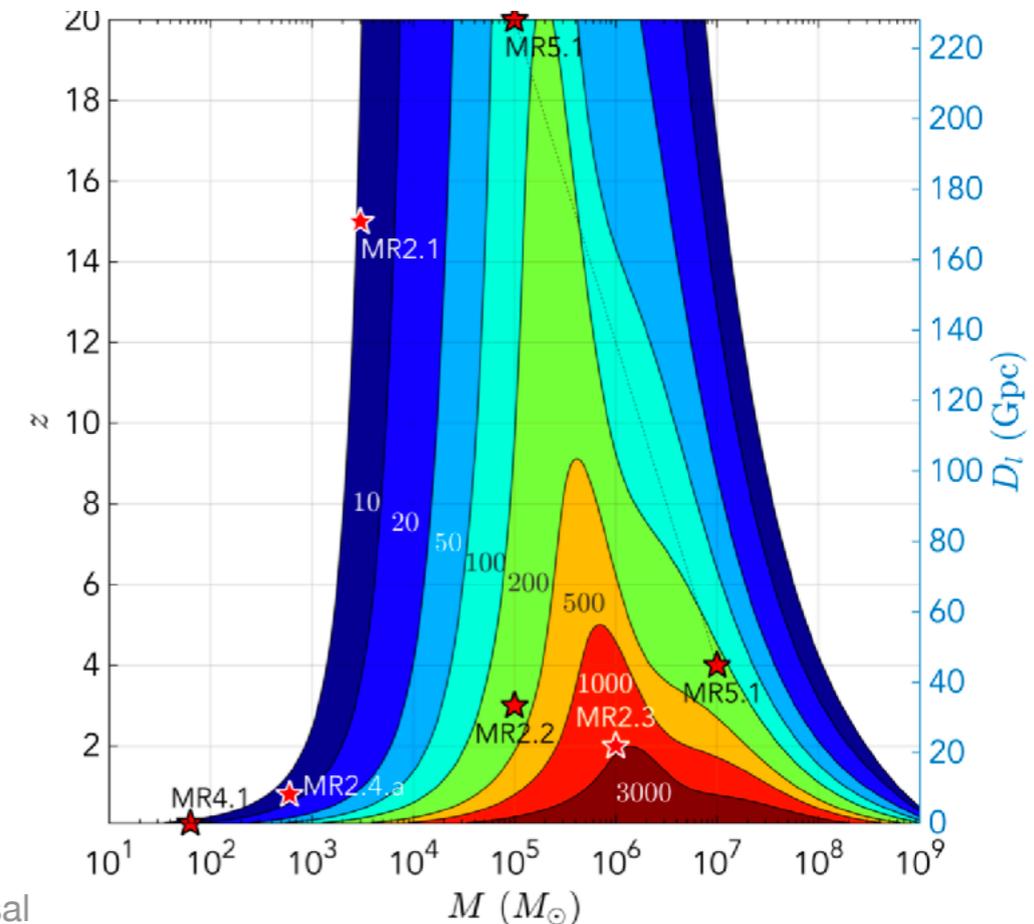
