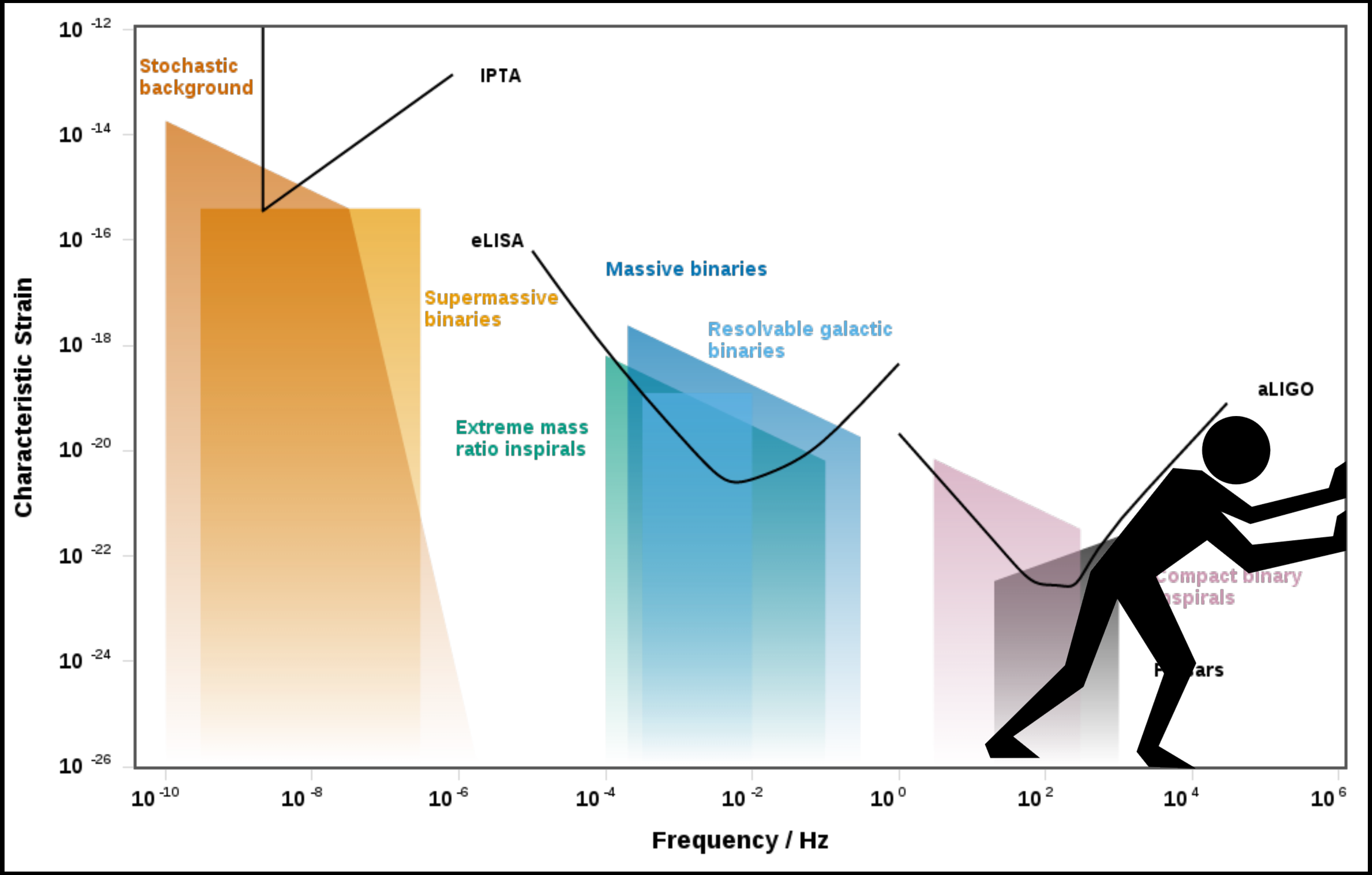
Ultra High Frequency GWs Challenges and Opportunities



Francesco Muia

GWADW
17/05/2021

UNIVERSITY OF CAMBRIDGE

UK Research and Innovation

EPSRC

New physics from UHF-GWs

natural frequency for a
self-gravitating body

$$f \simeq \sqrt{\frac{G\bar{\rho}}{4\pi}}$$

Schwarzschild radius
bound

$$R \gtrsim 2GM$$

known astrophysical objects can
emit GW at frequency
$$f \lesssim 10\,\mathrm{kHz}$$

ultra-high-frequency
$$f \gtrsim 10\,\mathrm{kHz}$$

cosmology

BSM physics

Speakers:
- A. Bauswein (GSI Darmstadt)
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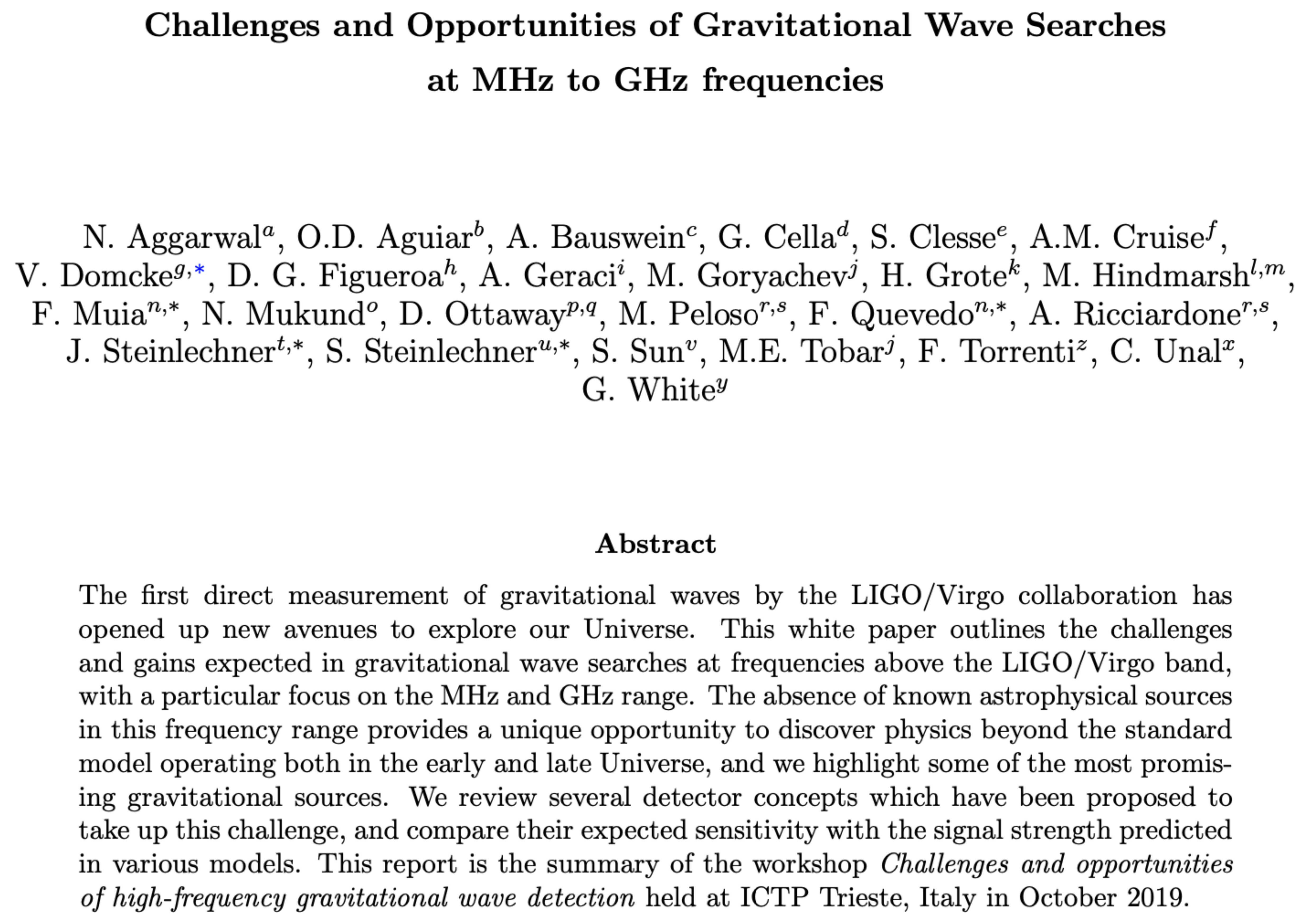
Challenges and Opportunities of High Frequency Gravitational Wave Detection

14 - 16 October 2019, Miramare - Trieste, Italy

Organisers: V. Domcke, F. Muia, F. Quevedo, J. Steinlechner, S. Steinlechner



Challenges and Opportunities of Gravitational Wave Searches at MHz to GHz frequencies

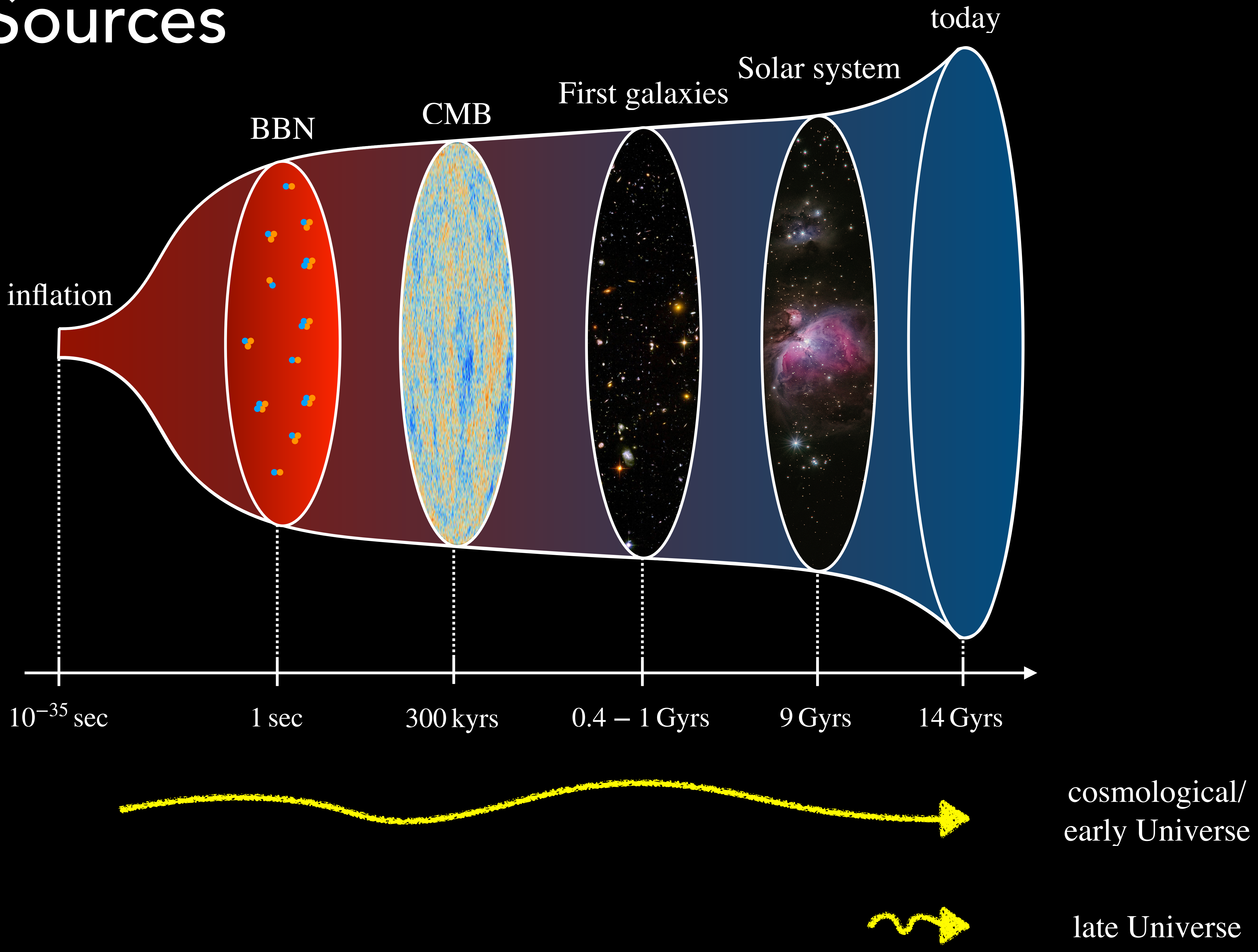
N. Aggarwal[a], O.D. Aguiar[b], A. Bauswein[c], G. Cella[d], S. Clesse[e], A.M. Cruise[f], V. Domcke[g,*], D. G. Figueroa[h], A. Geraci[i], M. Goryachev[j], H. Grote[k], M. Hindmarsh[l,m], F. Muia[n,*], N. Mukund[o], D. Ottaway[p,q], M. Peloso[r,s], F. Quevedo[n,*], A. Ricciardone[r,s], J. Steinlechner[t,*], S. Steinlechner[u,*], S. Sun[v], M.E. Tobar[j], F. Torrenti[z], C. Unal[x], G. White[y]

Abstract

The first direct measurement of gravitational waves by the LIGO/Virgo collaboration has opened up new avenues to explore our Universe. This white paper outlines the challenges and gains expected in gravitational wave searches at frequencies above the LIGO/Virgo band, with a particular focus on the MHz and GHz range. The absence of known astrophysical sources in this frequency range provides a unique opportunity to discover physics beyond the standard model operating both in the early and late Universe, and we highlight some of the most promising gravitational sources. We review several detector concepts which have been proposed to take up this challenge, and compare their expected sensitivity with the signal strength predicted in various models. This report is the summary of the workshop *Challenges and opportunities of high-frequency gravitational wave detection* held at ICTP Trieste, Italy in October 2019.

