

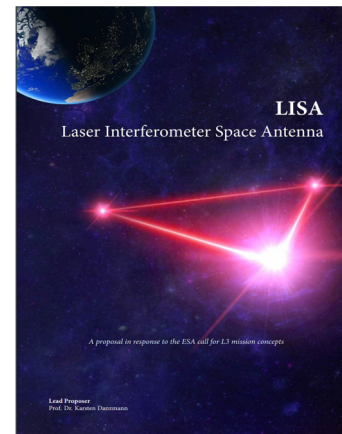
Gravitational Waves, Cosmology & Fundamental Physics



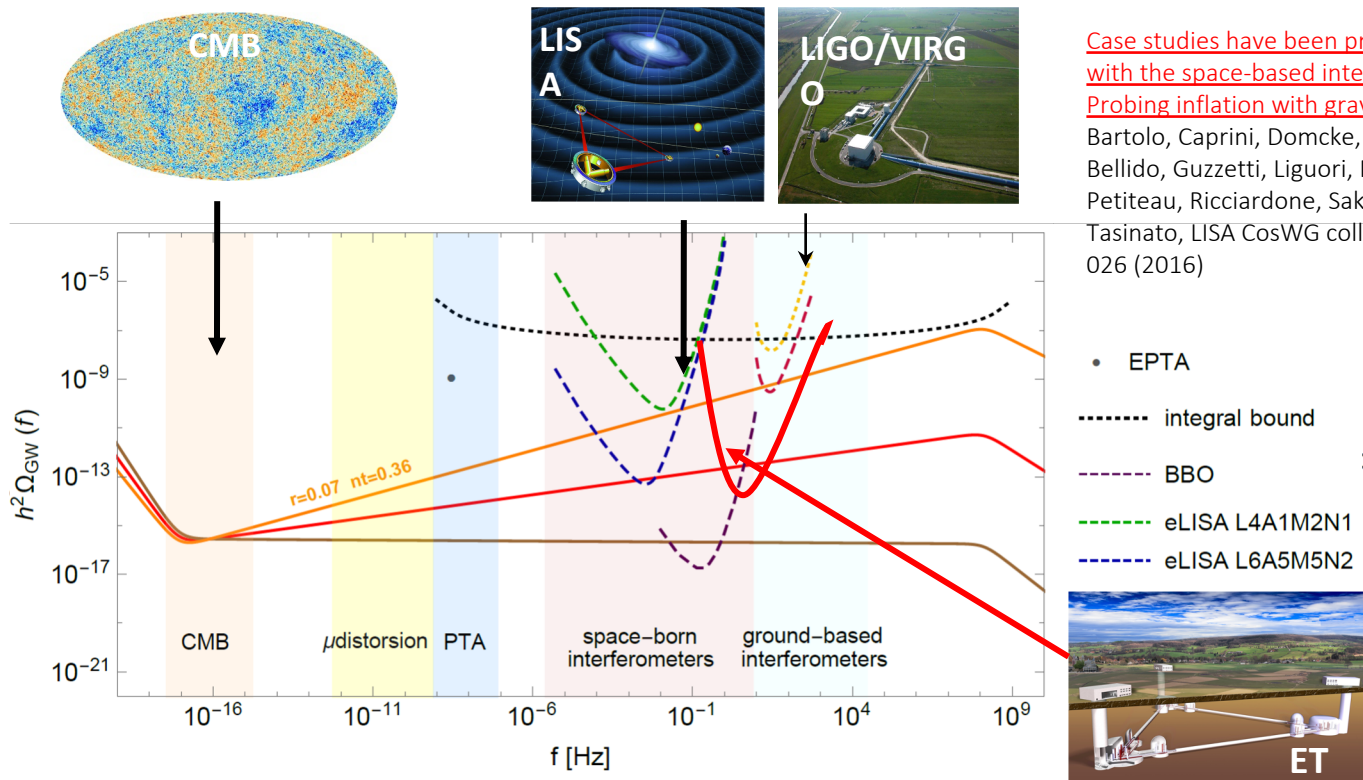
Comitato di Coordinamento della Cosmologia - C³
28 Aprile 2020