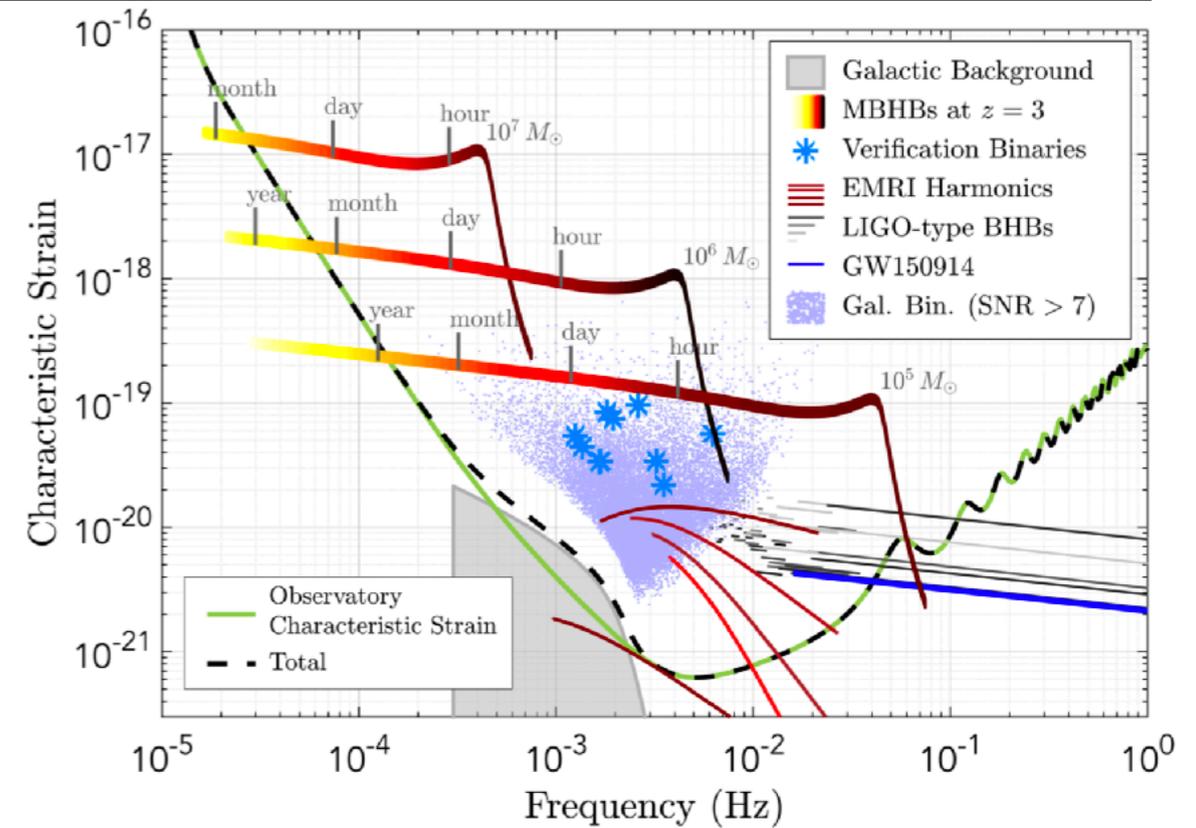
## Testing GR



