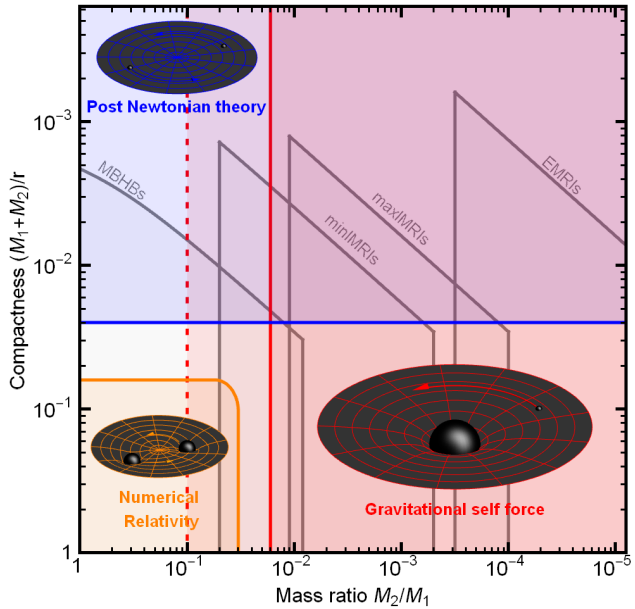
LISA Waveform modelling and the AstroWG

Maarten van de Meent
Co-chair LISA Waveform Working Group



LISA Astrophysics Working Group Meeting, Nijmegen 10 March 2020

No waveforms, no GW science

Waveform templates are essential for (almost) any science investigation involving gravitational waves. We needed for:

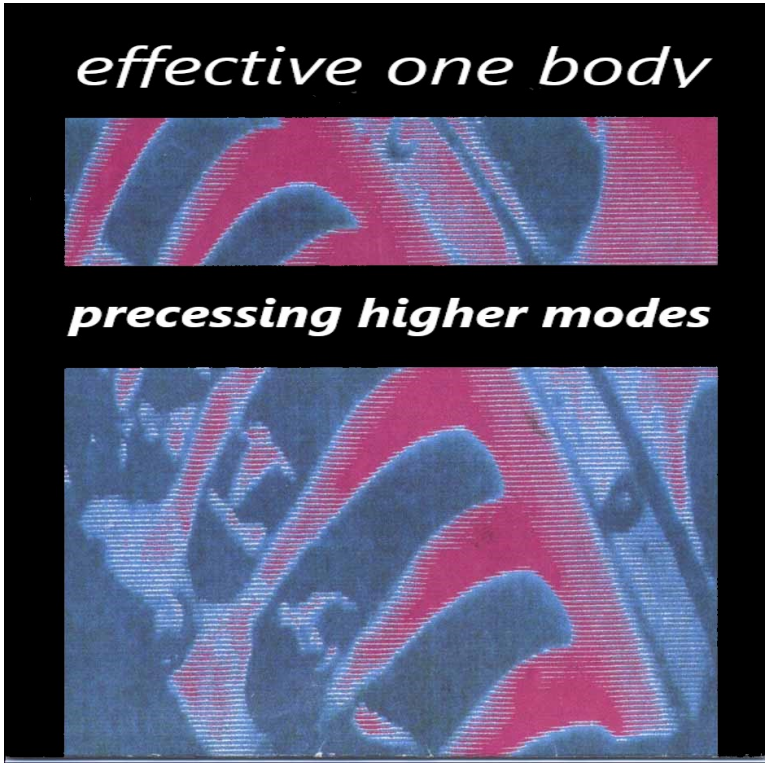
1. Detection of sources
2. Identification of source parameters
3. Source subtraction in “global fit”

Current status waveform modelling

State-of-the-art

For use with LIGO/Virgo/KAGRA, the current best waveform models include:

- Quasicircular inspirals (no eccentricity)
- Precessing spins
- Higher (multipole) modes
- Mass ratios between $\frac{1}{10}$ and 1.



Not good enough

These waveform models will not be sufficient for LISA (or 3G ground based observatories)...

Main challenges in LISA waveform modelling

Mass-ratio

- Extreme (intermediate) mass-ratio inspirals
- MBHBs can have mass-ratios as low as $1:100$?

Eccentricity

Many sources (EMRIs, GBs, MBHBs?, SOBHBs?) will exhibit some level of eccentricity.

Accuracy

Needed waveforms that are more faithful than current LIGO models by several orders of magnitude.

Speed

Needed waveforms that can be evaluated on sub-second timescale.

LISA Waveform Work Packages

Responsibility

Provide waveform related deliverables for the consortium.