[2011.12414, to be published in Living Reviews in Relativity]

Sources



inflation

BBN

CMB

First galaxies

Solar system

today

10^{-35} sec

1 sec

300 kyrs

0.4 – 1 Gyrs

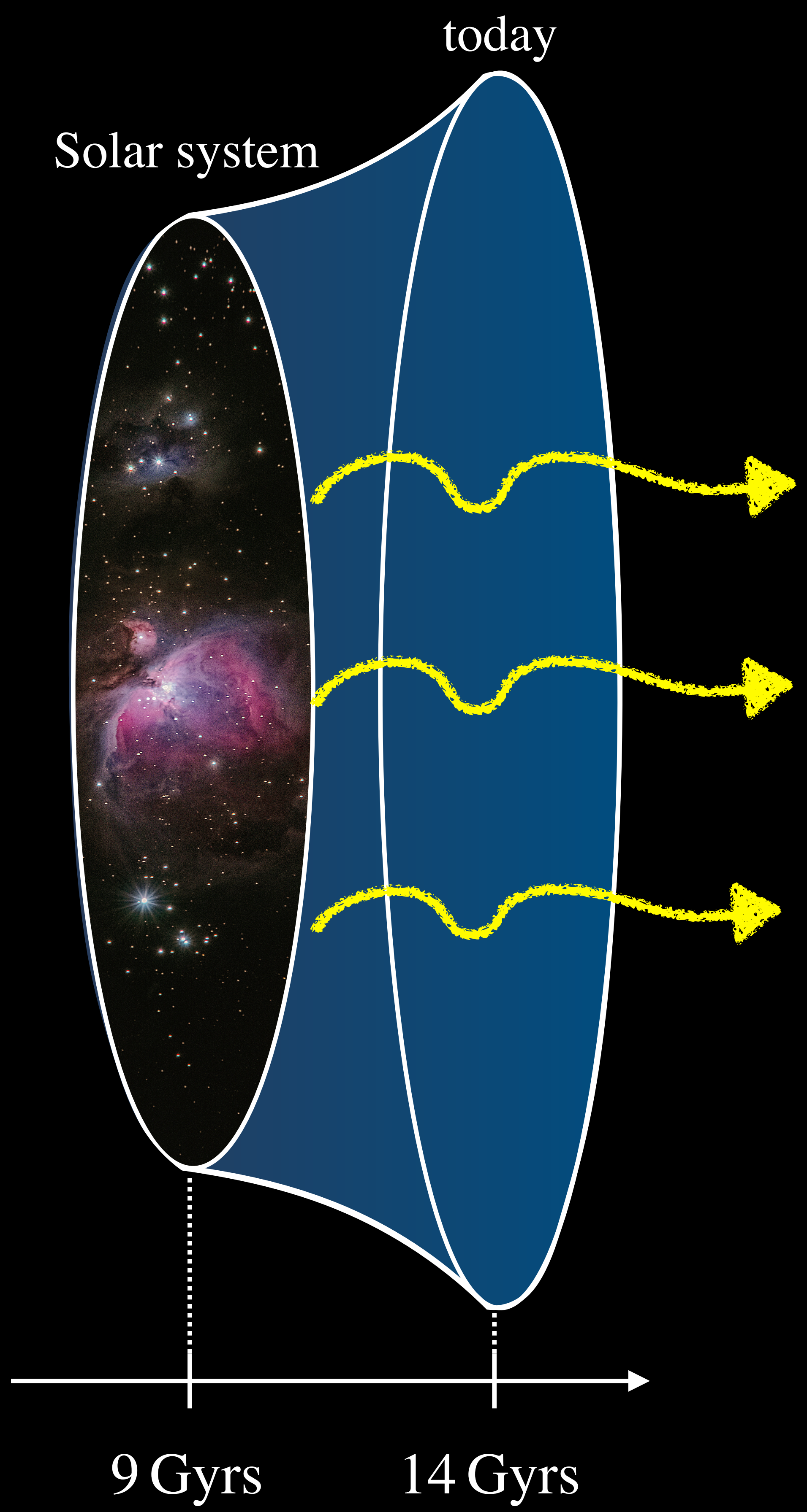
9 Gyrs

14 Gyrs

cosmological/
early Universe

late Universe

Late Universe sources



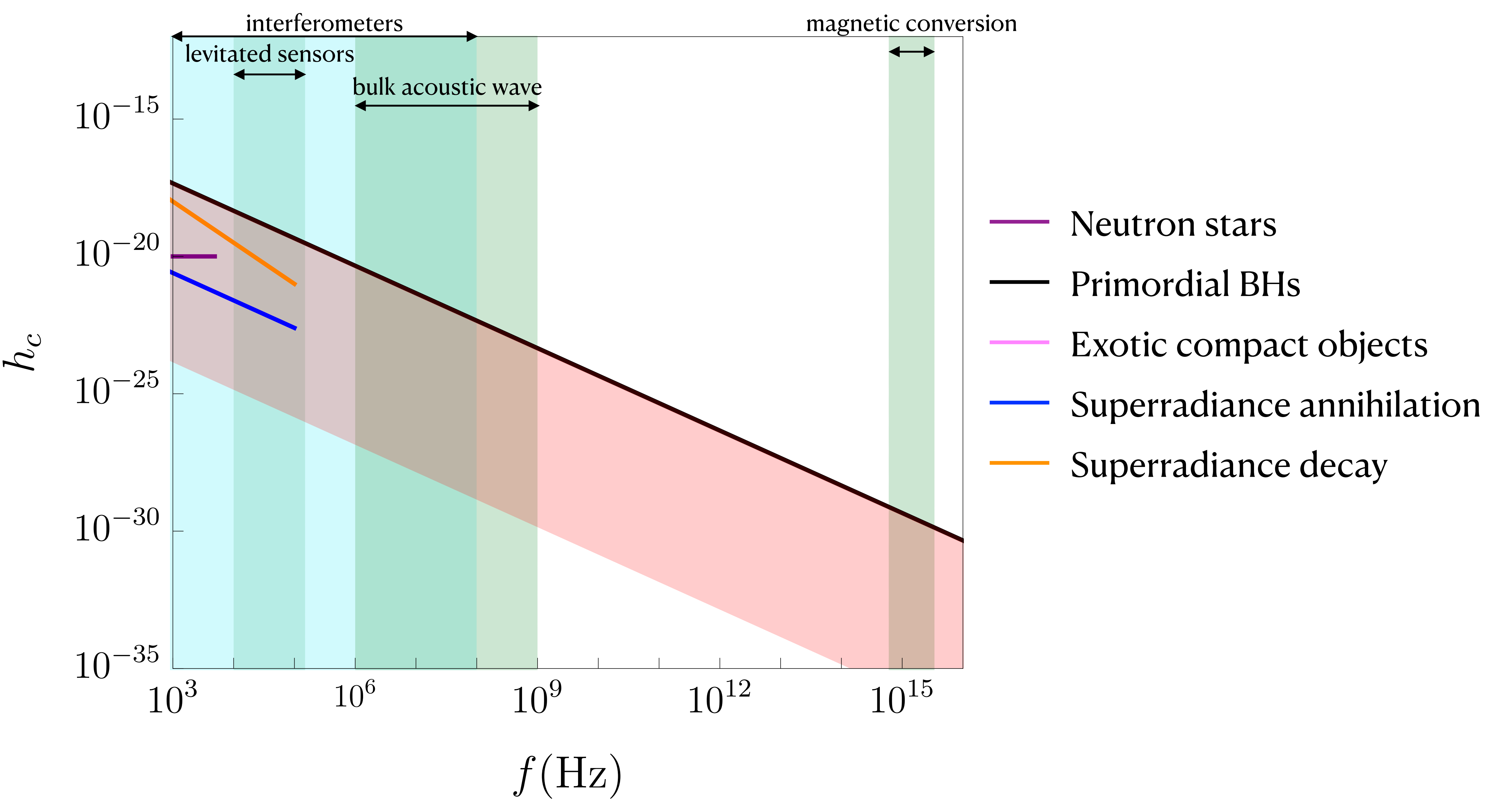
Sub-solar PBH mergers

Exotic compact objects

Superradiance

BSM physics

Late Universe: summary



Benchmark distance: 10 kpc

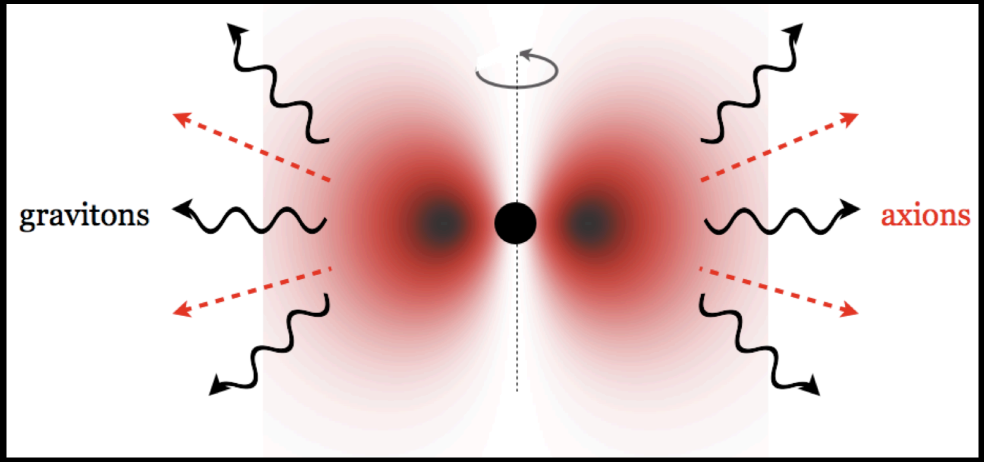
ECO compactness: $10^{-5} < C < 1/2$

PBH mass: $10^{-9} < m_{\mathrm{PBH}}/M_{\odot} < 1$

Superradiance: $M_{\mathrm{BH}} \gtrsim M_{\odot}$

GWs from superradiance

[A. Arvanitaki, A. Geraci, 1207.5320]



- Superradiance requires $1/m_a \sim 2GM_{\rm BH}$

$\downarrow$

axion mass

$$m_a \simeq \frac{M_\odot}{M_{\rm BH}} 10^{-10}\,{\rm eV}$$

- Axion cloud form around a rotating BH → A. extract rotational energy from BH (superradiance instability) B. lose energy into GWs.

$\downarrow$

'gravitational atom' with energy levels similar to the hydrogen atom

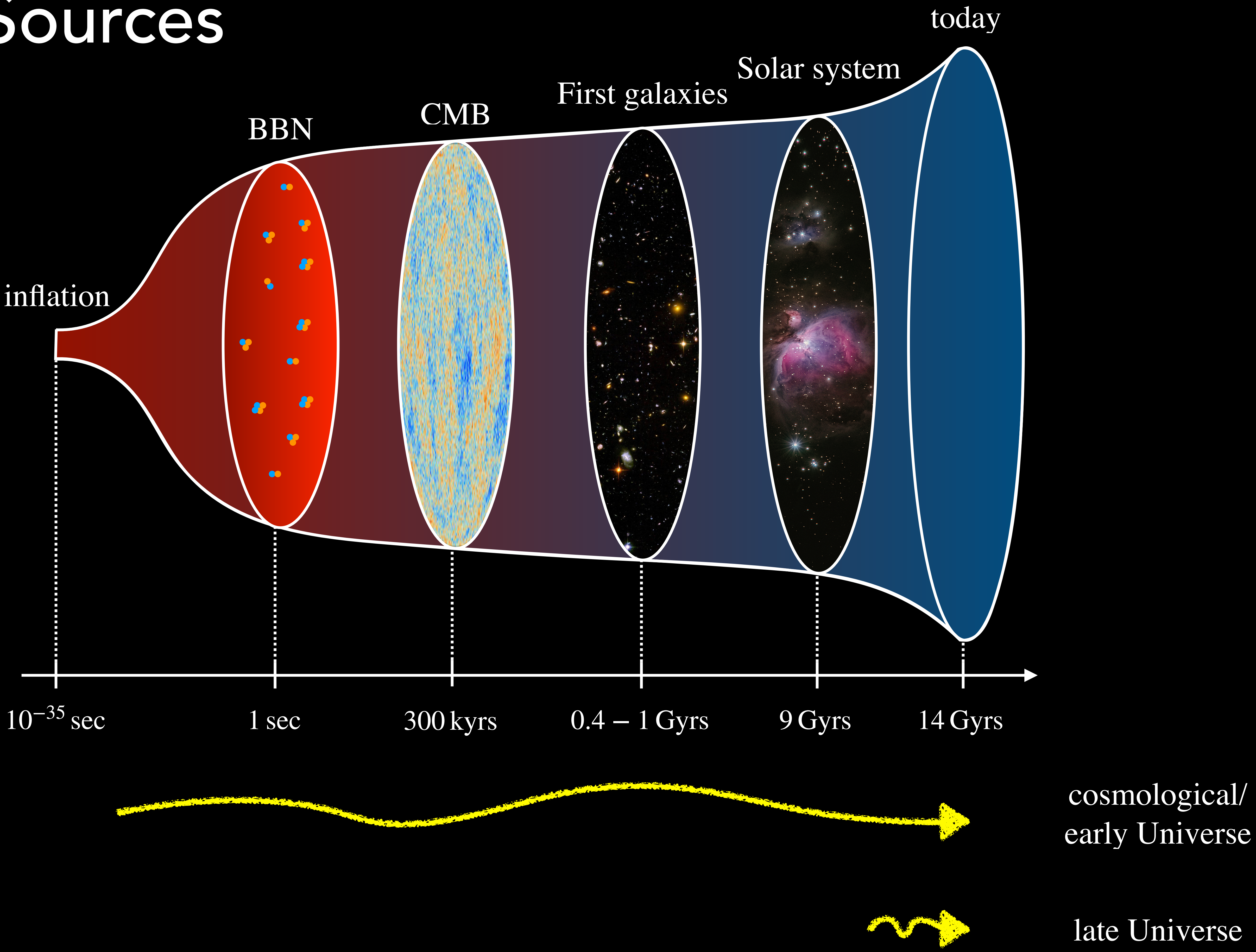
- Axions can transition from one level to another or annihilate into a graviton

→ long-lived, monochromatic source of GWs

$$f \simeq \left(\frac{m_a}{10^{-9}\,{\rm eV}}\right) 10^6\,{\rm Hz} \simeq \frac{100\,{\rm kHz}}{M_{\rm BH}/M_\odot}$$

$$h_c \lesssim 10^{-23}\left(\frac{10\,{\rm kpc}}{D}\right)\left(\frac{100\,{\rm kHz}}{f}\right)$$