LIGO+Virgo (2010.14529)

# LISA is harder than (current) ground-based GW detectors

- **More diverse sources**
  - novel types
  - more extreme parameters
- **Higher SNR**
- **More ambitious science goals**
  - e.g. eccentricity measurement to  $\delta e < 0.001$



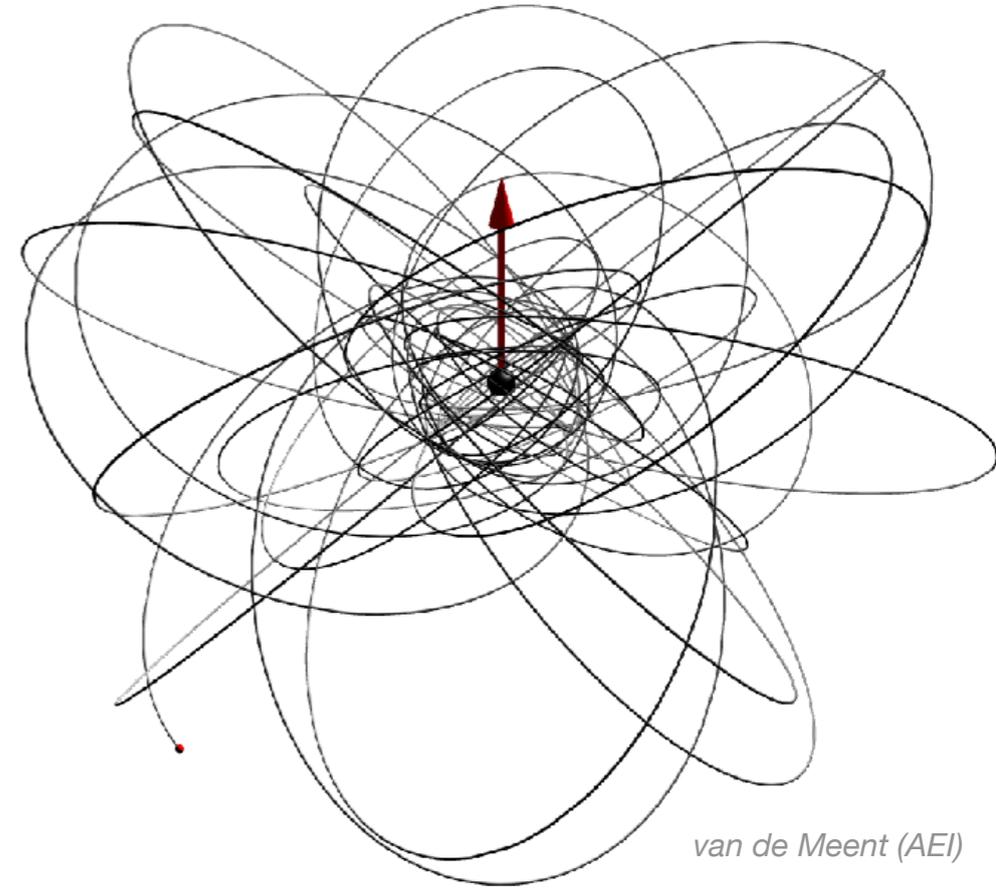
# Primary goals and tasks

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Ensure that the quality of LISA Science is not limited by capability to solve Einstein's equations

