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LISA AND SYNERGIES WITH ELT

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Abstract. LISA is a low-frequency gravitational wave experiment, which will have the ability to detect merging massive black holes with masses in the range $10^4 - 10^7$ solar masses. Some of these events are expected to have an electromagnetic counterpart, and multi-messenger observations can inform us on the physical conditions when and where massive black hole merge: the relative role of gas and stars in the dynamical evolution of binaries, constraining accretion physics – and how that differs from single massive black holes, the delay between galaxy and massive black hole mergers. Furthermore, if we can measure the redshift via electromagnetic observations we can constrain cosmological parameters, since gravitational wave measurements provide the luminosity distance. At variance with LIGO/Virgo, which can perform these cosmological tests only at low redshift, LISA has the capability of detecting massive black hole mergers out to high redshift. Since LISA's massive black holes have relatively low masses, the sources will be relatively faint: high-sensitivity telescopes, such as ELT, are expected to play a crucial role in characterizing these sources. I will discuss possible synergies between LISA and ELT in this context.

Keywords: massive black holes, gravitational waves, electromagnetic counterparts

1 Introduction

LISA is a ESA+NASA mission, planned for the mid-2030s. Laser Interferometers in space with 2.5 Mkm armlength and sensitivity at 10^{-4}-0.1 Hz gravitational wave (GW) frequency. The expected sources are massive black hole ($10^4 - 10^7$ solar masses) mergers, white dwarf binaries +other compact stellar-mass binaries, extreme mass ratio inspirals (e.g., 10^6 solar masses+ 1 solar mass black holes), plus backgrounds/foregrounds.

2 Multimessenger science with LISA

2.1 Tests of General Relativity; Measure cosmological parameters

Gravitational wave sources can be standard sirens: the measured parameter is the luminosity distance. If we measure the redshift of an electromagnetic counterpart we obtain cosmological parameters and constrain several models of modified gravity, to redshift $>>$ than what LIGO/Virgo can do.

2.2 Properties of white dwarf binaries

See Baker et al. (2019).

2.3 Massive black hole/galaxy evolution

GWs provide accurate and precise measurement of black hole masses. Determine properties (e.g., mass, SFR) of the host galaxy to test how the relation between galaxies and massive black holes evolve with time.

2.4 Accretion physics in extreme conditions

Prior to merger: accretion in a circumbinary disc. Post merger: response of the accretion disc to sudden changes (mass, dynamics, kicks)

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3 Electromagnetic counterparts to MBH mergers

Massive black holes (MBHs) grow along with galaxies through accretion and MBH-MBH mergers. Over time they sweep the LISA band and shine as quasars when they accrete matter: detection possible in GW + Electromagnetic (EM) radiation. Several counterparts are predicted.

Pre-merger:

- Periodic variability;
- Spectral anomalies.

At merger:

- Burst at merger as gas plows in;
- Perturbed discs;
- Effect of recoils;
- Dual/single jet.

Sky localization improves with signal-to-noise ratio, implying that the error box decreases as we get closer to the merger proper, down to a fraction of a degree for the most favorable sources (Mangiagli et al. 2020).

LISA's MBHs have low mass, therefore the counterparts will be faint sources: ELT will be crucial for taking spectra (and obtain redshift, galaxy mass, SFR) and imaging (and ontain galaxy morphology)

4 Conclusions

There is rich multimessenger science with LISA waiting for us. Extragalactic sources are expected to be (relatively) faint: $10^4 - 10^7$ solar mass black holes in $10^8 - 10^{10}$ solar mass galaxies out to $z >> 3$. We need to measure redshift and properties of the sources: ELT is the best (if not only) telescope for the high-z sources. Synergies also with ATHENA, LSST, SKA are envisaged.

References

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