Coordination:

Leor Barack and Harald Pfeiffer

WP1: Waveforms

1.1. Waveform requirements (Ed Porter)
- 1.1.1 EMRI/IMRI requirements (Maarten van de Meent)
- 1.1.2 MBHB/SOBH requirements (Richard O'Shaughnessy)

1.2. Provide EMRI waveforms (Leor Barack)
- 1.2.1 Self-force theory (Adam Pound)
- 1.2.2 Implementation (Niels Warburton)
- 1.2.3 non-GR and environmental effects (Richard Brito)

1.3. Provide MBHB waveforms
- 1.3.1 Numerical Relativity (Deirdre Shoemaker)
- 1.3.2 Analytical Modelling (Tanja Hinderer)
- 1.3.3 non-GR and environmental effects (Paolo Pani)

1.4. Provide GB waveforms (Guillaume Faye)

1.5. Provide IMRI waveforms (Eliu Huerta)

1.6. Provide SOBHB waveforms
- 1.6.1 PN Modelling (Sylvain Marsat)
- 1.6.2 NR Modelling (Carlos Lousto)

1.7. Other modelled transient events (Barry Wardell)

1.8. Waveform interface and tools
- 1.8.1 Tools for generating ROM
- 1.8.2 Efficient MBHB models (Sascha Husa)
- 1.8.3 Efficient EMRI models (Alvin Chua)

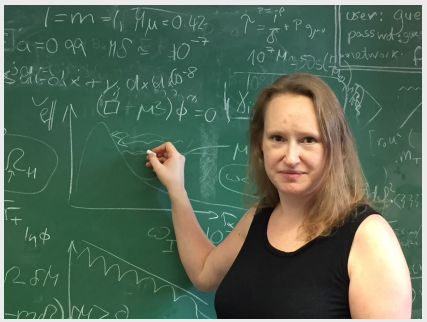
LISA Waveform Working Group

Chairs (wav-wg-chairs@lisamission.org)

Deirdre Shoemaker

Maarten van de Meent

Niels Warburton



Helvi Witek

Responsibilities

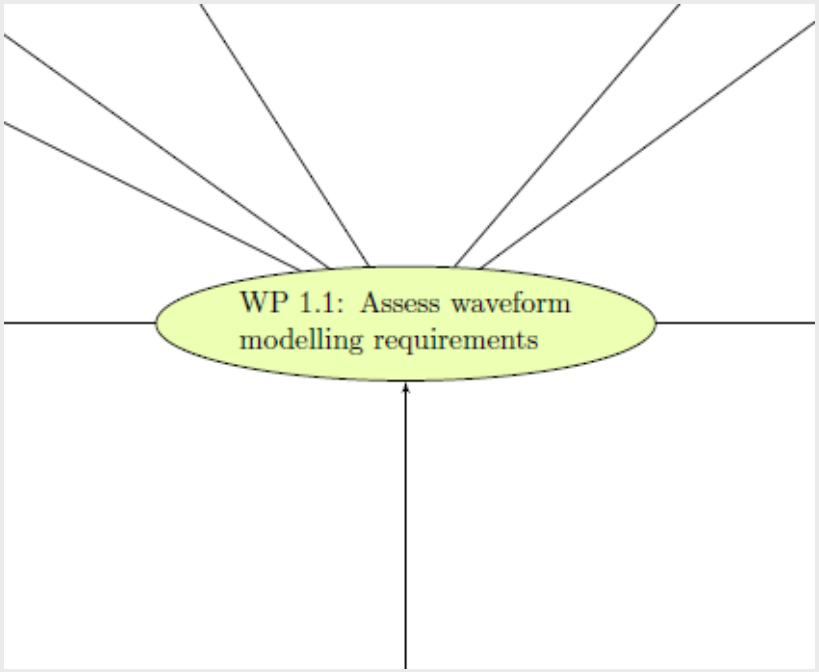
- Manage waveform community
- Monitor waveform developments (white paper)
- Talent pool for WPs

Inputs required

The LISA waveform modelling efforts will need some inputs form the astrophysics working group.

Questions

At the root of it all...



Environmental effects:

What kind of astrophysical environmental effects (third bodies, external potentials, accretion disks) should be taken into account? (Presumably mostly an issue for EMRIs and galactic binaries?)

Parameter space coverage:

- What parameter to expect?
- Any range that we need to be able to exclude?
- Are there any sources (MBHBs?) with mass-ratios between $1:10$ and $1:100$?
- eccentricity?

Other sources?

Are there any (potential) LISA sources that can be modelled and are not currently on the radar?

Whitepaper wishlist

1. Consensus predictions for event rates.
2. Consensus predictions for event parameter distributions.
3. Inventory of potential environmental effects.

The End

Thank you for your attention!