Sources



today

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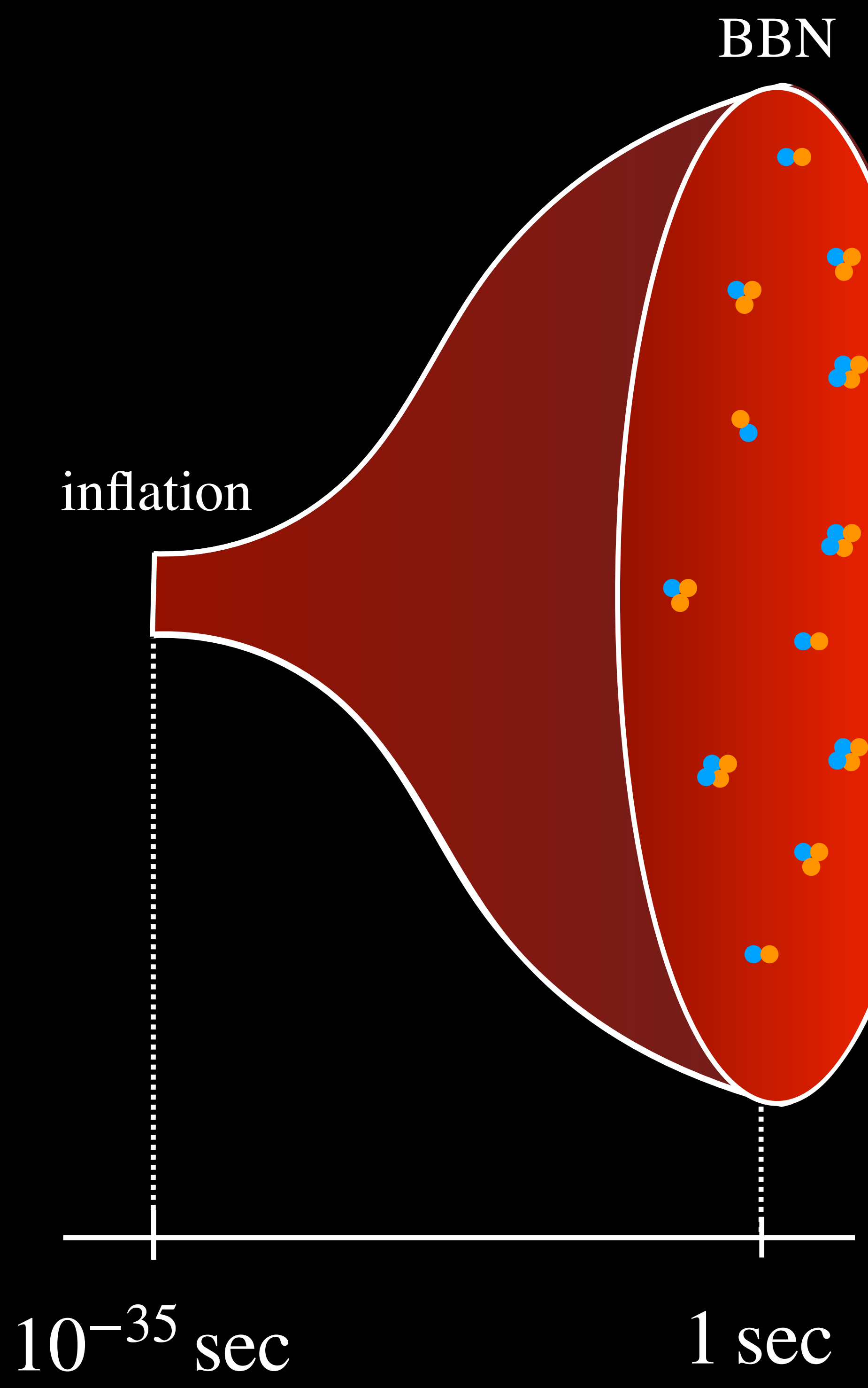
cosmological/
early Universe

late Universe

Early Universe sources



- Characteristic frequency

$$f_0 \simeq \frac{1}{\epsilon}\left(\frac{T_p}{10^{10}\,\mathrm{GeV}}\right)\,\mathrm{kHz}$$

$$\epsilon = \frac{\text{GW wavelength at production}}{\text{horizon size at production}} \leq 1$$

(causality)

for $\epsilon \sim 1$

frequency	prod. time	prod. T
10^{-5} Hz	10^{-11} sec	100 GeV
0.16 Hz	10^{-19} sec	10^{6} GeV
1.6 kHz	10^{-27} sec	10^{9} GeV
1.6 MHz	10^{-33} sec	10^{13} GeV
1.6 GHz	10^{-39} sec	10^{16} GeV

beyond LIGO ↓

~GUT/string

- GWs from the early Universe produce a stochastic background.

Cosmological GWs

characteristic value of the
GW amplitude per unit
logarithmic frequency interval

- Stochastic background

$$\Omega_{\rm gw} = \frac{1}{\rho_c}\frac{d\rho_{\rm gw}}{d\log f} = \frac{2\pi^2}{3H_0^2} f^2 h_c^2$$

$$\boxed{h_c \simeq 1.3 \times 10^{-21}\left(\frac{1\,\mathrm{kHz}}{f}\right)\sqrt{h_0^2\Omega_{\rm gw}(f)}}$$

$$h_0^2\,\Omega_{\rm gw} \sim 10^{-9}$$

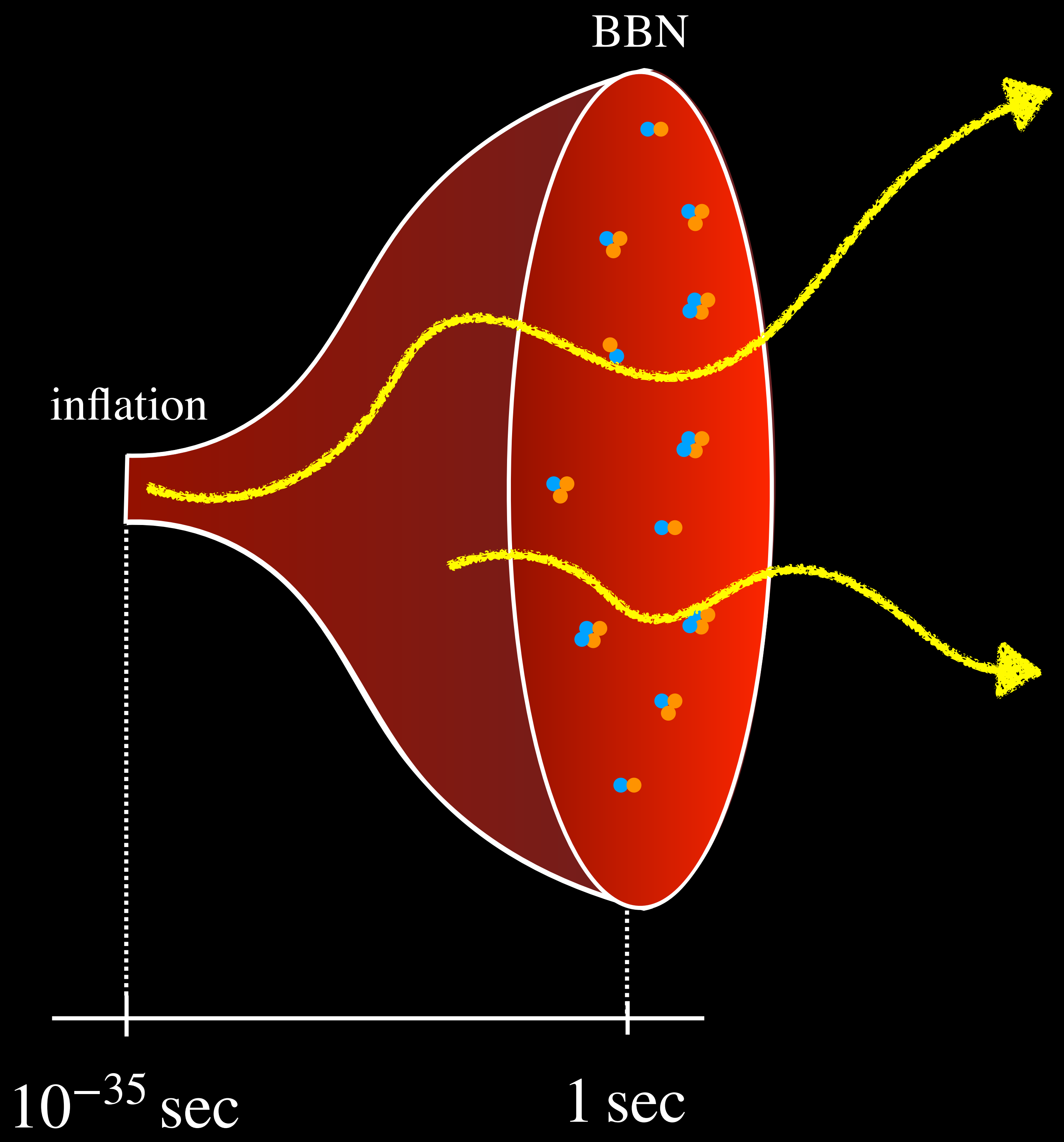
f_0	h_c
10^2 Hz	4.1×10^{-25}
MHz	4.1×10^{-29}
GHz	4.1×10^{-32}

LIGO
(design)

- GWs redshift as radiation → bounds from CMB and BBN

$$\Omega_{\rm gw,0} \lesssim 10^{-6} \longrightarrow h_c \lesssim 3 \times 10^{-27}\,\frac{\mathrm{MHz}}{f}$$

Early Universe sources



Production mechanisms during inflation

- Extra species.
- Modified gravity.
- Second order scalar perturbations.

Production mechanisms after inflation

- Preheating.
- Oscillons.
- Phase transitions.
- Defects.
- Primordial BH evaporation.
- Cosmic gravitational wave background.

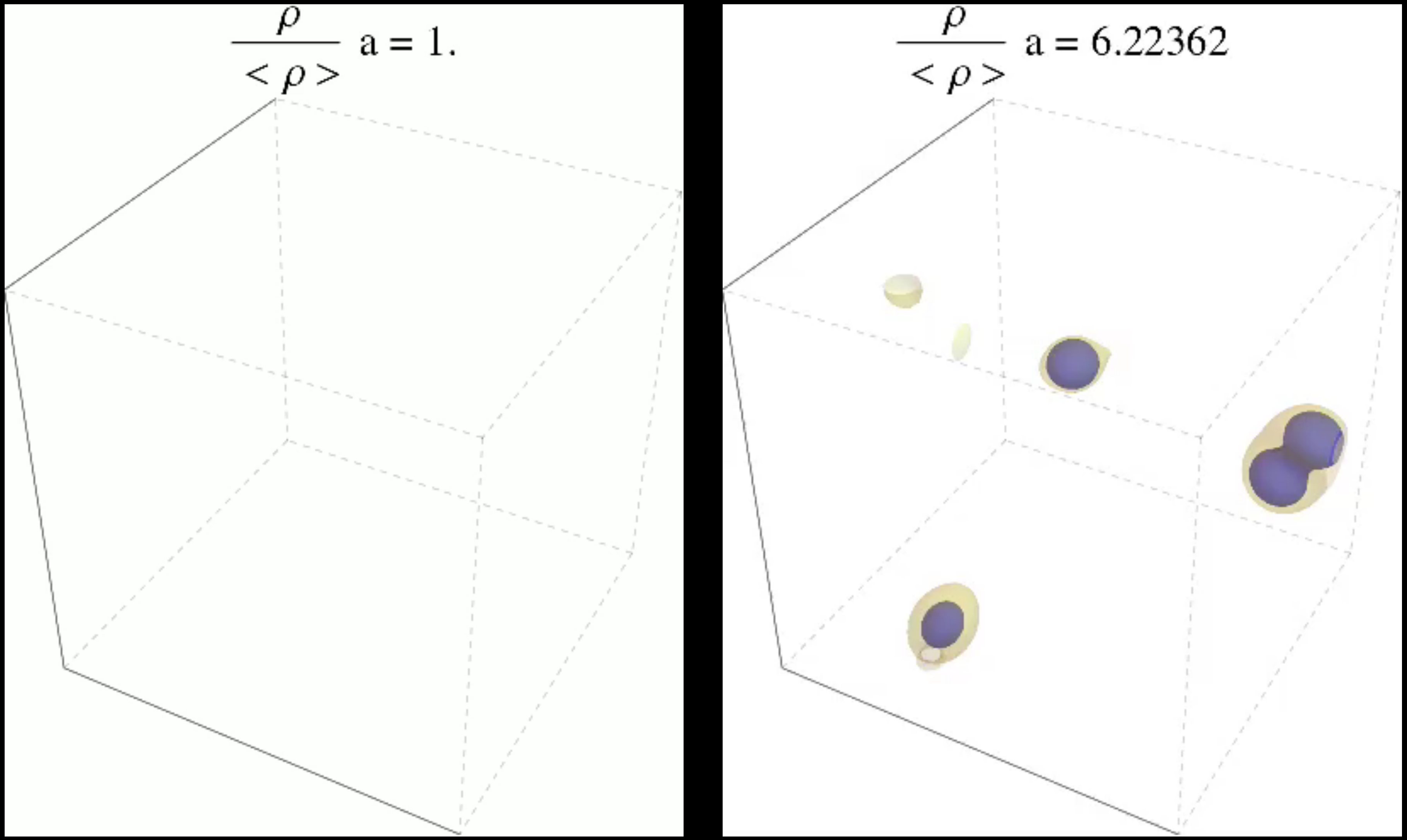
Post-Inflation: preheating

- After inflation, the energy density stored in the inflaton must (eventually) be converted into SM degrees of freedom.

if non-perturbative effects are involved

PREHEATING

- Simplest example: self-resonance of bosons. [L. Kofman, A. Linde, A. Starobinsky, hep-th/9405187]



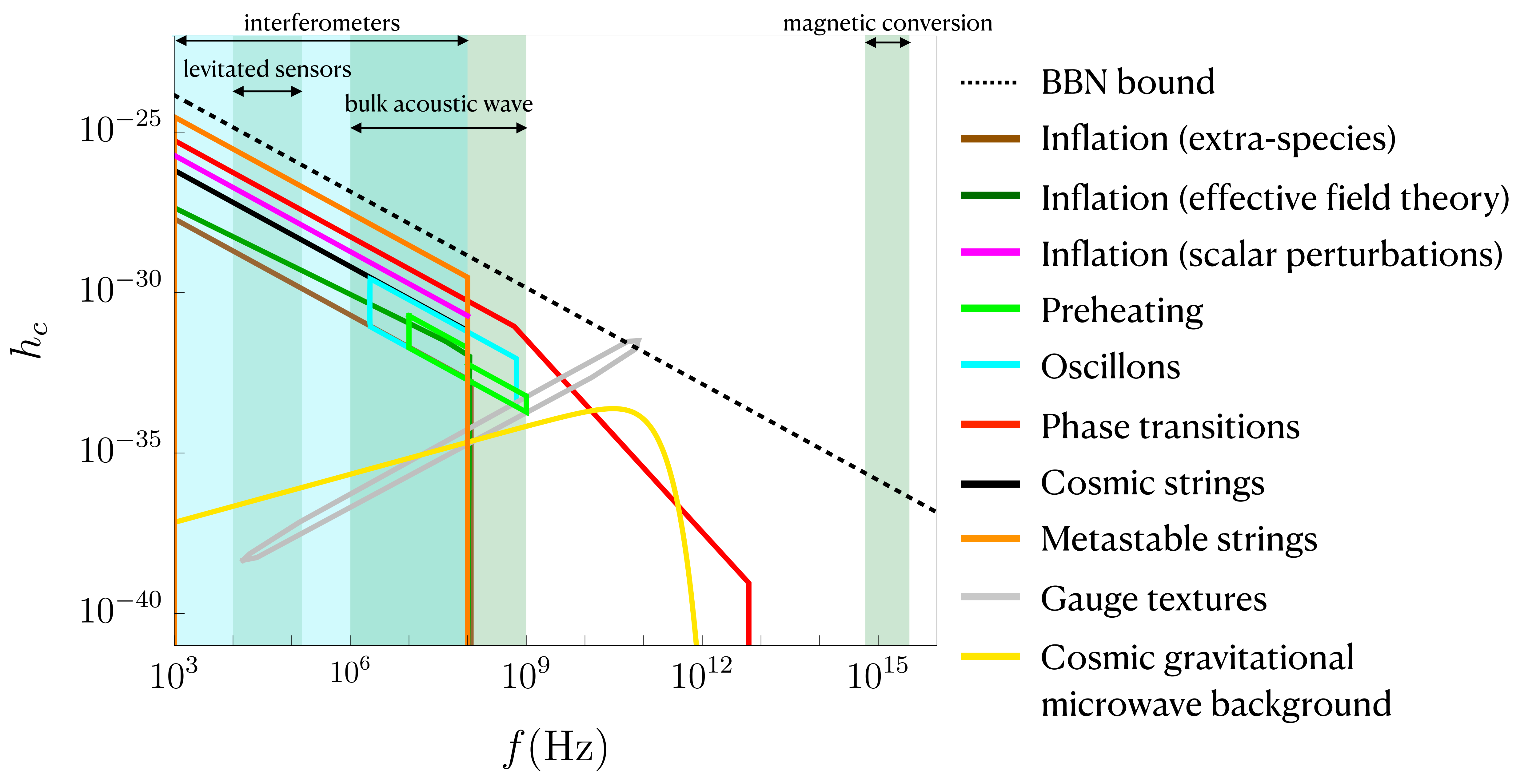
[S. Antusch, F. Cefalà, S. Krippendorf, F. Muia, S. Orani, F. Quevedo, 1708.08922]

$$\boxed{\begin{array}{c} f_0 \sim 10^8\,\mathrm{Hz} \\ \Omega_{\mathrm{gw}} \sim 10^{-9} \end{array}}$$

generic result

[D. Figueroa, F. Torrenti, 1707.04533]