# Astrophysical sources

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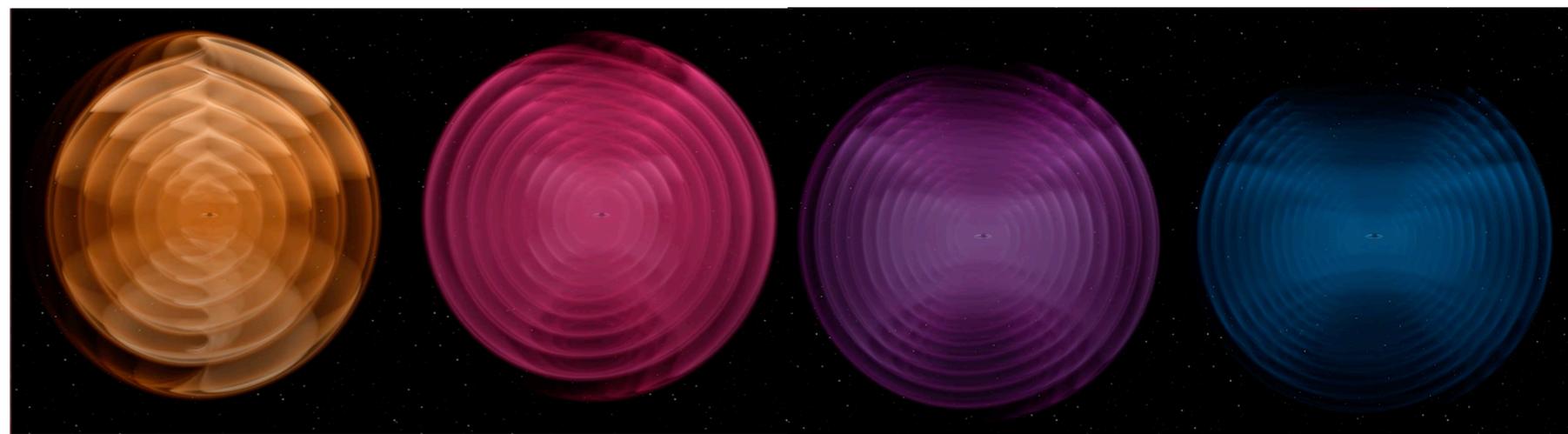
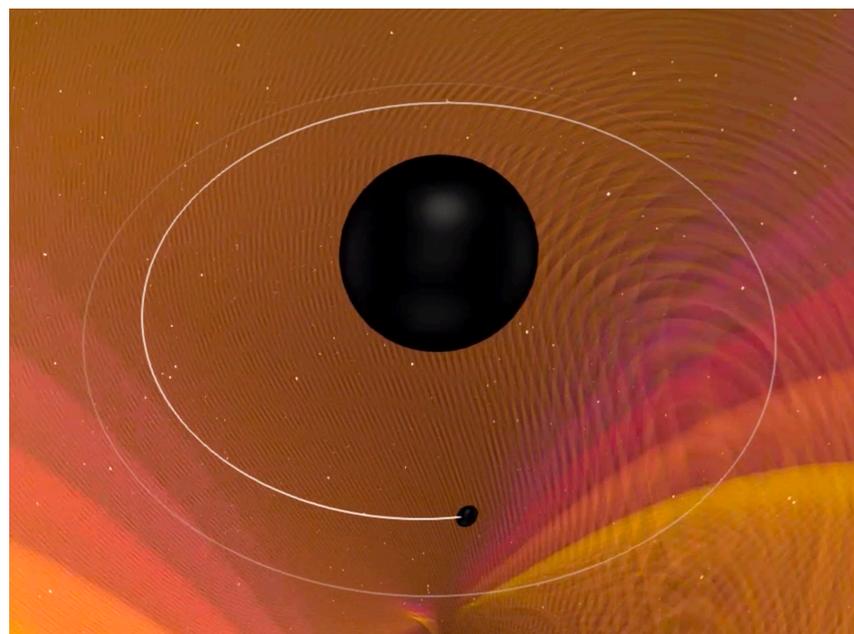


## 2 LISA Sources

2.1 Massive black hole binaries (MBHBs) . . .	
2.2 Extreme mass-ratio inspirals (EMRIs) . .	
2.3 Intermediate mass-ratio inspirals (IMRIs) .	
2.4 Galactic Binaries (GBs) . . . . .	
2.5 Stellar origin black hole binaries (SOBHBs) . . . . .	15
2.6 Transient sources, cosmic strings, and other sources . . . . .	17
2.7 Beyond GR and beyond standard model sources . . . . .	20

# Modeling approaches & tools

<b>4</b>	<b>Modelling approaches for compact binaries</b>	<b>34</b>
4.1	Numerical Relativity	34
4.2	Weak field approximations (post-Newtonian/post-Minkowskian)	46
4.3	Small mass-ratio approximation (Gravitational Self-Force)	56
4.4	Effective one body models	66
4.5	Phenomenological waveform models	73
<b>5</b>	<b>Waveform generation acceleration</b>	<b>81</b>
5.1	Computational techniques	81
5.2	Hardware accelerators / configurations	85

