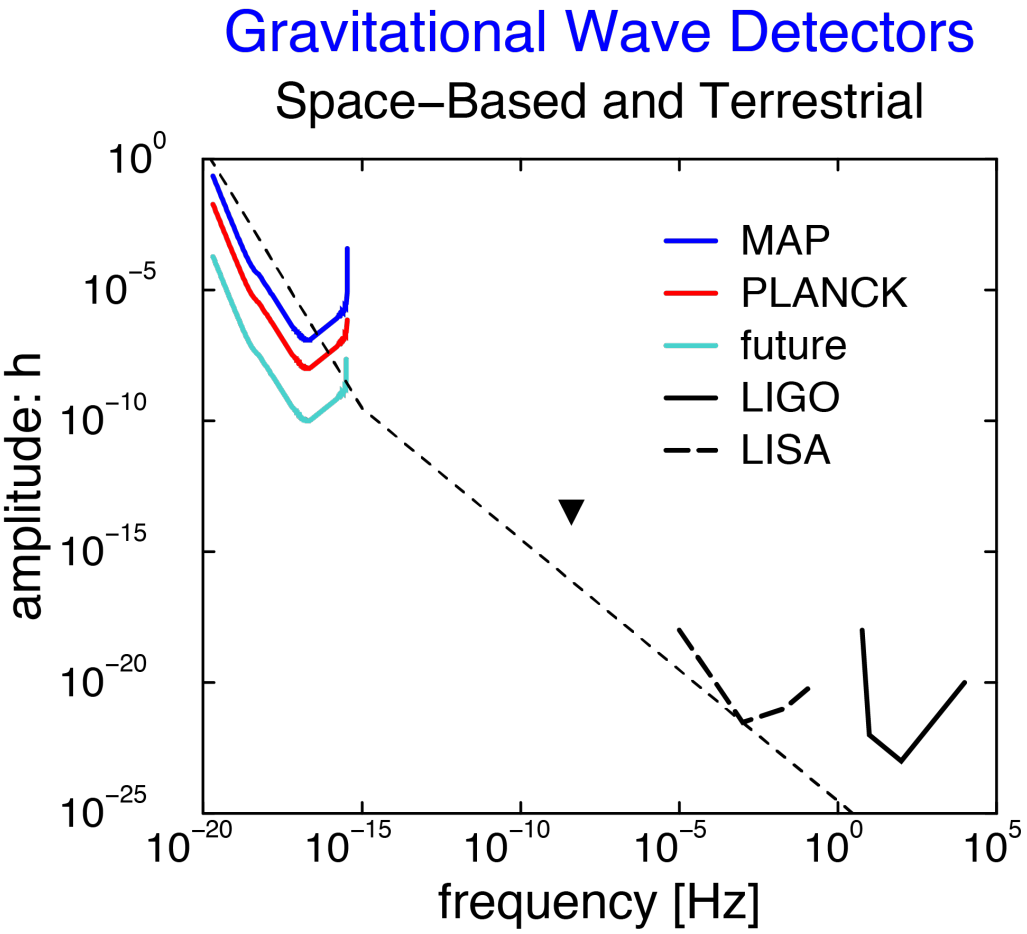
The *Laser Interferometer Space Antenna* and Gravitational Wave Cosmology across 29 decades in frequency

lisa

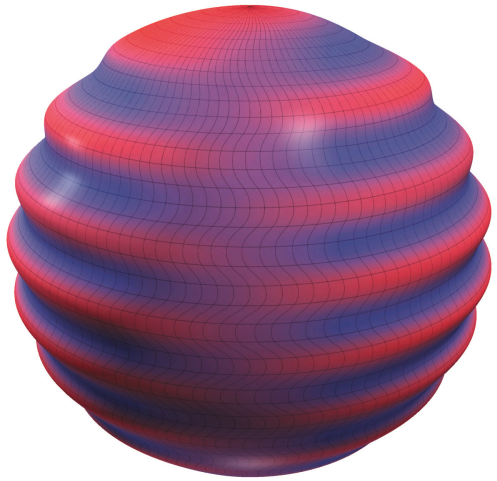
Robert Caldwell / Dartmouth College / 11 Aug 21