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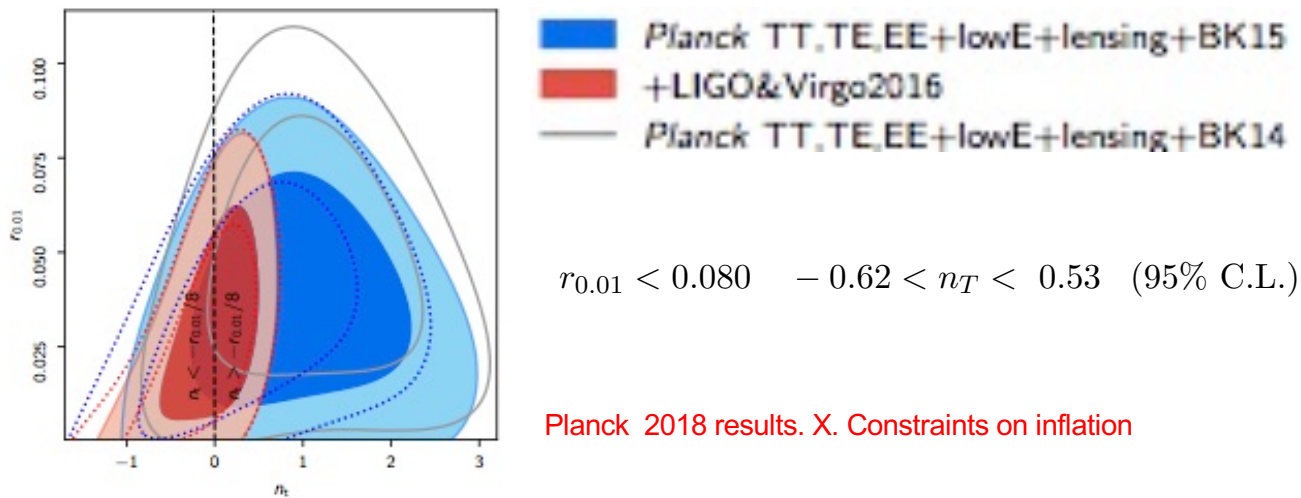
Primordial GWs: synergy between CMB and interferometers



[Case studies have been proposed in "Science with the space-based interferometer LISA. IV: Probing inflation with gravitational waves"](#), Bartolo, Caprini, Domcke, Figueroa, Garcia-Bellido, Guzzetti, Liguori, Matarrese, Peloso, Petiteau, Ricciardone, Sakellariadou, Sorbo & Tasinato, LISA CosWG collaboration, JCAP **1612**, 026 (2016)

Complementarity between CMB and interferometers

- Data from interferometers have already provided very important constraints



Different types of SGWB

Cosmological GW background: signature of the Early Universe

Inflation, preheating, reheating ($10^{-18} - 10^8$ Hz)

Phase transitions (a narrow band feature peaking at 10^{-12} Hz + broad band component in the band $10^{-5} - 1$ Hz).

Cosmic strings ($10^{-10} - 10^{10}$ Hz)

Alternative cosmologies ...

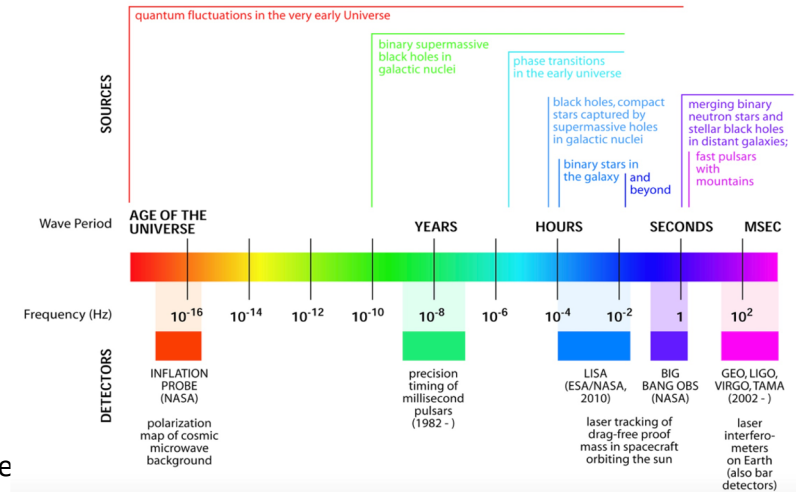
(e.g. Guzzetti et al. 2016, Caprini & Figueroa 2018; Bartolo et al. (LISA CosWG) 2018, Maggiore et al. (ET Collaboration) 2020; Barausse et al. (2020) (LISA Collaboration), ...