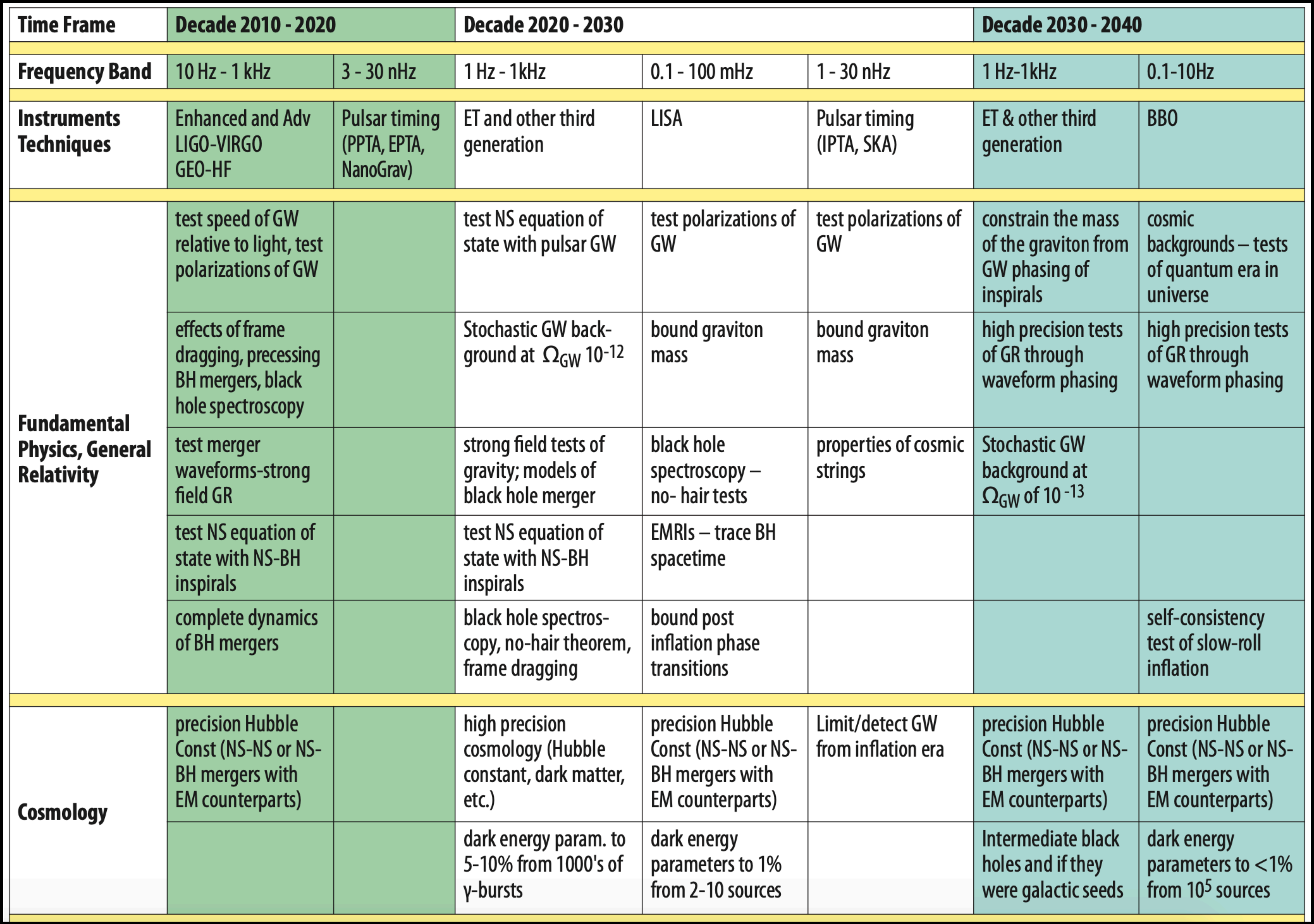
Early Universe: summary



Miscellaneous

- Evaporating PBHs. [Anantua, Easther, Giblin, 2009]
- Quintessential inflation. [Giovannini, 1999]
- Magnetars. [Wen, Li, Li, Fang, Beckwith, 2017]
- Reheating. [Ema, Jinno, Nakayama, 2020]
- Thermal gravitational noise of the Sun. [Bisnovatyi-Kogan, Rudenko, 2004]
- Plasma instabilities. [Servin, Brodin, 2003]
- Brane world scenarios. [Seahra, Clarckson, Maartens, 2010]
- Pre Big-Bang cosmology. [Gasperini, Veneziano, 2003]

GWIC roadmap



Time Frame	Decade 2010 - 2020		Decade 2020 - 2030			Decade 2030 - 2040	
Frequency Band	10 Hz - 1 kHz	3 - 30 nHz	1 Hz - 1kHz	0.1 - 100 mHz	1 - 30 nHz	1 Hz-1kHz	0.1-10Hz
Instruments Techniques	Enhanced and Adv LIGO-VIRGO GEO-HF	Pulsar timing (PPTA, EPTA, NanoGrav)	ET and other third generation	LISA	Pulsar timing (IPTA, SKA)	ET & other third generation	BBO
Fundamental Physics, General Relativity	test speed of GW relative to light, test polarizations of GW		test NS equation of state with pulsar GW	test polarizations of GW	test polarizations of GW	constrain the mass of the graviton from GW phasing of inspirals	cosmic backgrounds – tests of quantum era in universe
	effects of frame dragging, precessing BH mergers, black hole spectroscopy		Stochastic GW background at Ω_{GW} 10^{-12}	bound graviton mass	bound graviton mass	high precision tests of GR through waveform phasing	high precision tests of GR through waveform phasing
	test merger waveforms-strong field GR		strong field tests of gravity; models of black hole merger	black hole spectroscopy – no- hair tests	properties of cosmic strings	Stochastic GW background at Ω_{GW} of 10^{-13}	
	test NS equation of state with NS-BH inspirals		test NS equation of state with NS-BH inspirals	EMRIs – trace BH spacetime			
	complete dynamics of BH mergers		black hole spectroscopy, no-hair theorem, frame dragging	bound post inflation phase transitions			self-consistency test of slow-roll inflation
Cosmology	precision Hubble Const (NS-NS or NS-BH mergers with EM counterparts)		high precision cosmology (Hubble constant, dark matter, etc.)	precision Hubble Const (NS-NS or NS-BH mergers with EM counterparts)	Limit/detect GW from inflation era	precision Hubble Const (NS-NS or NS-BH mergers with EM counterparts)	precision Hubble Const (NS-NS or NS-BH mergers with EM counterparts)
			dark energy param. to 5-10% from 1000's of γ-bursts	dark energy parameters to 1% from 2-10 sources		Intermediate black holes and if they were galactic seeds	dark energy parameters to <1% from 10^5 sources

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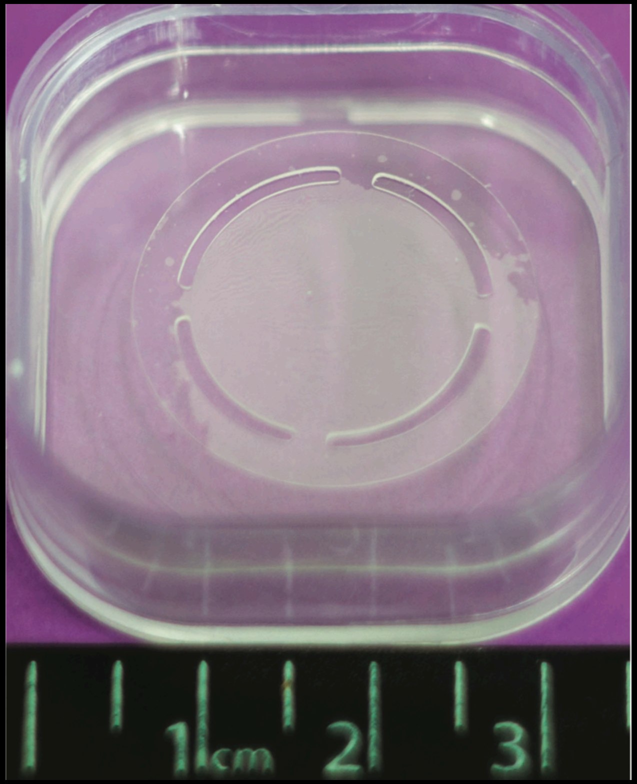
Small scale experiments?

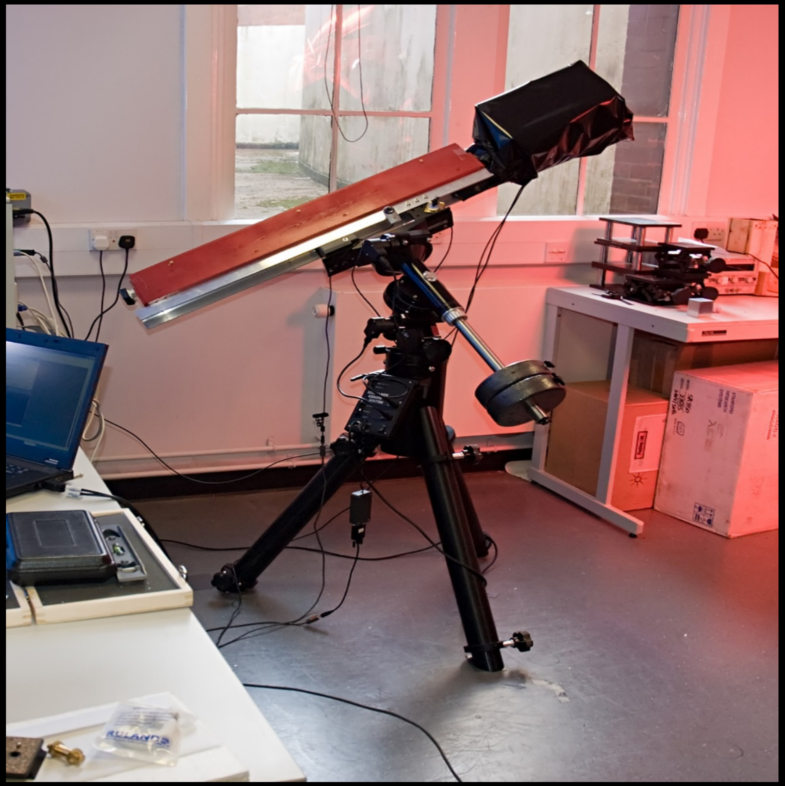
$$f_0 \simeq 1\,\mathrm{GHz} \quad \longleftrightarrow \quad \lambda_0 \simeq 1\,\mathrm{cm}$$

Potentially small scale experiments



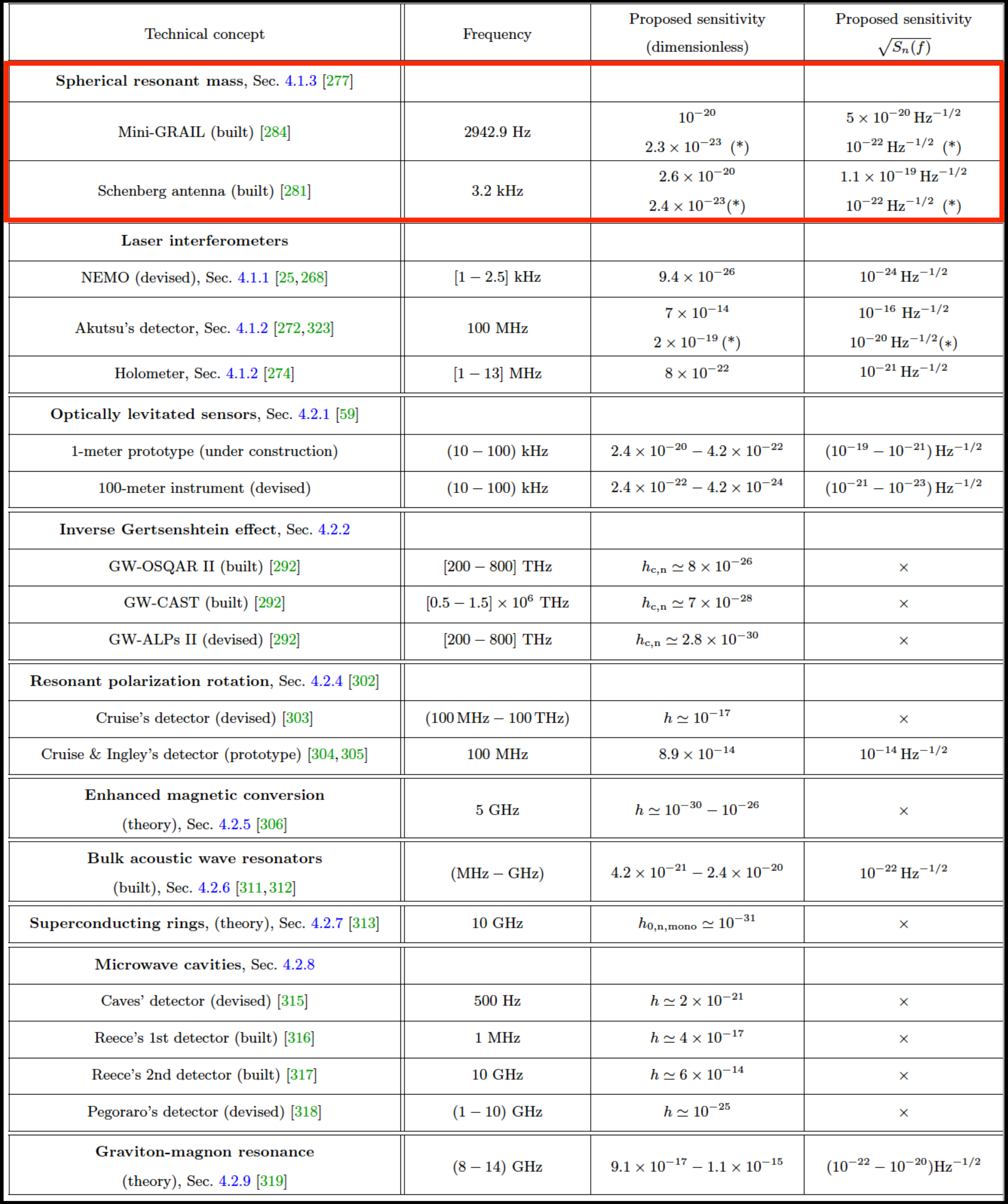
Bulk acoustic wave devices

[M. Goryachev, M. Tobar, 2014]