The First Space-Based Gravitational-Wave Detectors

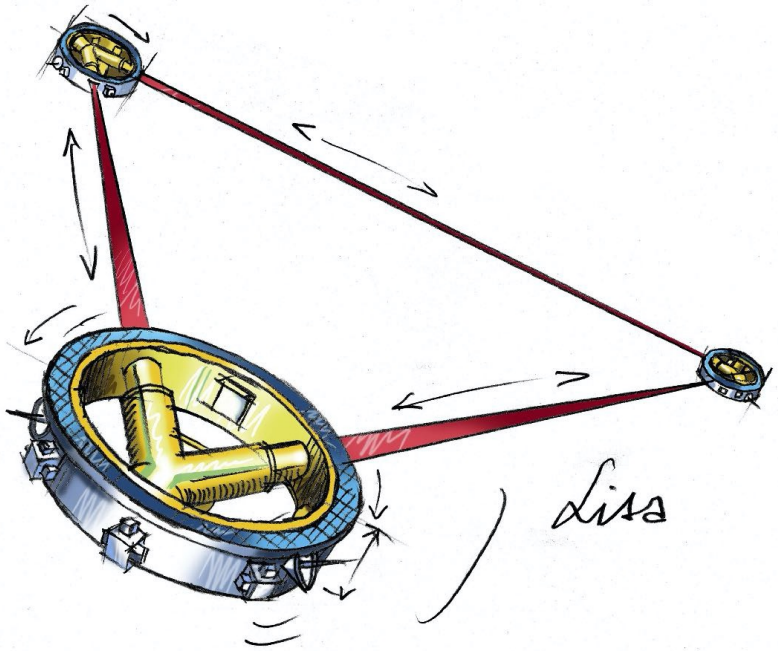
Kamionkowski, Wadley, RC 1998

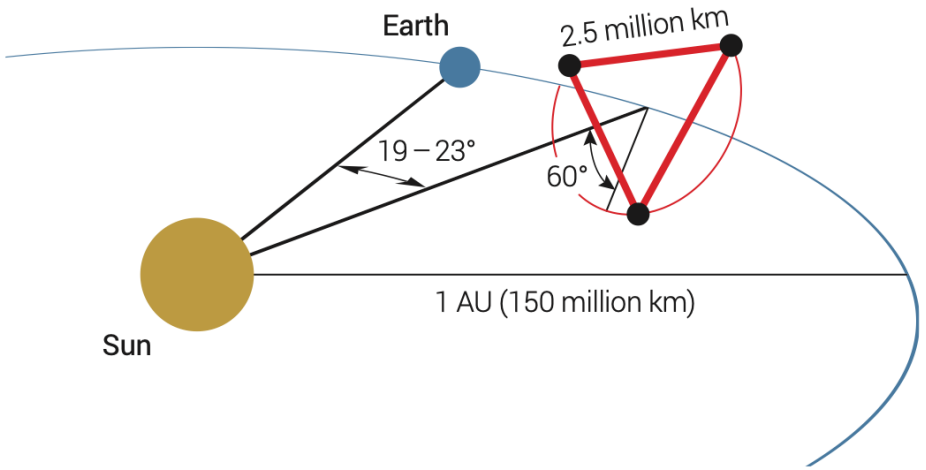


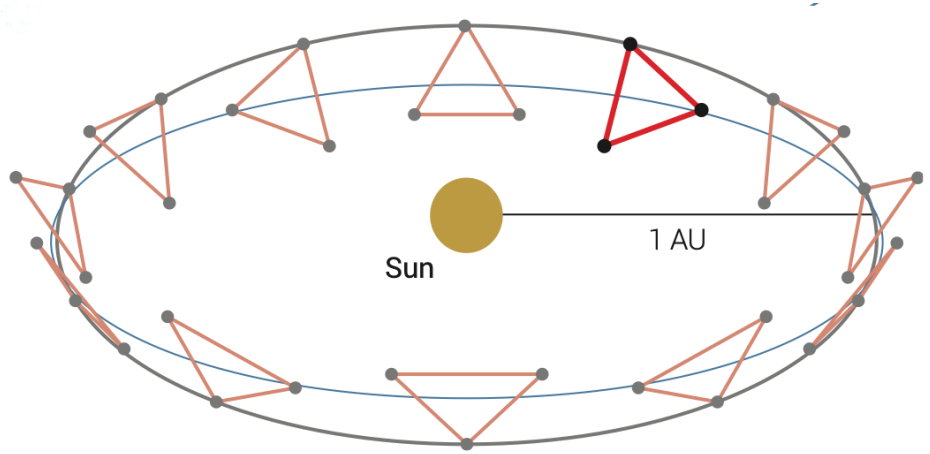
CMB plasma is like a resonant mass detector



LISA Mission







What Will LISA See?