Astrophysical GW background (ASGWB)

Such a GW background may result from the superposition of a large number of unresolved sources since the beginning of stellar activity. Its detection would constrain the physics of compact objects, the IMF, the star formation history. It would probe the Universe at $z \sim 0.02-10$. However, from the point of view of detecting the cosmological background produced in the primordial Universe, the astrophysical background is a 'noise', which could possibly mask the relic cosmological signal

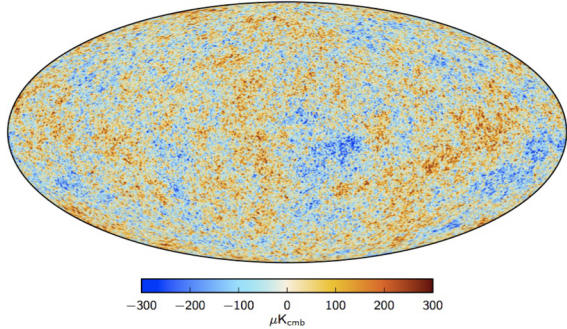
Cusin et al. 2018, ...; Jenkins et al. 2018, ...; Bertacca et al. 2019

Detectors and potential sources of GWBs across the GW spectrum



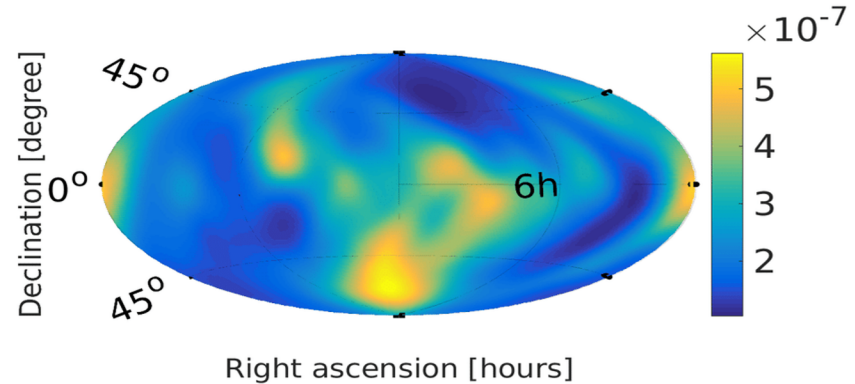
Multi-messenger Cosmology

CMB



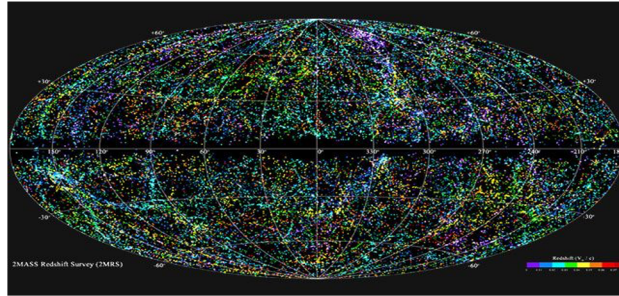
X

SGWB



X

LSS



Derivation of the angular power-spectrum of cosmological SGW anisotropies important to:

disentangle cosmological from astrophysical SGWB

probe the evolution of cosmological perturbations including primordial (scalar and tensor) NG

Common sources of anisotropies during the propagation → Cross-correlations (Bartolo et al. 2019a,b, 2020, Bertacca et al. 2019, ...).

Italian GW-Cosmology (+ Multi-messenger) Community

WARNING: this is only a partial list, to be completed with your help!

MILANO: Standard sirens,
Multi-messenger, Grav.
Lensing, ...

PISA: Standard sirens,
Parameter Estimation

ROMA: Fundamental
Physics, Multi-
messenger, Early
Universe

CAGLIARI: Multi-
messenger

NAPOLI: Fundamental
Physics

SISSA: SMBH, Galaxy
catalogues, Fundamental
Physics

PADOVA: Cosmo: SGWB,
Cross-correlations, ...
Astro: multi-messenger

FERRARA: Early Universe
BOLOGNA: Early Universe

PERUGIA: Fundamental
Physics

TERAMO: Multi-
messenger

L'AQUILA: Multi-
messenger +
Fundamental Physics



Different groups and initiatives which have a potential connection with GW & Cosmology

A partial list:

- INAF: GRAWITA - multi-messenger, cosmography
- ASTROBLACK - compact objects, ...
- INFN GR.IV: INDARK, TEONGRAV, GQSKY, TASP, QUAGRAP, ... - cosmology and fundamental physics
- COSMOS-LiteBIRD - connection with CMB and Early Universe

Scientific Priorities

- ✓ **Precision Cosmology on standard cosmological parameters** (e.g., H_0 , Ω_m , equation of state parameter, dark energy evolution, ...)
- ✓ **Tests of GR and modified gravity** models
- ✓ **Tests of fundamental physics:** Physics near the black hole horizon: from tests of GR to quantum gravity; Testing the GR predictions for space-time dynamics near the horizon. Exotic compact objects and signals from quantum gravity; Nature of dark matter; The nature of dark energy
- ✓ **(Primordial) Black Holes and Dark Matter**
- ✓ **Gravitational Waves from inflation** → **Characterization of the SGWB** (anisotropies, polarization, non-Gaussianity)
- ✓ **Impact of cosmological Large-Scale Structures on GWs**
- ✓ **Cross-correlation among CMB, LSS & SGWB**