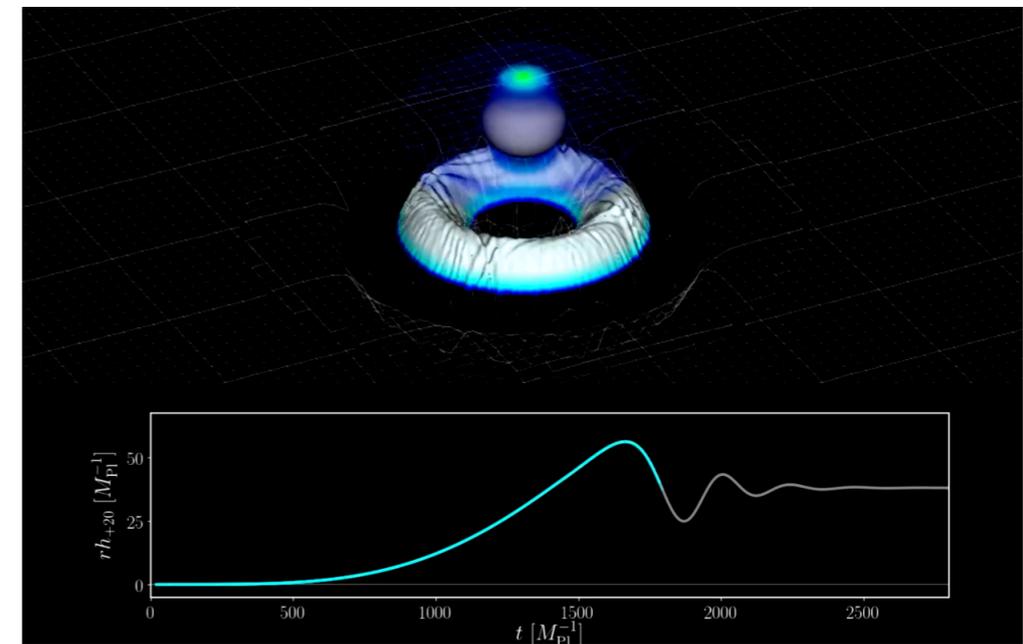


Fischer, Pfeiffer, Buonanno (AEI)

# beyond GR

## 6 Modelling for beyond GR, beyond standard model, and cosmic string

<b>sources</b>	<b>88</b>
6.1 Numerical Relativity . . . . .	88
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6.3 Perturbation theory for post-merger waveforms . . . . .	93
6.4 Self-force . . . . .	
6.5 Effective-one-body waveform models . . . . .	
6.6 Phenomenological waveform models . . . . .	
6.7 Modeling for cosmic strings . . . . .	



Aurrekoetxea ea 2020, <https://youtu.be/-dhYA2788LA>

# Fine print, which matters

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<b>3</b>	<b>Modelling requirements</b>	<b>26</b>
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3.2	Efficiency considerations . . . . .	29
3.3	Interface and data format requirements . . . . .	32

# Organization

- **Waveform Working Group**

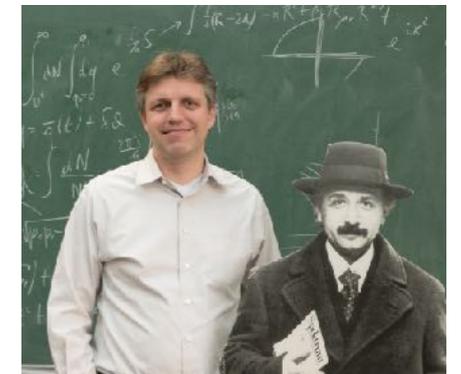
- Entry point for interested people
- presently 199 members
- Preparing Whitepaper
- Chairs: Deidre Shoemaker, Maarten van de Meent, Niels Warburton, Helvi Witek



email: [wav-wg-chairs@lisamission.org](mailto:wav-wg-chairs@lisamission.org)

- **Waveform Work-Package Group**

- subset of researchers who commit research time to LISA efforts
- Work-packages roughly structured by source-type
- Chairs Leor Barack, Harald Pfeiffer



- **Very big overlap** between both groups

# Getting involved

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- Join the Waveform Working Group (WavWG)
- **Annual meetings** (modulo pandemic)
- **monthly WavWG calls** to learn more
- Immediate opportunity:
  - **Read & give feedback** on the WavWG whitepaper
    - learn what's going on
    - connect to others researchers in WavWG
    - opportunity to feed back your knowledge
- Students & Postdocs are very welcome to join