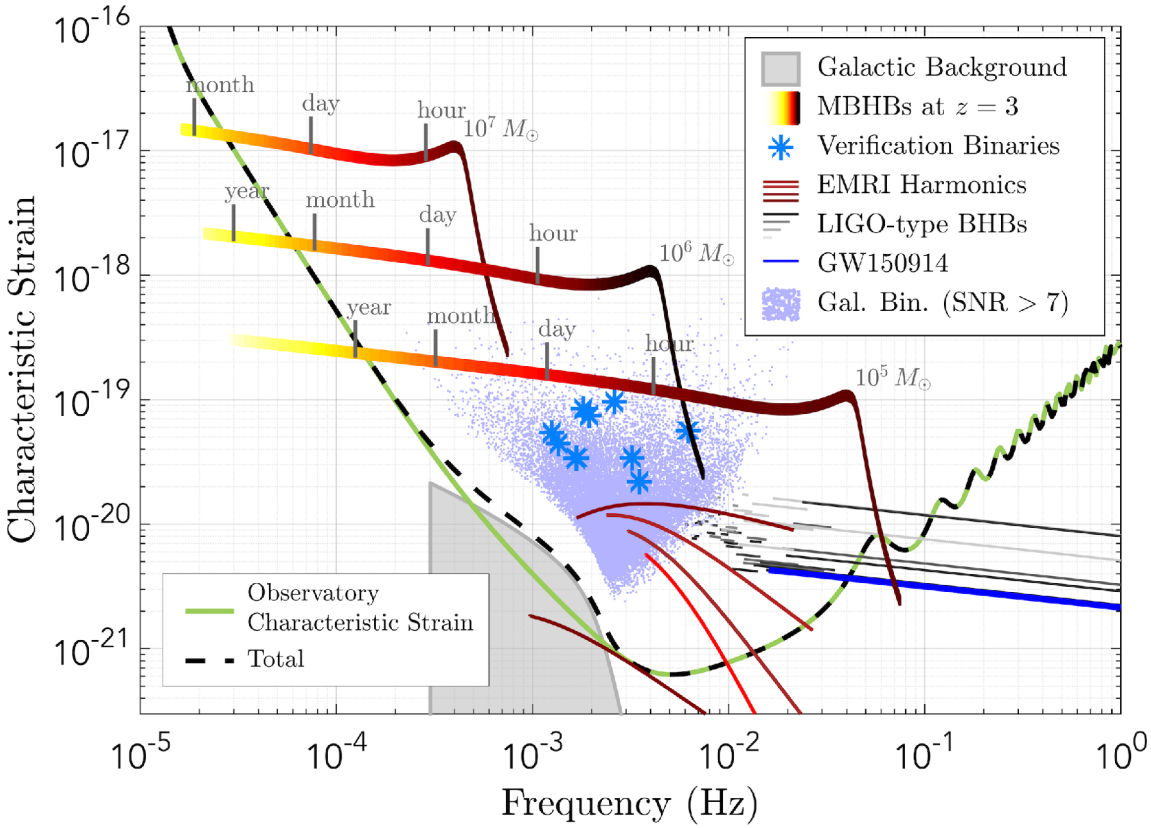
Tens of thousands of various classes of sources, to z=10 and beyond

~10^4 galactic binaries

~10-1000 extreme mass ratio inspirals at z<1

~10^2 massive black hole mergers at z<30

something unexpected?



Expected accuracy:

δM/M to 0.01-1% (chirp mass)

δD/D to 3-10% (luminosity distance)

δA to 10 arcmin^2 – 10 deg^2 (position)

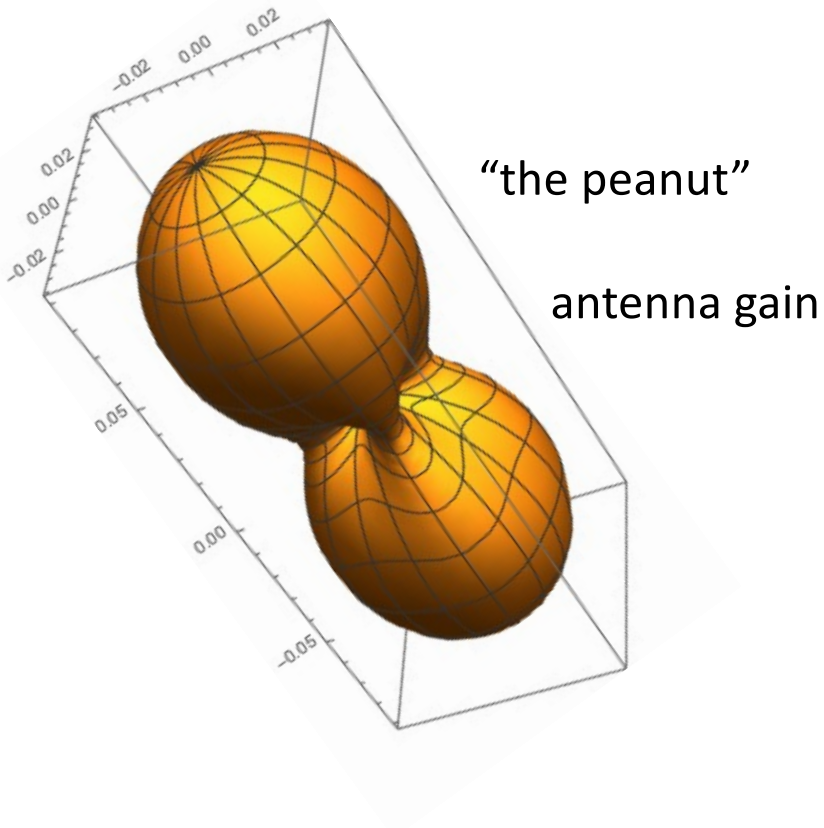
LISA: 1702.00786

What Will LISA See?

