Istituto Nazionale di Fisica Nucleare

Iniziativa Specifica TEONGRAV - Sezione di Pisa

Gravitational Wave Sources

The TEONGRAV Network

10 Research Units:

Milano, TIFPA, Torino, SISSA, Padova, Firenze, Roma, GSSI, Napoli, Pisa *(from 1/1/2023)*

National Coordinator: Bruno Giacomazzo (Milano Bicocca)

Local Coordinators:
(from 1/1/2023)

- Bruno Giacomazzo (Milano Bicocca)
- Albino Perego (TIFPA)
- Enrico Barausse (SISSA)
- Michela Mapelli (Padova)
- Alessandro Nagar (Torino)
- Luca Del Zanna (Firenze)
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The PISA Local Unit of TEONGRAV (formally active from 1/1/2023)

At the moment there are Staff Members only:

- Leonardo Gualtieri (100%) [in University of Pisa from today 1/7/22!]
- Walter Del Pozzo (10%)
- Ignazio Bombaci (10%)

we plan to extend soon the unit to PhD students and postdocs as well.

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We address the following questions:

- Which are the features of the GW signal emitted by the sources of present (Virgo, LIGO) and future (ET, LISA) detectors? We consider comparable mass binaries of black holes and/or neutron stars, extreme mass-ratio inspirals, rotating neutron stars.

- Which information on the emitting source could be extracted from a GW detection? For instance, what could we learn on the equation of state of the matter in the inner core of a neutron star? Could we find hints of dark matter around black holes?

- Which information on the nature of gravity could be extracted from a GW detection? For instance, which could be the imprint of modifications or extensions of general relativity on the gravitational wave signal from astrophysical sources?

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We are part of the *LISA consortium* and of the *ET Observational Science Board*

Some of our lines of research:

- Modelling of BH binaries and of the emitted GW signals beyond GR
  - comparable mass binaries: inspiral, merger, ringdown
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  (e.g. PRD 99, 064035 '19; PRD 101, 124055, '20; PRL 125, 141101 '20; PRD 103, 124017 '21; CQG 39, 105055 '22; Nat. Astron. 6, 464 '22; arXiv:2203.05003)

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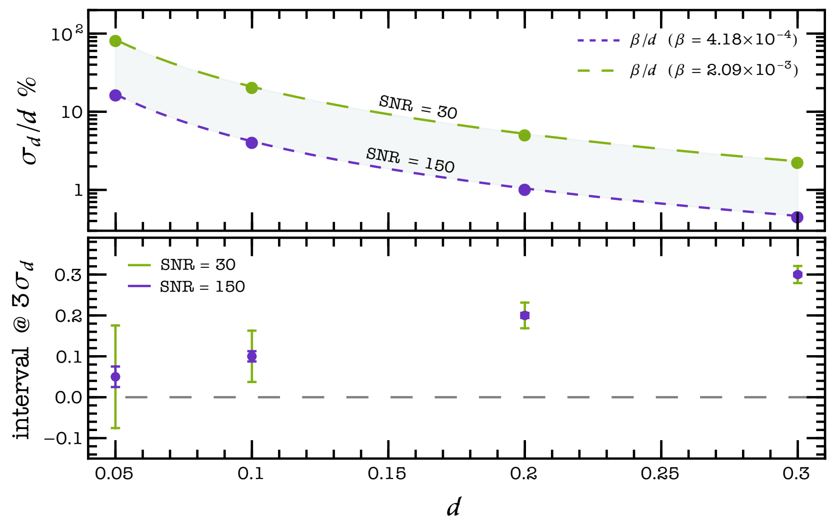
We have shown that a (ultra-light) scalar field coupled with gravity would affect the GW waveform in a theory-independent way, and even very small scalar charges would be detectable by LISA



Nat. Astron. 6,464 '22

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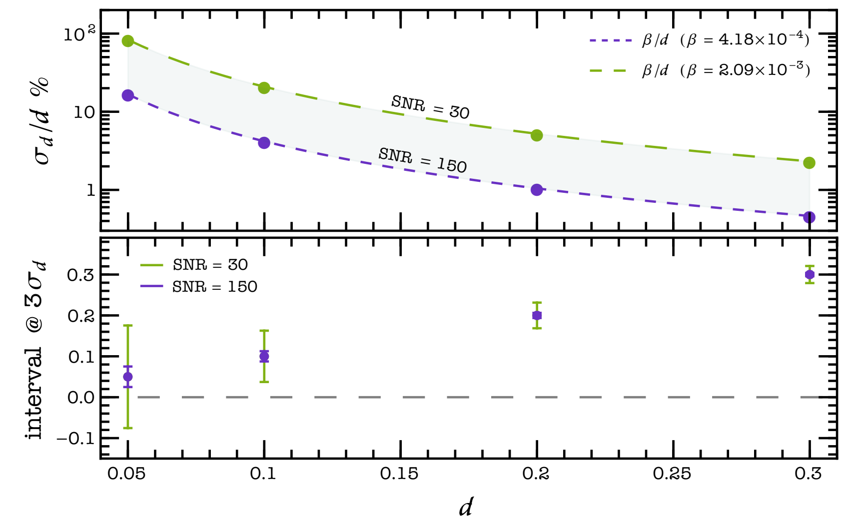

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The scalar field could be that of a modified gravity theory as for instance scalar Gauss-Bonnet gravity

$$S = \frac{1}{16\pi G}\int d^4x\sqrt{-g}\left\{R - \frac{1}{2}\partial_\mu\phi\partial^\mu\phi + \alpha_{GB}f(\phi)\mathcal{R}^2_{GB}\right\} \qquad (\mathcal{R}^2_{GB} = R_{\mu\nu\alpha\beta}R^{\mu\nu\alpha\beta} - 4R_{\mu\nu}R^{\mu\nu} + R^2)$$

or an ultra-light dark matter candidate, but these results are fully general

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  - spontaneous scalarization
  - floating orbits

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- Binary neutron stars as probes of the NS equation of state
  - tidal deformations in late inspiral
  - multimessenger observations

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- Inference of astrophysical and cosmological models

  (e.g. PRD 105, 104066 '22; PRD 105, 043509 '22)