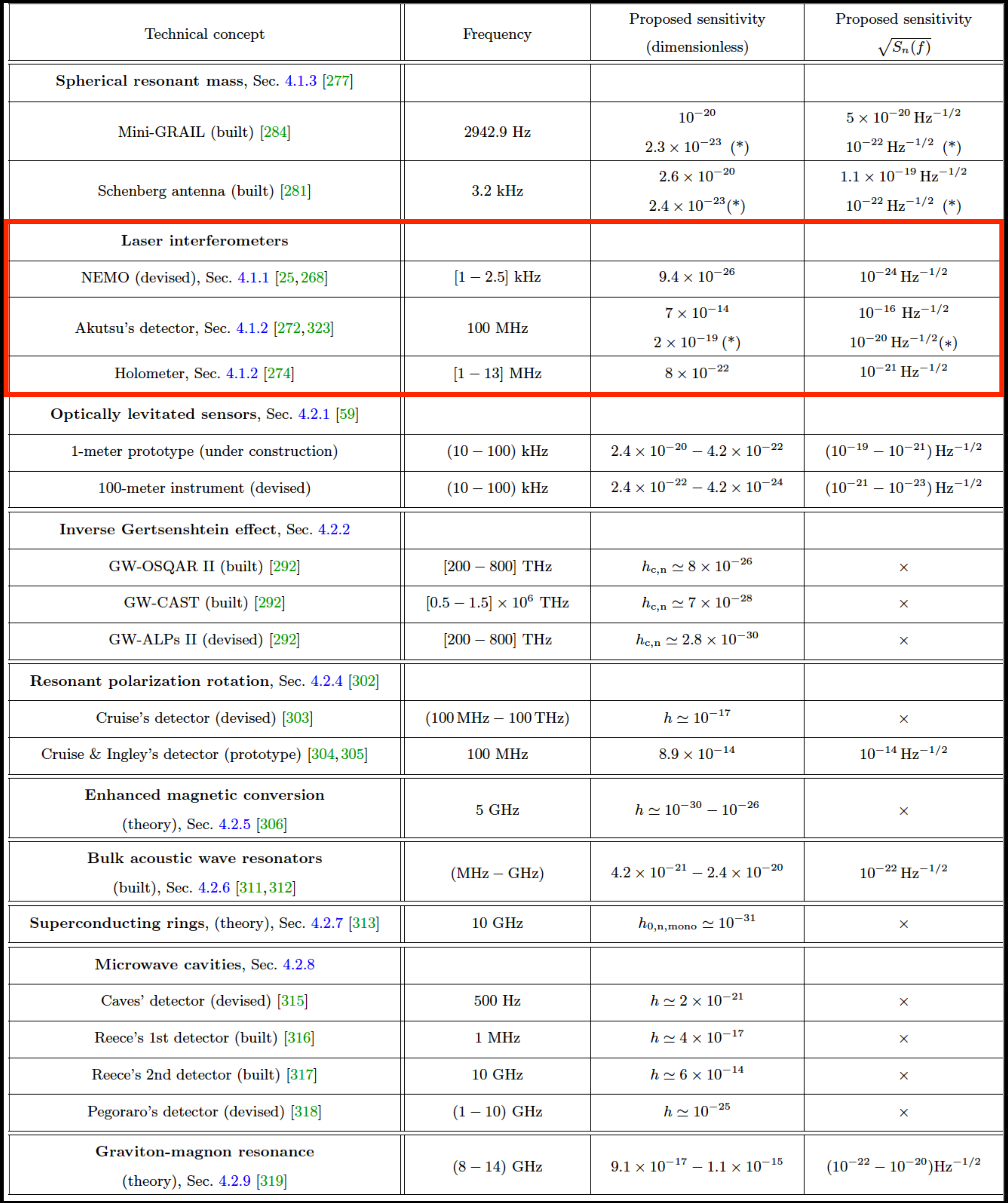
Magnetic conversion

[M. Cruise, 2012]



Technical concept	Frequency	Proposed sensitivity (dimensionless)	Proposed sensitivity $\sqrt{S_n(f)}$
Spherical resonant mass, Sec. 4.1.3 [277]			
Mini-GRAIL (built) [284]	2942.9 Hz	10^{-20} 2.3×10^{-23} (*)	$5 \times 10^{-20}\,\mathrm{Hz}^{-1/2}$ $10^{-22}\,\mathrm{Hz}^{-1/2}$ (*)
Schenberg antenna (built) [281]	3.2 kHz	2.6×10^{-20} 2.4×10^{-23}(*)	$1.1 \times 10^{-19}\,\mathrm{Hz}^{-1/2}$ $10^{-22}\,\mathrm{Hz}^{-1/2}$ (*)
Laser interferometers			
NEMO (devised), Sec. 4.1.1 [25,268]	[1 – 2.5] kHz	9.4×10^{-26}	$10^{-24}\,\mathrm{Hz}^{-1/2}$
Akutsu's detector, Sec. 4.1.2 [272,323]	100 MHz	7×10^{-14} 2×10^{-19} (*)	$10^{-16}\,\mathrm{Hz}^{-1/2}$ $10^{-20}\,\mathrm{Hz}^{-1/2}$(*)
Holometer, Sec. 4.1.2 [274]	[1 – 13] MHz	8×10^{-22}	$10^{-21}\,\mathrm{Hz}^{-1/2}$
Optically levitated sensors, Sec. 4.2.1 [59]			
1-meter prototype (under construction)	(10 – 100) kHz	$2.4 \times 10^{-20} - 4.2 \times 10^{-22}$	$(10^{-19} - 10^{-21})\,\mathrm{Hz}^{-1/2}$
100-meter instrument (devised)	(10 – 100) kHz	$2.4 \times 10^{-22} - 4.2 \times 10^{-24}$	$(10^{-21} - 10^{-23})\,\mathrm{Hz}^{-1/2}$
Inverse Gertsenshtein effect, Sec. 4.2.2			
GW-OSQAR II (built) [292]	[200 – 800] THz	$h_{c,n} \simeq 8 \times 10^{-26}$	×
GW-CAST (built) [292]	$[0.5 - 1.5] \times 10^6$ THz	$h_{c,n} \simeq 7 \times 10^{-28}$	×
GW-ALPs II (devised) [292]	[200 – 800] THz	$h_{c,n} \simeq 2.8 \times 10^{-30}$	×
Resonant polarization rotation, Sec. 4.2.4 [302]			
Cruise's detector (devised) [303]	(100 MHz – 100 THz)	$h \simeq 10^{-17}$	×
Cruise & Ingley's detector (prototype) [304,305]	100 MHz	8.9×10^{-14}	$10^{-14}\,\mathrm{Hz}^{-1/2}$
Enhanced magnetic conversion (theory), Sec. 4.2.5 [306]	5 GHz	$h \simeq 10^{-30} - 10^{-26}$	×
Bulk acoustic wave resonators (built), Sec. 4.2.6 [311,312]	(MHz – GHz)	$4.2 \times 10^{-21} - 2.4 \times 10^{-20}$	$10^{-22}\,\mathrm{Hz}^{-1/2}$
Superconducting rings, (theory), Sec. 4.2.7 [313]	10 GHz	$h_{0,n,\mathrm{mono}} \simeq 10^{-31}$	×
Microwave cavities, Sec. 4.2.8			
Caves' detector (devised) [315]	500 Hz	$h \simeq 2 \times 10^{-21}$	×
Reece's 1st detector (built) [316]	1 MHz	$h \simeq 4 \times 10^{-17}$	×
Reece's 2nd detector (built) [317]	10 GHz	$h \simeq 6 \times 10^{-14}$	×
Pegoraro's detector (devised) [318]	(1 – 10) GHz	$h \simeq 10^{-25}$	×
Graviton-magnon resonance (theory), Sec. 4.2.9 [319]	(8 – 14) GHz	$9.1 \times 10^{-17} - 1.1 \times 10^{-15}$	$(10^{-22} - 10^{-20})\mathrm{Hz}^{-1/2}$

more than 20
experimental proposals



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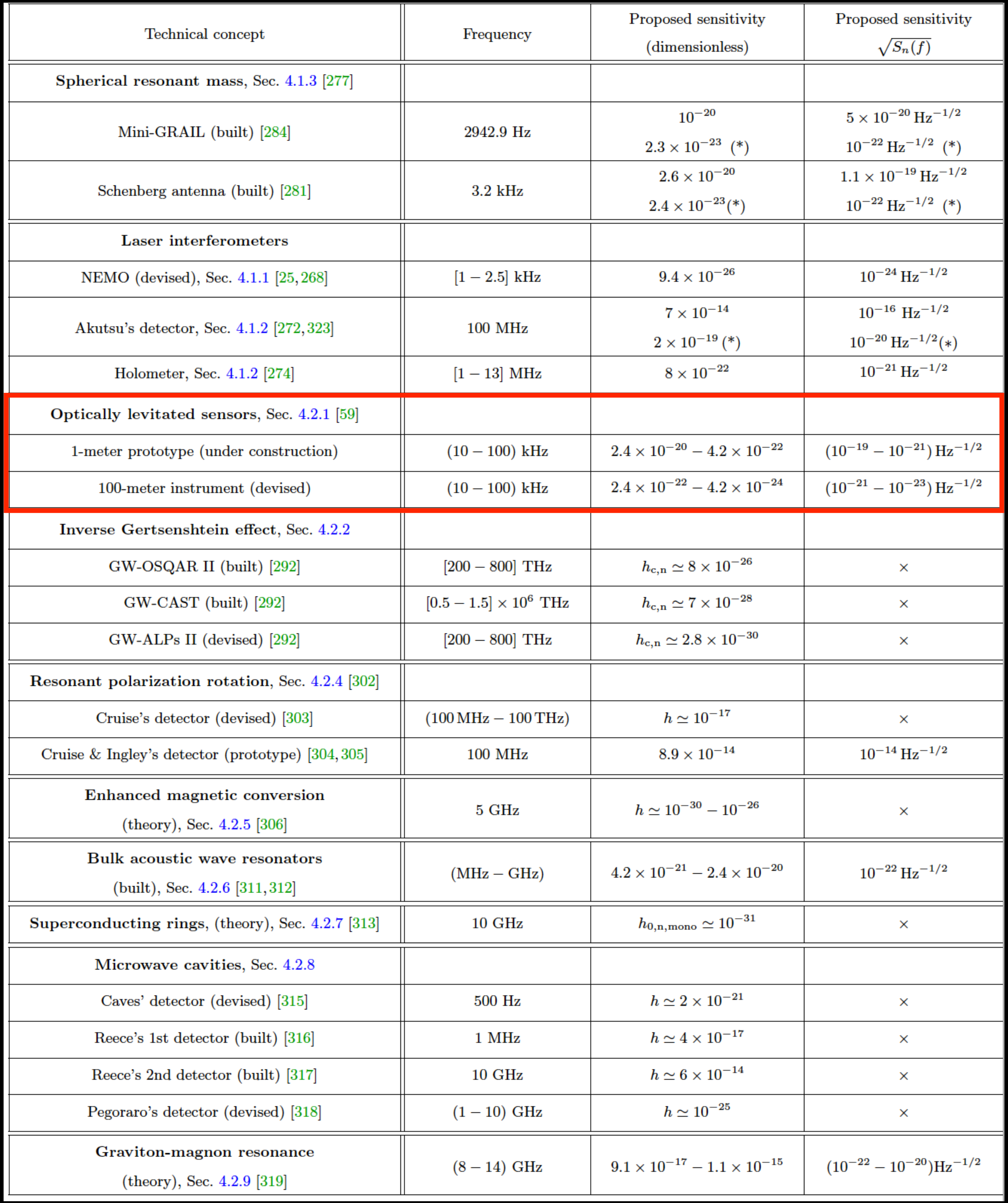

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Reece's 1st detector (built) [316]	1 MHz	$h \simeq 4 \times 10^{-17}$	×
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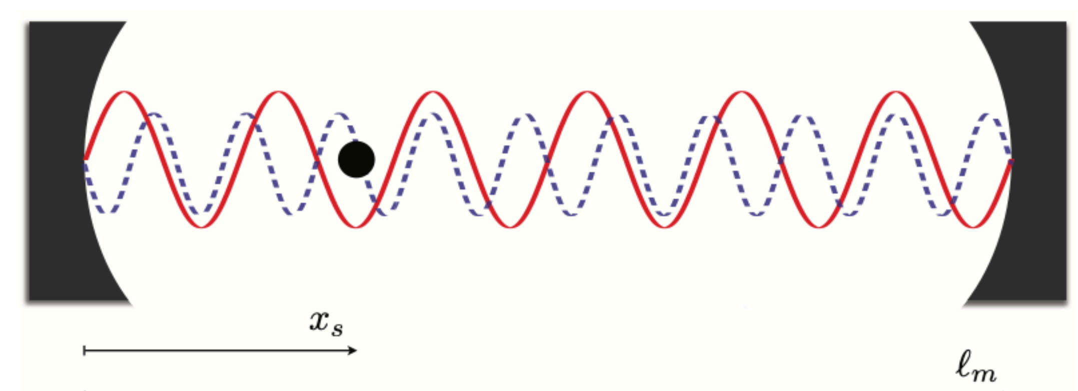
Graviton-magnon resonance (theory), Sec. 4.2.9 [319]	$(8-14)$ GHz	$9.1 \times 10^{-17} - 1.1 \times 10^{-15}$	$(10^{-22} - 10^{-20})\mathrm{Hz}^{-1/2}$

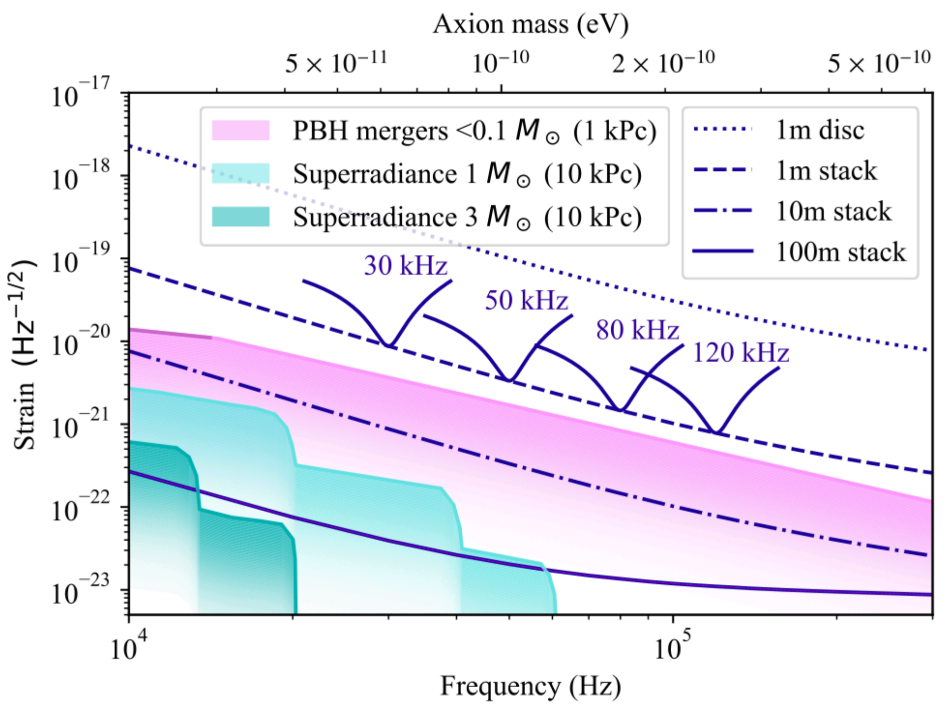
more than 20
experimental proposals

Optically levitated sensors



[A. Arvanitaki, A. Geraci, 1207.5320]