Tasks: Set limits on a SGWB, and characterize foregrounds

$$\Omega_{\rm GW} \equiv d(\rho_{\rm GW}/\rho_c)/d\ln f$$

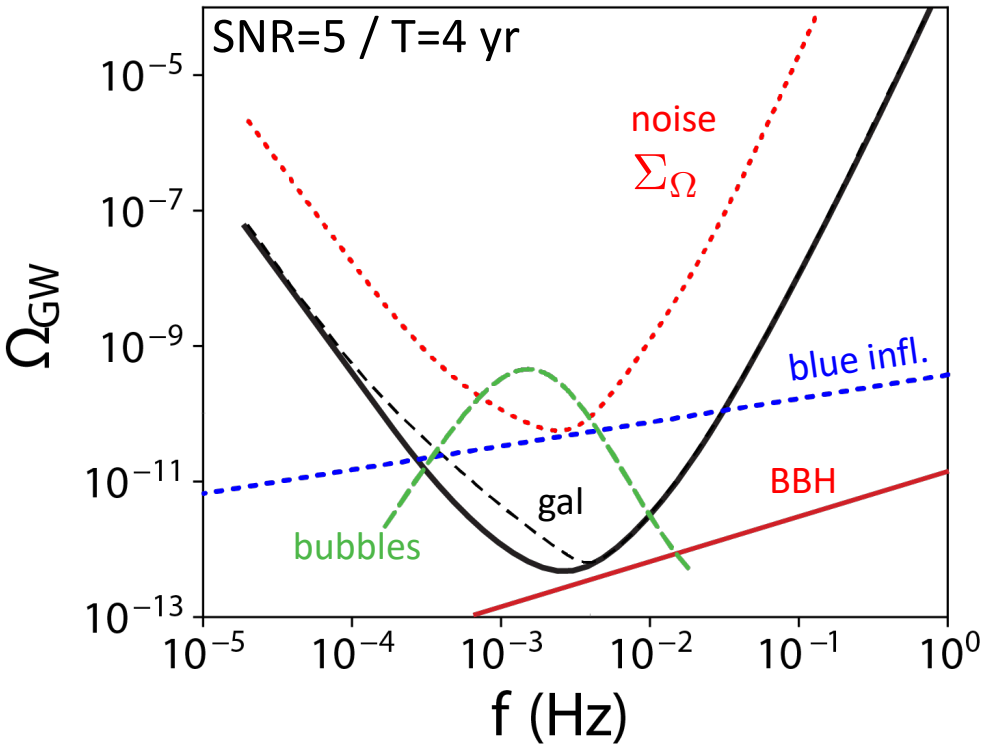
$$\mathrm{SNR}^2 = T\int_{f_{min}}^{f_{max}} df\ \left(\Omega_{GW}/\Sigma_\Omega\right)^2$$



"the peanut"

