

Discussion on model independent tests

LISA in Copenhagen

SIWP Sub-WP Goals Related to Fundamental Physics

https://docs.google.com/document/d/1dUQemVsxj-7c_qpiZ1TieqgaYU99sog23cvdmBwdgpg/edit

purpose: to gather thoughts from the FP WG on sub-WP goals related to fundamental physics

wish to **revisit/reassess** these goals

0. Theory Specific Tests

construction of waveforms in non-GR theories

- extension of post-Newtonian analyses
[synergy between traditional PN, EFT, scattering]
- effective-one-body methods
- black hole perturbation & self-force techniques
- numerical relativity simulations
[scalar-tensor, quadratic gravity, ...]

1. Model Independent Tests

Parametrized Tests

- parametrized models including higher PN corrections in the inspiral, as well as merger-ringdown, also extension of parametrized EOB
- need to understand the potential of parametrized tests of gravity with LISA by considering specific sources for LISA, such as super-massive BH binaries, EMRIs, galactic binaries and multi-band sources [already done by e.g. Perkins, Yunes & Berti 2010.09010?]
- extension of PPE waveform to large spin precession and eccentricity [precessing PPE waveforms in Loutrel, Pani & Yunes 2210.10571]
- parametrized models for EMRIs, including DM effects [inspired by Barsanti+ 2212.03888 for light scalar fields]

inspiral-merger-ringdown-consistency tests

- need to study how well LISA can do in IMR consistency tests
[partially done using Fisher analysis]

2. Violations of the Equivalence Principle

Sensitivities in non-GR Theories

- sensitivities for compact objects computed in only limited theories of gravity [scalar-tensor theories, Einstein-dilaton Gauss-Bonnet gravity, Einstein-AEther theories, Horava gravity, ...
not much on higher order sensitivities (higher derivatives)]
- tidal effects (3PN effect in ST)

3. Modified Dispersion Relations

Anisotropic Dispersion Relations

- momentum-dependent dispersion relation of gravitons in Lorentz-violating gravity with preferred frames

4. GWs with cosmological screening

GW Propagation

- Study how cosmological screening affects the propagation of GWs.

GW Generation

- Study how cosmological screening affects the generation of GWs.

5. Astrophysical Systematics

Resonances in EMRIs

- tidal resonances being activated onto EMRIs (relativistic version of the Kozai-Lidov effect), causing large amount of dephasing in the waveform [also self-force resonance in GR; non-Kerr resonance]

Distinguishing Non-GR & Astrophysical Effects

- Astrophysical effects vary from one source to another, while non-GR effects (or fundamental theoretical constants controlling such effects) are common in all sources. Should be able to distinguish statistically.

some discussion points

- Which of the items need to be updated?
- Other important tests of GR to be added? (Especially those that LISA can probe better than ground-based detectors)
e.g. polarization tests? SGWB?
- Are codes needed to achieve these goals well-understood?
If yes, please add relevant codes to the sheet here:
<https://docs.google.com/spreadsheets/d/13Nk5tuwmE-07KjNSp5Hqck0nko5JhK6J8wEiiSGqFLs/edit?usp=sharing>

other discussion points

- Do we need pipelines that are different from LIGO's when testing GR with LISA?
- What model-independent tests, other than PPE, should we include for future WP studies in terms of mission designs?
- anything else from the audience?