[N. Aggarwal's talk]



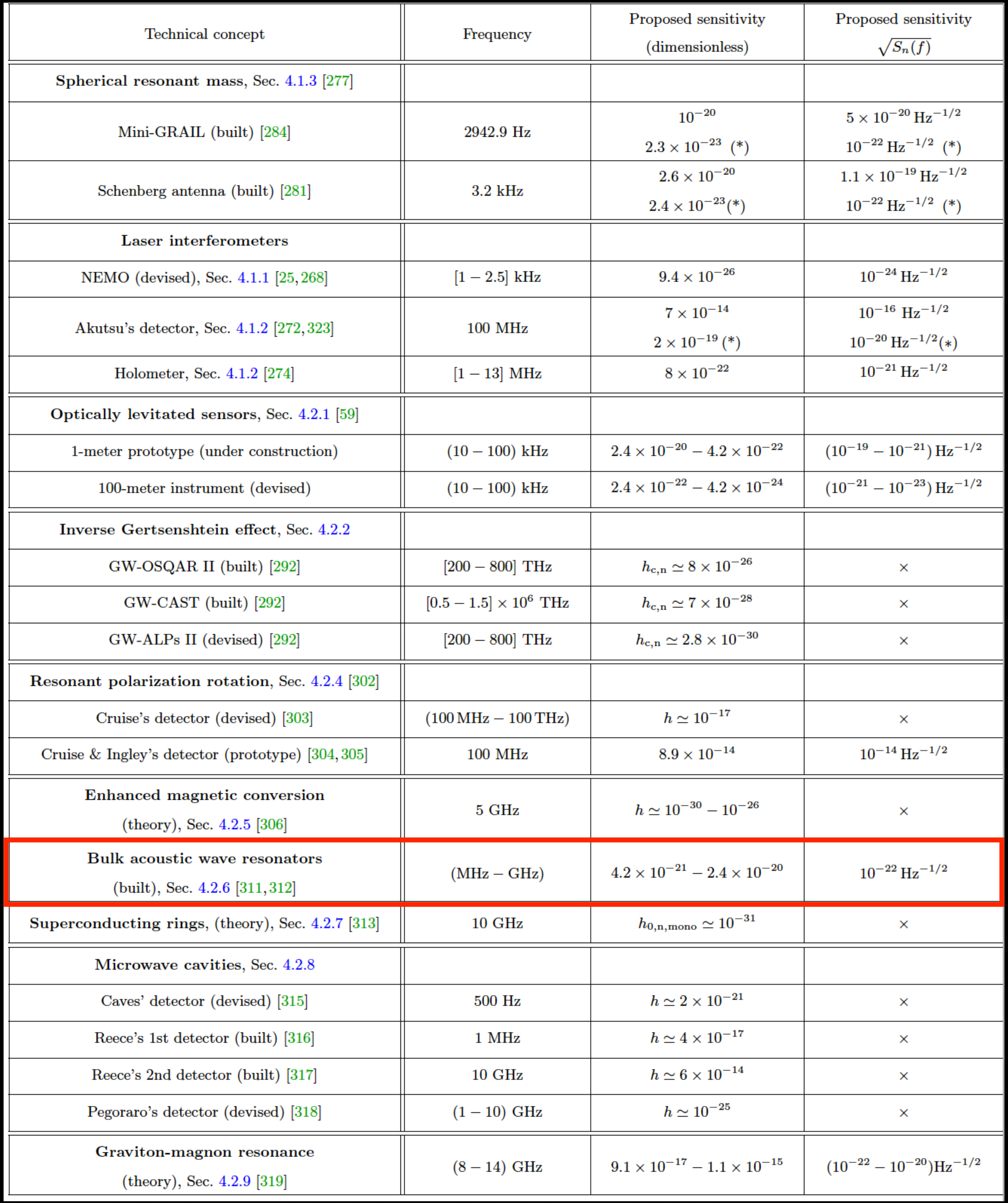
[N. Aggarwal, G. Winstone, M. Teo,
M. Baryakhtar, S. Larson, V. Kalogera,
A. Geraci, 2010.13157]

- 1-meter prototype under construction @ Northwestern University (budget ~ 1M $).

$$\sqrt{S_n} \simeq 10^{-19}\,\mathrm{Hz}^{-1/2} \quad @\,10\,\mathrm{kHz}$$

$$\sqrt{S_n} \simeq 10^{-21}\,\mathrm{Hz}^{-1/2} \quad @\,100\,\mathrm{kHz}$$

- 10-meter instrument → 1 order of magnitude
- 100-meter instrument → 2 orders of magnitude
- Possible improvements: fiber-based cavities, more massive suspended particles.



Technical concept	Frequency	Proposed sensitivity (dimensionless)	Proposed sensitivity $\sqrt{S_n(f)}$
Spherical resonant mass, Sec. 4.1.3 [277]			
Mini-GRAIL (built) [284]	2942.9 Hz	10^{-20} 2.3×10^{-23} (*)	$5 \times 10^{-20}\,\mathrm{Hz}^{-1/2}$ $10^{-22}\,\mathrm{Hz}^{-1/2}$ (*)
Schenberg antenna (built) [281]	3.2 kHz	2.6×10^{-20} 2.4×10^{-23}(*)	$1.1 \times 10^{-19}\,\mathrm{Hz}^{-1/2}$ $10^{-22}\,\mathrm{Hz}^{-1/2}$ (*)
Laser interferometers			
NEMO (devised), Sec. 4.1.1 [25,268]	$[1-2.5]$ kHz	9.4×10^{-26}	$10^{-24}\,\mathrm{Hz}^{-1/2}$
Akutsu's detector, Sec. 4.1.2 [272,323]	100 MHz	7×10^{-14} 2×10^{-19} (*)	$10^{-16}\,\mathrm{Hz}^{-1/2}$ $10^{-20}\,\mathrm{Hz}^{-1/2}$($\ast$)
Holometer, Sec. 4.1.2 [274]	$[1-13]$ MHz	8×10^{-22}	$10^{-21}\,\mathrm{Hz}^{-1/2}$
Optically levitated sensors, Sec. 4.2.1 [59]			
1-meter prototype (under construction)	$(10-100)$ kHz	$2.4 \times 10^{-20} - 4.2 \times 10^{-22}$	$(10^{-19} - 10^{-21})\,\mathrm{Hz}^{-1/2}$
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GW-OSQAR II (built) [292]	$[200-800]$ THz	$h_{\mathrm{c,n}} \simeq 8 \times 10^{-26}$	×
GW-CAST (built) [292]	$[0.5-1.5] \times 10^6$ THz	$h_{\mathrm{c,n}} \simeq 7 \times 10^{-28}$	×
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Resonant polarization rotation, Sec. 4.2.4 [302]			
Cruise's detector (devised) [303]	(100 MHz – 100 THz)	$h \simeq 10^{-17}$	×
Cruise & Ingley's detector (prototype) [304,305]	100 MHz	8.9×10^{-14}	$10^{-14}\,\mathrm{Hz}^{-1/2}$
Enhanced magnetic conversion (theory), Sec. 4.2.5 [306]	5 GHz	$h \simeq 10^{-30} - 10^{-26}$	×
Bulk acoustic wave resonators (built), Sec. 4.2.6 [311,312]	(MHz – GHz)	$4.2 \times 10^{-21} - 2.4 \times 10^{-20}$	$10^{-22}\,\mathrm{Hz}^{-1/2}$
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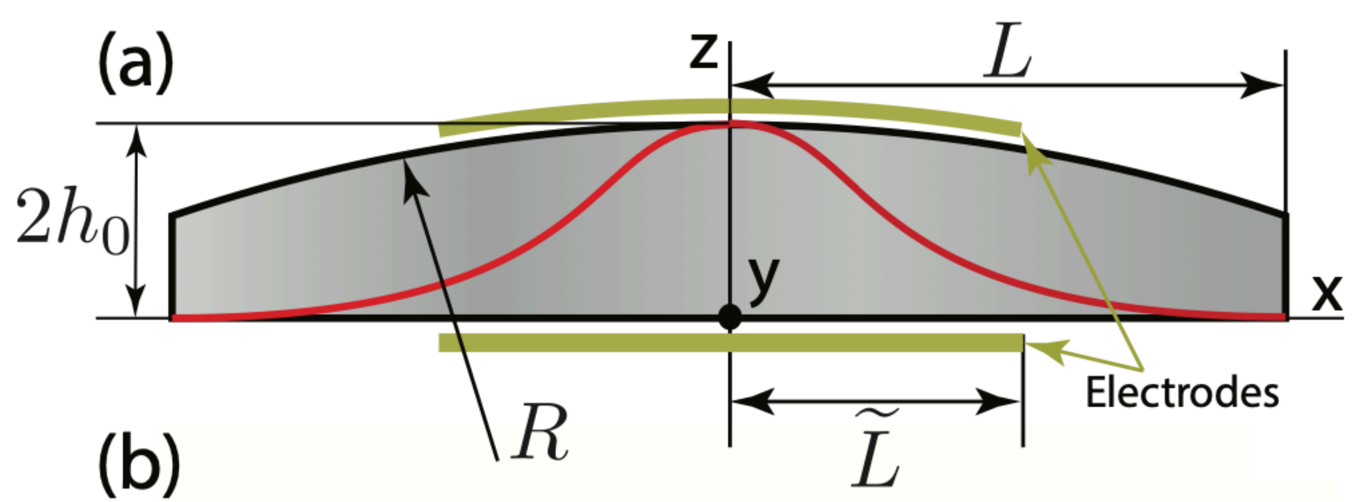
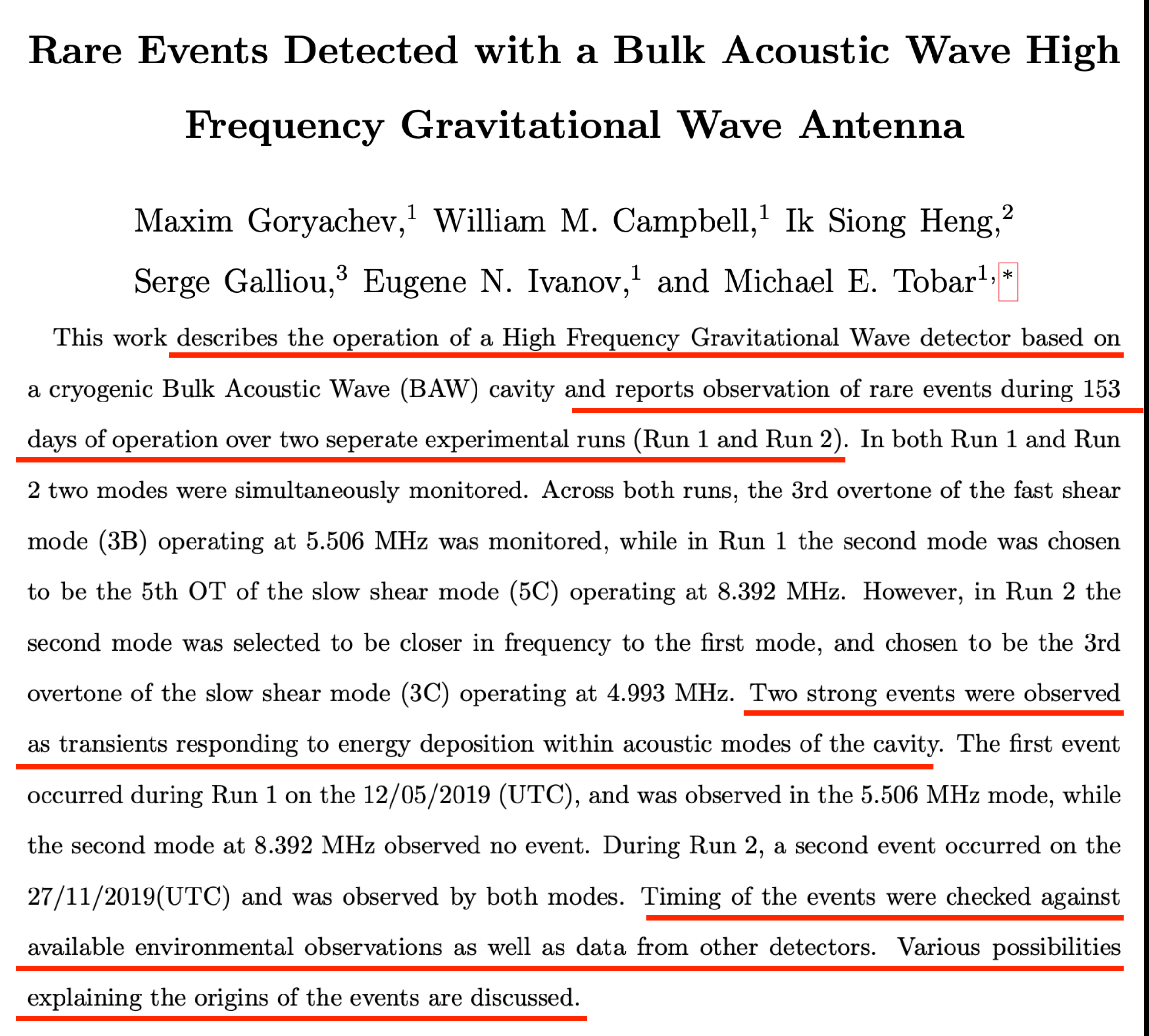
more than 20
experimental proposals

Bulk acoustic wave resonators



[M. Goryachev, M. Tobar, 1410.2334]