antenna gain

Constraint on a *power-law* SGWB



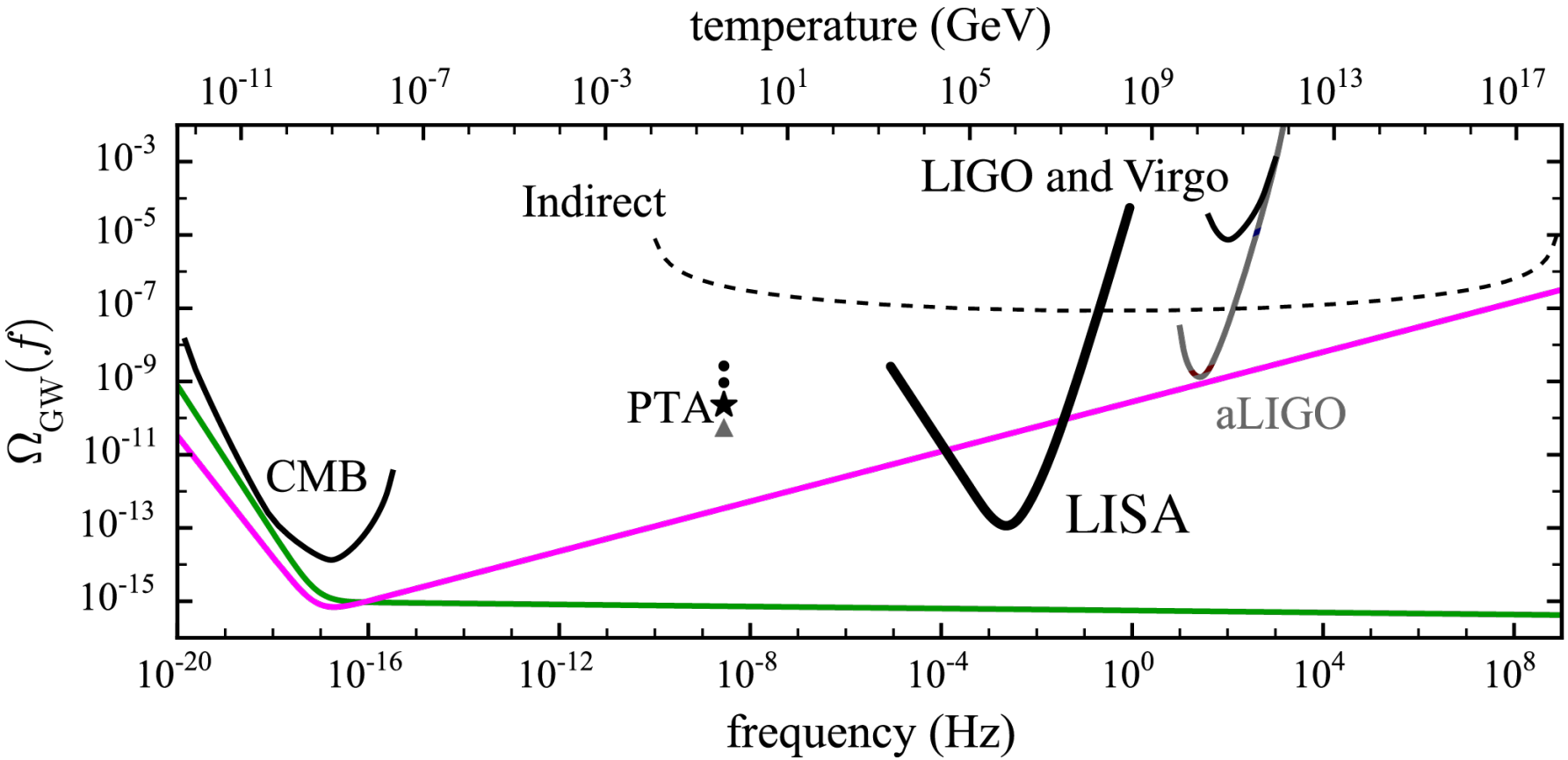
Galaxy: Cornish et al, 1703.09858

BBH: Cusin et al, 1904.07757

Caprini et al (CosWG), 1910.13125

Gravitational-wave cosmology across 29 decades in frequency

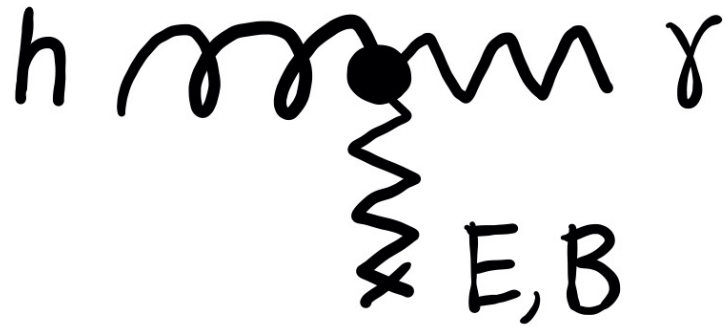
Lasky et al 2016



Tilting the long lever arm from CMB to LISA and beyond

A mechanism exists in E&M

$$\mathcal{L} = \sqrt{-g}\, F^2$$



Generalize to new, dark gauge fields “E”, “B”

Anber & Sorbo 2010; Maleknejad & Sheikh-Jabbari 2011
Adshead & Wyman 2012; Namba, Dimastrogiovanni, Peloso 2013;

Tilting the long lever arm from CMB to LISA and beyond

Three basic effects:

1. Amplification, suppression, depending on “E”, “B”
2. GW oscillation into “photon” and back
3. Excess chirality in the presence of both “E” and “B”

Simple examples: Tishue+RC 2021; Bielefeld+RC 2015,16

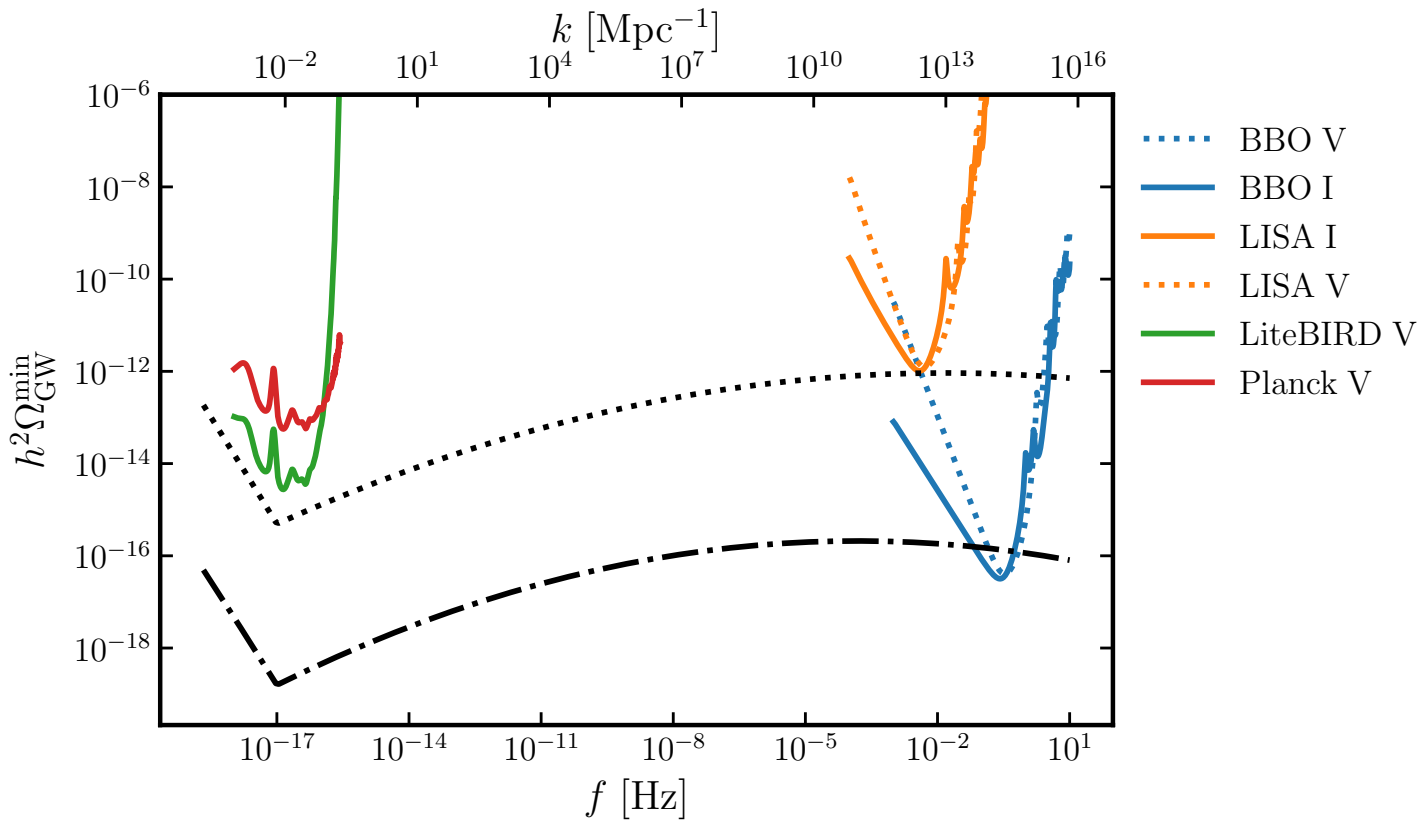
Inflationary scenario: Couple inflaton or spectator to gauge field, like axion