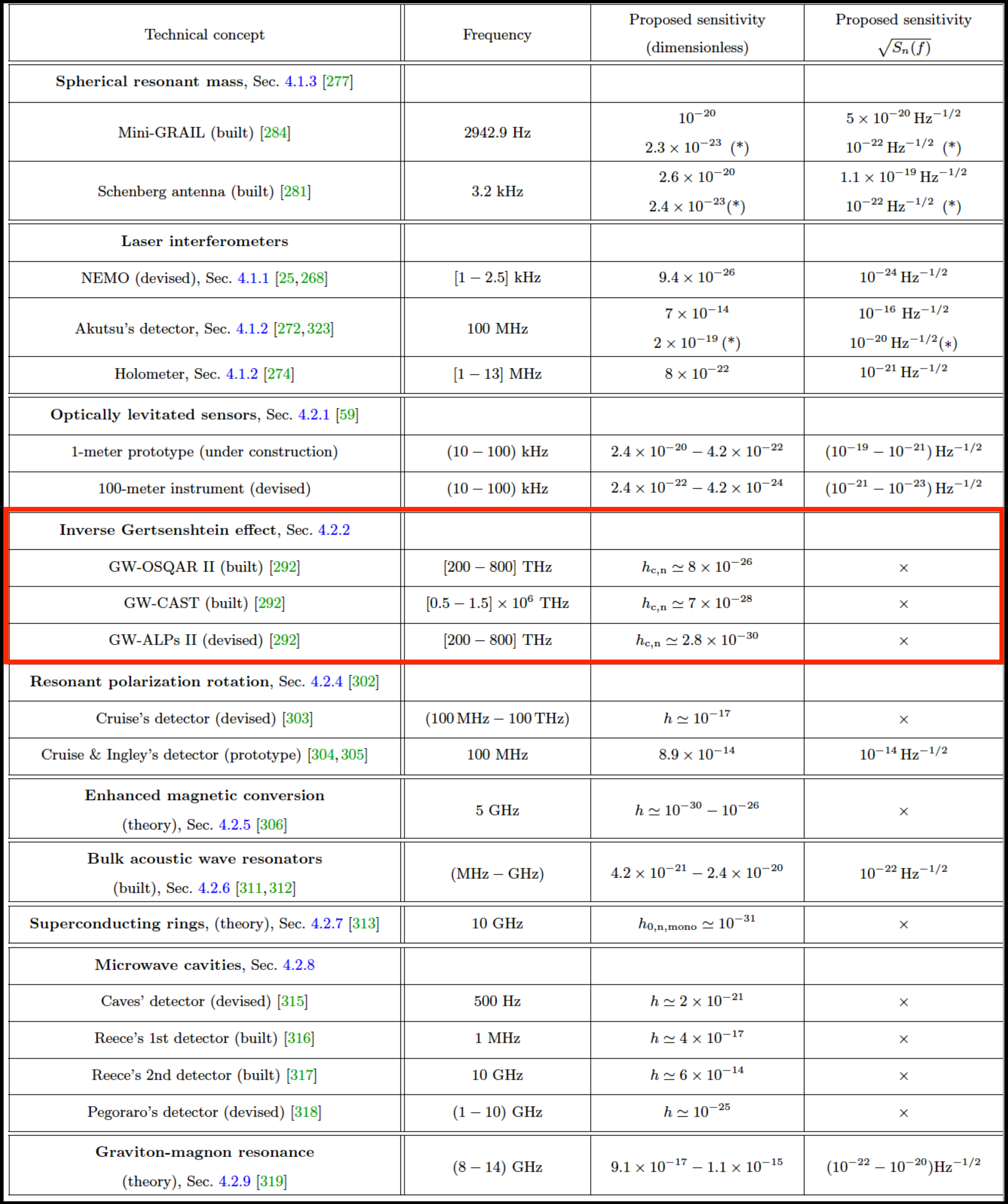


Rare Events Detected with a Bulk Acoustic Wave High Frequency Gravitational Wave Antenna

Maxim Goryachev,[1] William M. Campbell,[1] Ik Siong Heng,[2]
Serge Galliou,[3] Eugene N. Ivanov,[1] and Michael E. Tobar[1,*]

This work describes the operation of a High Frequency Gravitational Wave detector based on a cryogenic Bulk Acoustic Wave (BAW) cavity and reports observation of rare events during 153 days of operation over two seperate experimental runs (Run 1 and Run 2). In both Run 1 and Run 2 two modes were simultaneously monitored. Across both runs, the 3rd overtone of the fast shear mode (3B) operating at 5.506 MHz was monitored, while in Run 1 the second mode was chosen to be the 5th OT of the slow shear mode (5C) operating at 8.392 MHz. However, in Run 2 the second mode was selected to be closer in frequency to the first mode, and chosen to be the 3rd overtone of the slow shear mode (3C) operating at 4.993 MHz. Two strong events were observed as transients responding to energy deposition within acoustic modes of the cavity. The first event occurred during Run 1 on the 12/05/2019 (UTC), and was observed in the 5.506 MHz mode, while the second mode at 8.392 MHz observed no event. During Run 2, a second event occurred on the 27/11/2019(UTC) and was observed by both modes. Timing of the events were checked against available environmental observations as well as data from other detectors. Various possibilities explaining the origins of the events are discussed.

[2102.05859]



Technical concept	Frequency	Proposed sensitivity (dimensionless)	Proposed sensitivity $\sqrt{S_n(f)}$
Spherical resonant mass, Sec. 4.1.3 [277]			
Mini-GRAIL (built) [284]	2942.9 Hz	10^{-20} 2.3×10^{-23} (*)	$5 \times 10^{-20}\,\mathrm{Hz}^{-1/2}$ $10^{-22}\,\mathrm{Hz}^{-1/2}$ (*)
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NEMO (devised), Sec. 4.1.1 [25,268]	$[1 - 2.5]$ kHz	9.4×10^{-26}	$10^{-24}\,\mathrm{Hz}^{-1/2}$
Akutsu's detector, Sec. 4.1.2 [272,323]	100 MHz	7×10^{-14} 2×10^{-19} (*)	$10^{-16}\,\mathrm{Hz}^{-1/2}$ $10^{-20}\,\mathrm{Hz}^{-1/2}$(*)
Holometer, Sec. 4.1.2 [274]	$[1 - 13]$ MHz	8×10^{-22}	$10^{-21}\,\mathrm{Hz}^{-1/2}$
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1-meter prototype (under construction)	$(10 - 100)$ kHz	$2.4 \times 10^{-20} - 4.2 \times 10^{-22}$	$(10^{-19} - 10^{-21})\,\mathrm{Hz}^{-1/2}$
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GW-OSQAR II (built) [292]	$[200 - 800]$ THz	$h_{c,n} \simeq 8 \times 10^{-26}$	×
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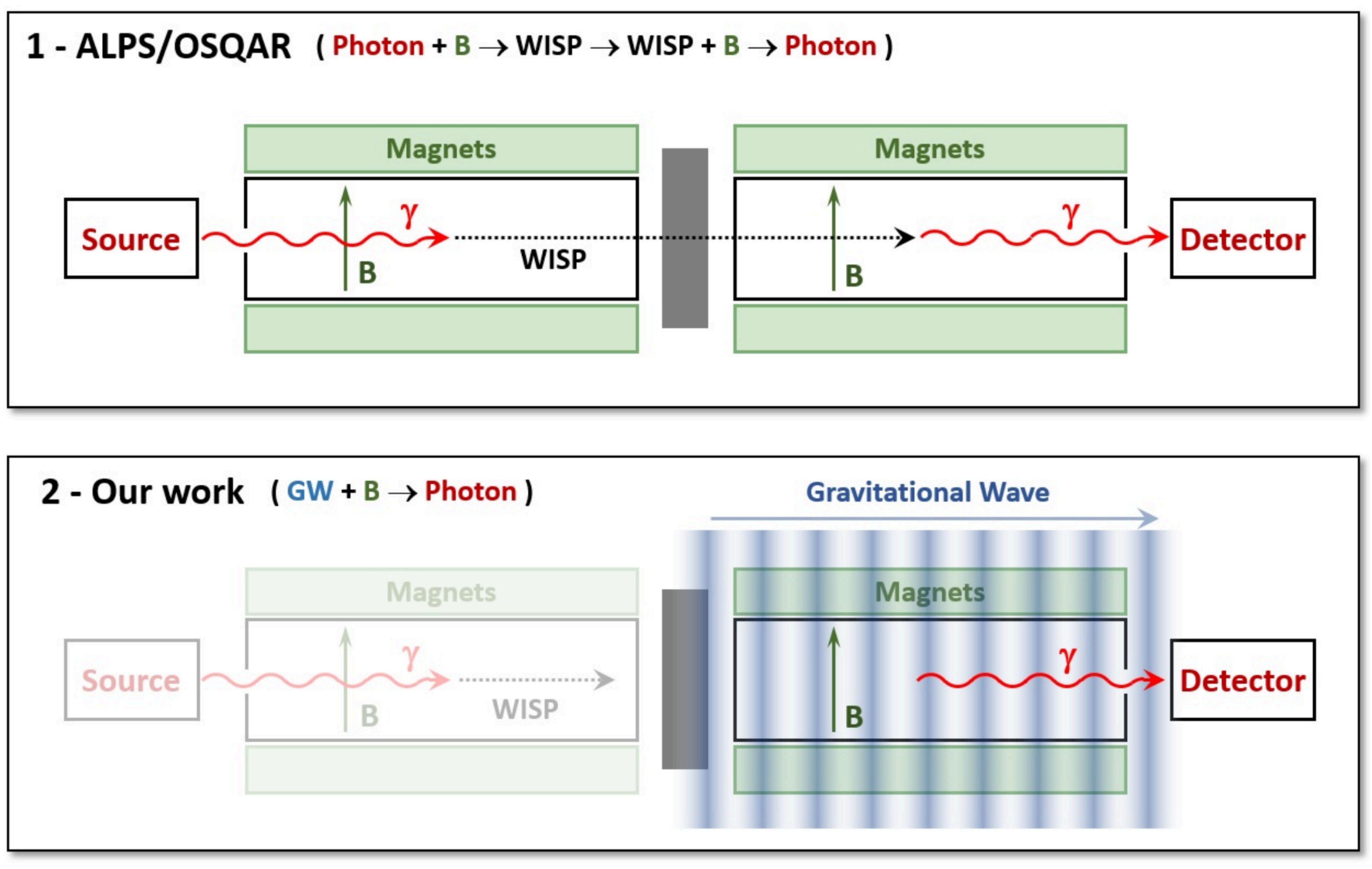
more than 20
experimental proposals

Magnetic conversion

[A. Ejlli, D. Ejlli, M. Cruise, G. Pisano, H. Grote, 1908.00232]



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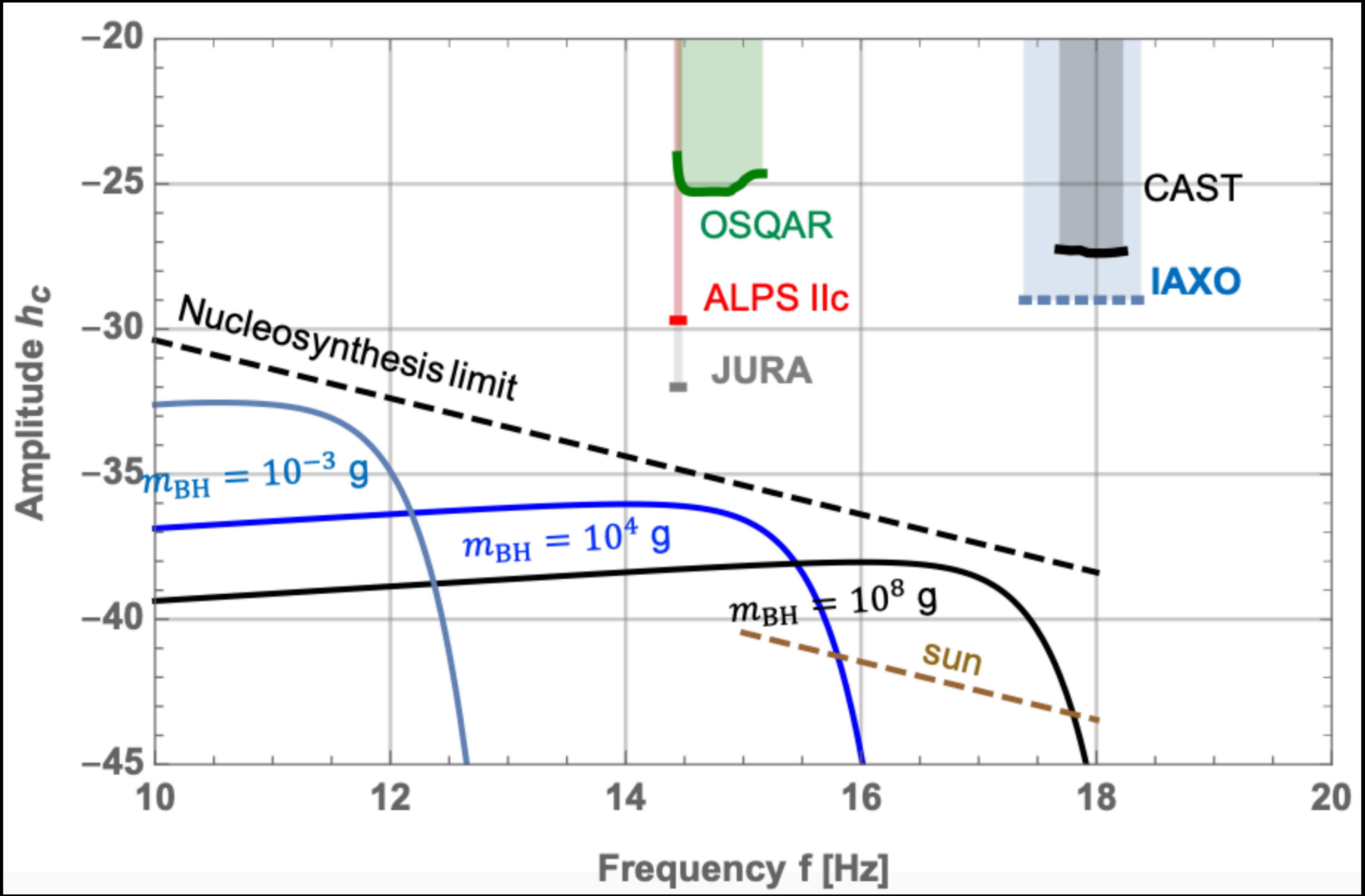

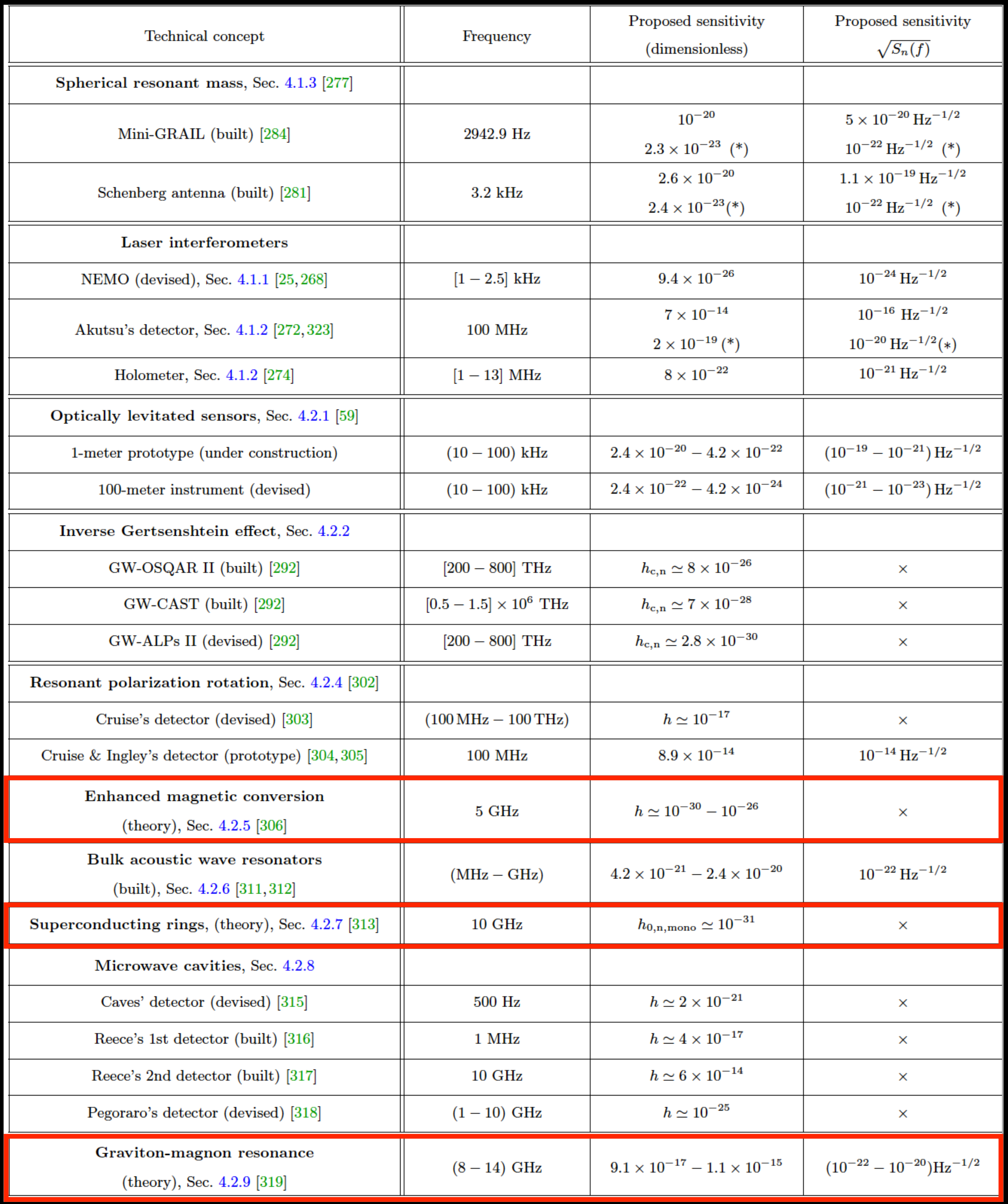

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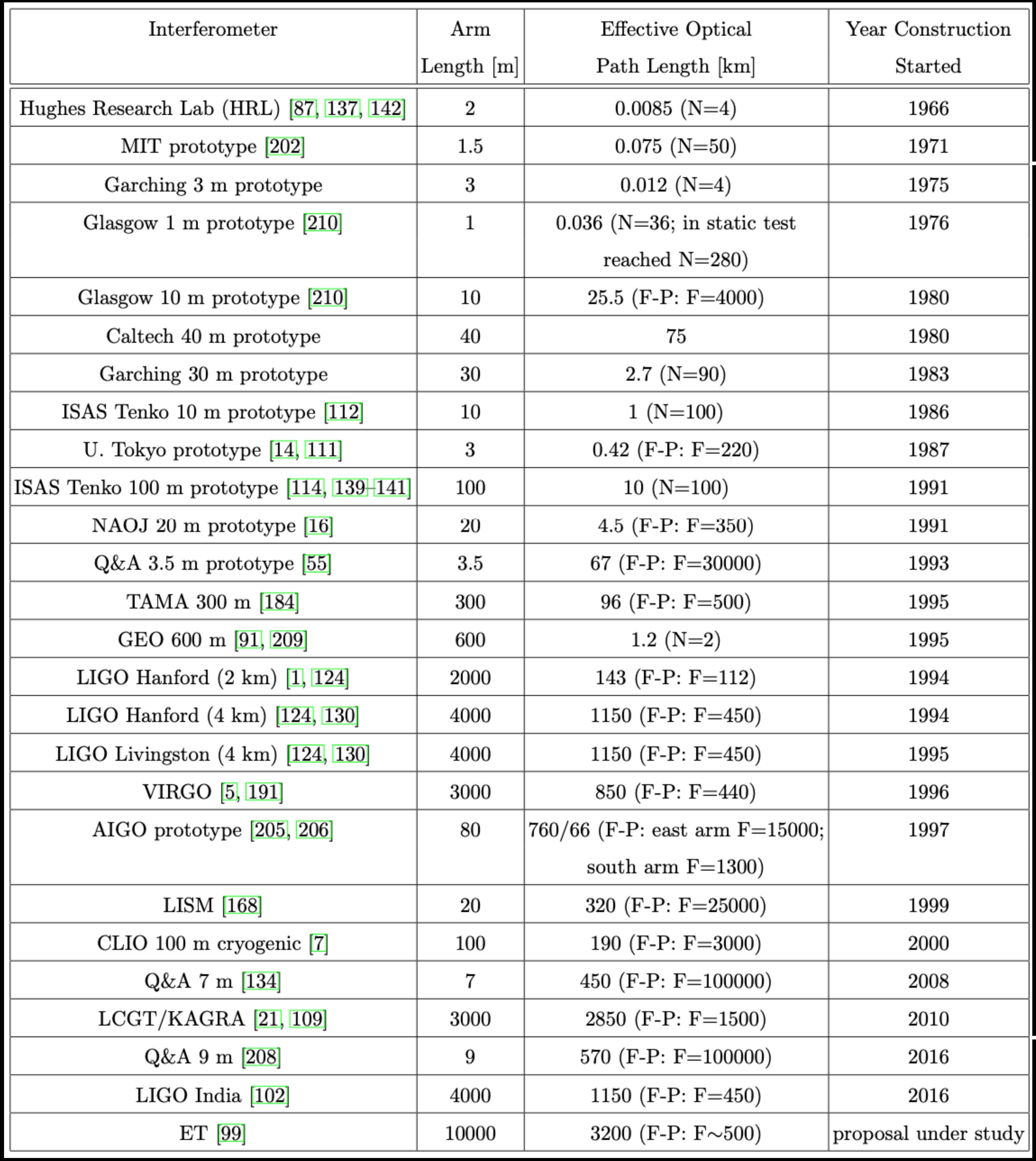
more than 20 experimental proposals

technological gap of at least 6 orders of magnitude

need technological development

Need technology development



Interferometer	Arm Length [m]	Effective Optical Path Length [km]	Year Construction Started
Hughes Research Lab (HRL) [87, 137, 142]	2	0.0085 (N=4)	1966
MIT prototype [202]	1.5	0.075 (N=50)	1971
Garching 3 m prototype	3	0.012 (N=4)	1975
Glasgow 1 m prototype [210]	1	0.036 (N=36; in static test reached N=280)	1976
Glasgow 10 m prototype [210]	10	25.5 (F-P: F=4000)	1980
Caltech 40 m prototype	40	75	1980
Garching 30 m prototype	30	2.7 (N=90)	1983
ISAS Tenko 10 m prototype [112]	10	1 (N=100)	1986
U. Tokyo prototype [14, 111]	3	0.42 (F-P: F=220)	1987
ISAS Tenko 100 m prototype [114, 139–141]	100	10 (N=100)	1991
NAOJ 20 m prototype [16]	20	4.5 (F-P: F=350)	1991
Q&A 3.5 m prototype [55]	3.5	67 (F-P: F=30000)	1993
TAMA 300 m [184]	300	96 (F-P: F=500)	1995
GEO 600 m [91, 209]	600	1.2 (N=2)	1995
LIGO Hanford (2 km) [1, 124]	2000	143 (F-P: F=112)	1994
LIGO Hanford (4 km) [124, 130]	4000	1150 (F-P: F=450)	1994
LIGO Livingston (4 km) [124, 130]	4000	1150 (F-P: F=450)	1995
VIRGO [5, 191]	3000	850 (F-P: F=440)	1996
AIGO prototype [205, 206]	80	760/66 (F-P: east arm F=15000; south arm F=1300)	1997
LISM [168]	20	320 (F-P: F=25000)	1999
CLIO 100 m cryogenic [7]	100	190 (F-P: F=3000)	2000
Q&A 7 m [134]	7	450 (F-P: F=100000)	2008
LCGT/KAGRA [21, 109]	3000	2850 (F-P: F=1500)	2010
Q&A 9 m [208]	9	570 (F-P: F=100000)	2016
LIGO India [102]	4000	1150 (F-P: F=450)	2016
ET [99]	10000	3200 (F-P: F∼500)	proposal under study

[Chen, Nester, Ni, 2016]

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"[interferometers] have so low sensitivity that they are of little experimental interest"

MTW book

50 years
23 attempts

first direct detection

UHF-GW initiative

V. Domcke
CERN
(theory)

F. Quevedo
Cambridge
(theory)

J. Steinlechner
Maastricht
(exp)

S. Steinlechner
Maastricht
(exp)

M. Cruise
Birmingham
(exp)

N. Aggarwal
Northwestern
(exp)

A. Ringwald
DESY
(theory)

Technology roadmap

- Involve all interested groups to collect information about current/planned technologies.
- Discuss fundamental limitations and best routes to pursue.
- Clarify achievable goals in terms of sensitivities, with and without new technical developments, within a given timeframe and budget.

Online questionnaire at https://forms.gle/hNbJYCcv4Zpcr6qz9

UHF-GW initiative


V. Domcke
CERN
(theory)


F. Quevedo
Cambridge
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J. Steinlechner
Maastricht
(exp)


S. Steinlechner
Maastricht
(exp)


M. Cruise
Birmingham
(exp)

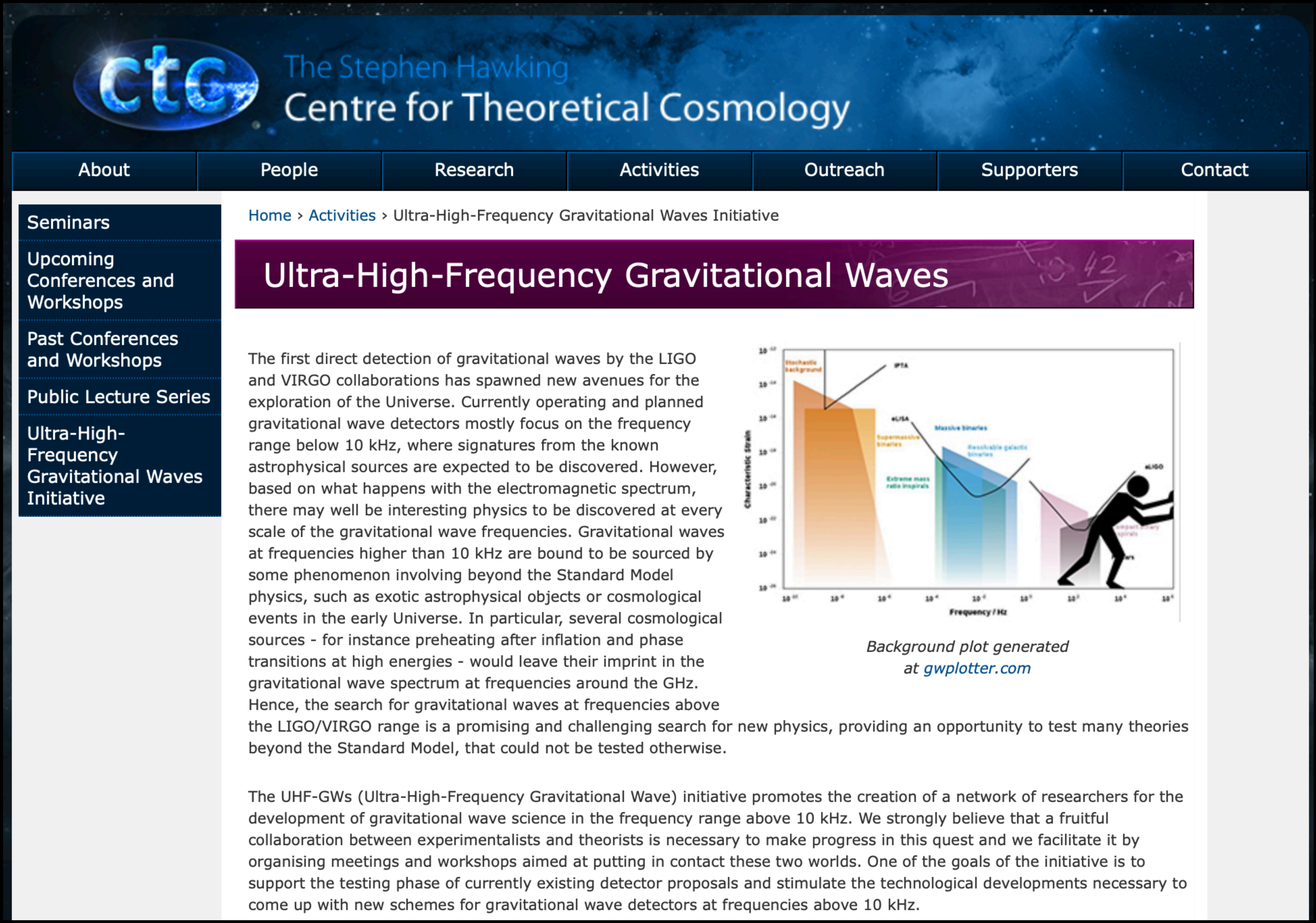

N. Aggarwal
Northwestern
(exp)


A. Ringwald
DESY
(theory)

new online meeting October ‘21

- discuss most promising technologies
- plan construction of prototypes
- discuss how to facilitate existing projects
- sharpen science case

Online questionnaire at https://forms.gle/hNbJYCcv4Zpcr6qz9 http://www.ctc.cam.ac.uk/activities/UHF-GW.php



Ultra-High-Frequency Gravitational Waves

The first direct detection of gravitational waves by the LIGO and VIRGO collaborations has spawned new avenues for the exploration of the Universe. Currently operating and planned gravitational wave detectors mostly focus on the frequency range below 10 kHz, where signatures from the known astrophysical sources are expected to be discovered. However, based on what happens with the electromagnetic spectrum, there may well be interesting physics to be discovered at every scale of the gravitational wave frequencies. Gravitational waves at frequencies higher than 10 kHz are bound to be sourced by some phenomenon involving beyond the Standard Model physics, such as exotic astrophysical objects or cosmological events in the early Universe. In particular, several cosmological sources - for instance preheating after inflation and phase transitions at high energies - would leave their imprint in the gravitational wave spectrum at frequencies around the GHz. Hence, the search for gravitational waves at frequencies above the LIGO/VIRGO range is a promising and challenging search for new physics, providing an opportunity to test many theories beyond the Standard Model, that could not be tested otherwise.

Background plot generated at gwplotter.com

The UHF-GWs (Ultra-High-Frequency Gravitational Wave) initiative promotes the creation of a network of researchers for the development of gravitational wave science in the frequency range above 10 kHz. We strongly believe that a fruitful collaboration between experimentalists and theorists is necessary to make progress in this quest and we facilitate it by organising meetings and workshops aimed at putting in contact these two worlds. One of the goals of the initiative is to support the testing phase of currently existing detector proposals and stimulate the technological developments necessary to come up with new schemes for gravitational wave detectors at frequencies above 10 kHz.

Thanks!