4. Tensor non-gaussianity

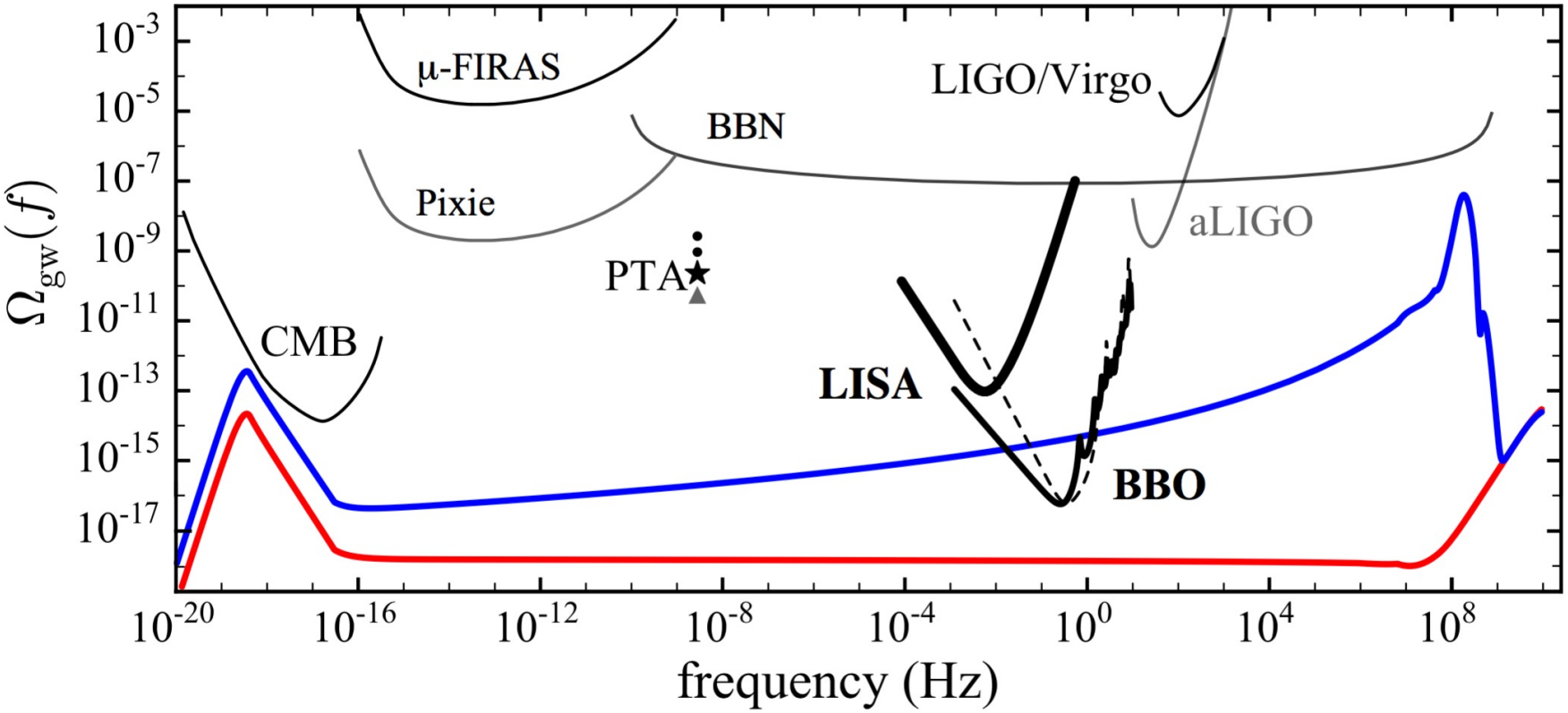
Agrawal, Fujita, Komatsu 2018

Examples: Spectator Axion – SU(2) Coupling

Thorne, Fujita, Hazumi, Katayama, and Komatsu 2018



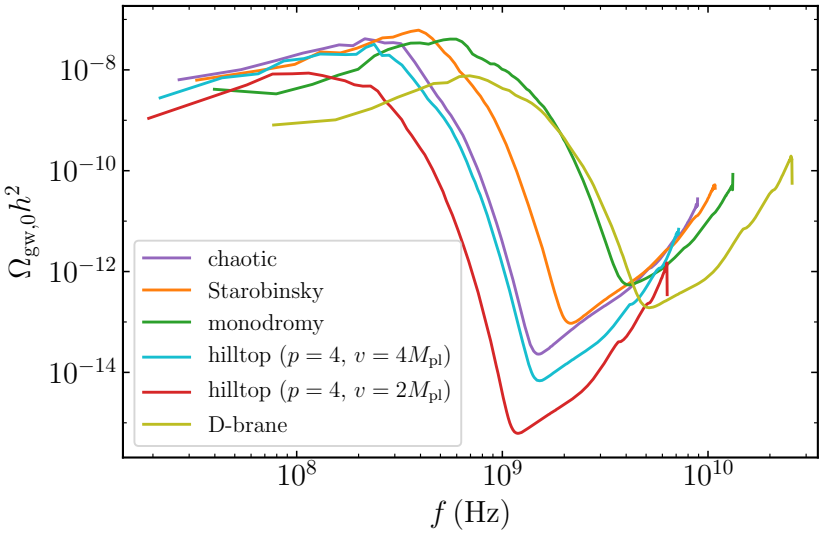
Examples: Axion – SU(2) Inflation

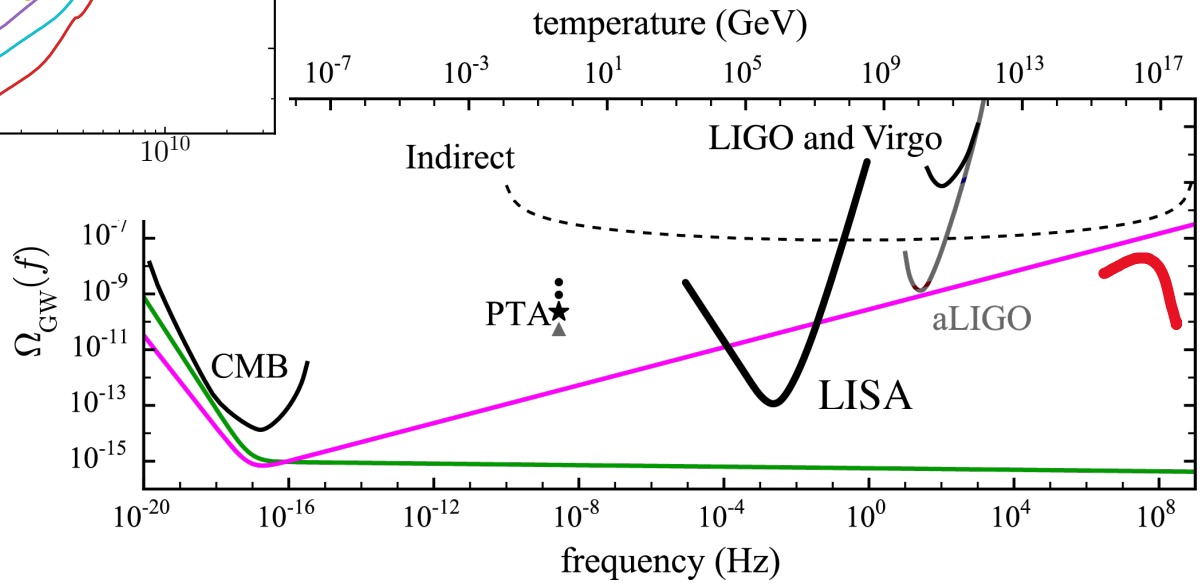


RC + Devulder 2018
Smith + RC 2017

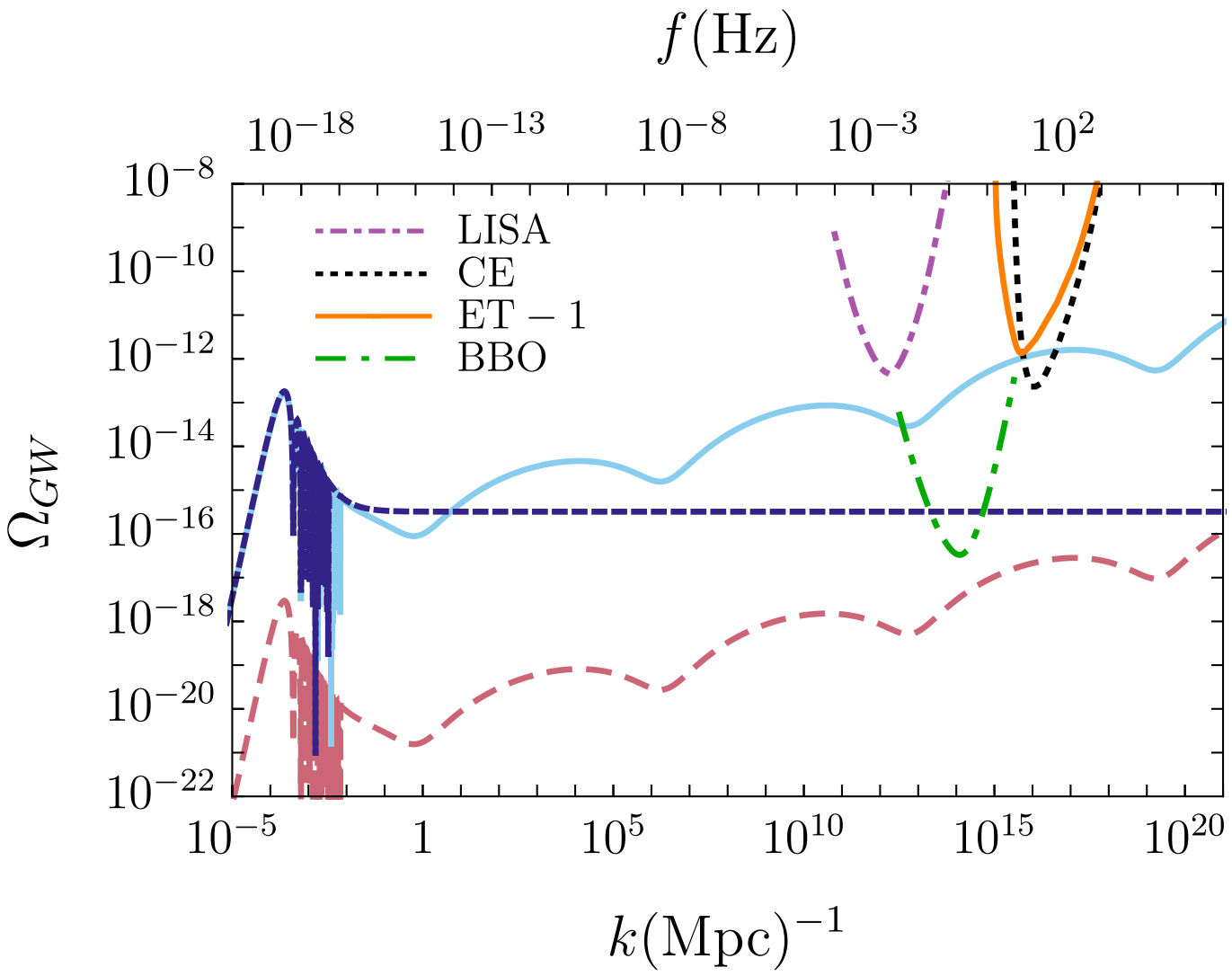
Examples: Axion – SU(2) Inflation Pre-Heating

Adshead, Giblin, Pieroni, Weiner 2020





Examples: Post-Inflationary Gauge Fields



Tishue & RC 2021

Take aways

- **CMB and GW observatories provide complementary information on GWs**

- Detect, or bound, primordial gravitational waves: tensor-to-scalar ratio
- Tilt, Running of the Tilt (BB)
- Chirality: Excess handedness of GW circular polarization (EB, TB)
- B-Mode Polarization Bispectrum: Non-Gaussianity of GW Spectrum (BBB)
- Neff from early production of high frequency GWs (TT+)