Einstein Telescope Observational Science

German ET Community Spring Meeting 2024 Apr 23

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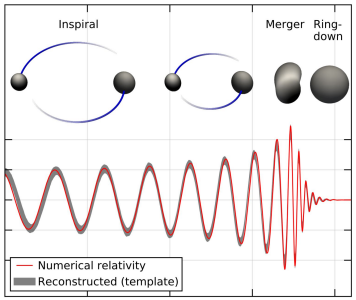
ET EINSTEIN TELESCOPE

Plan of the talk

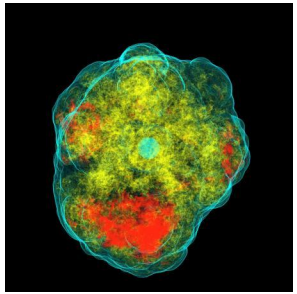
- Observational science with the ET
- ET Observational Science Board
- Comparison of different designs: “CoBA study”
- ET Observational Science Blue Book
- Mock data challenge
- Towards a future data analysis platform

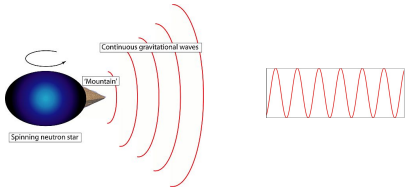
GW sources

Mergers of binaries of black holes and neutron stars

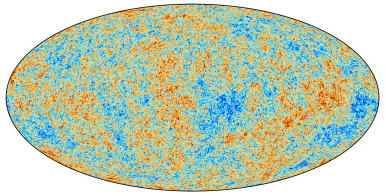


Bursts (supernovae)





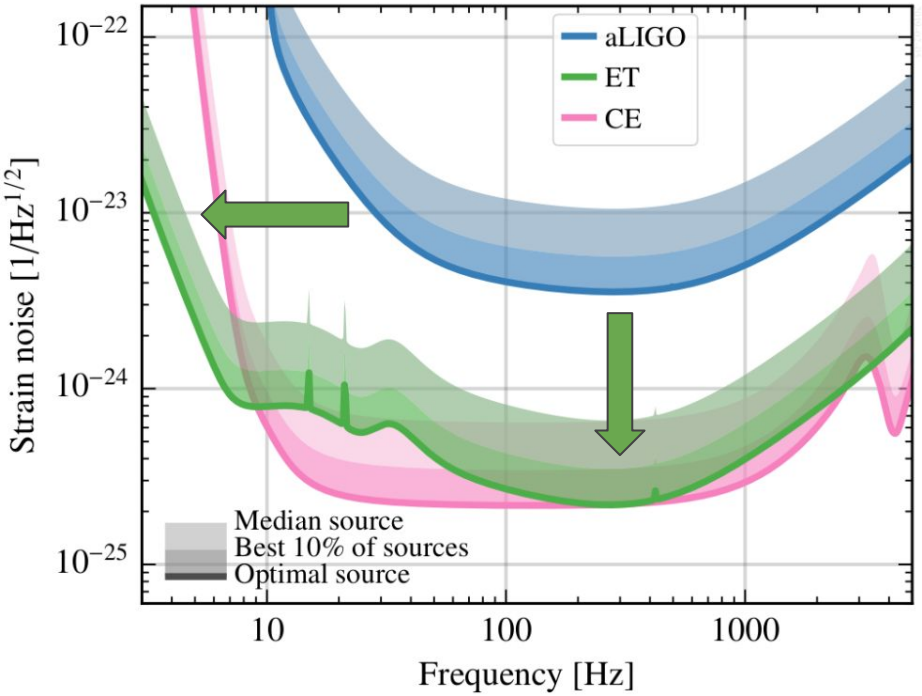
Spinning neutron stars



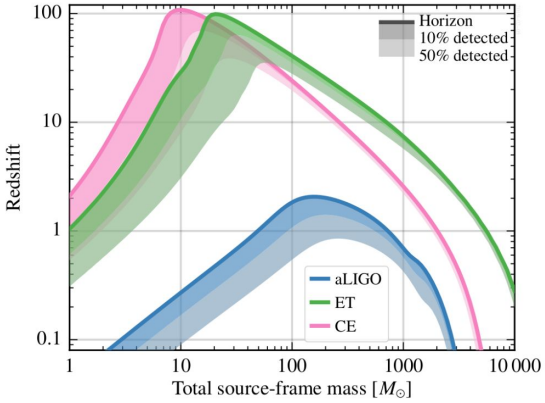
GW background (astrophysical and cosmological)

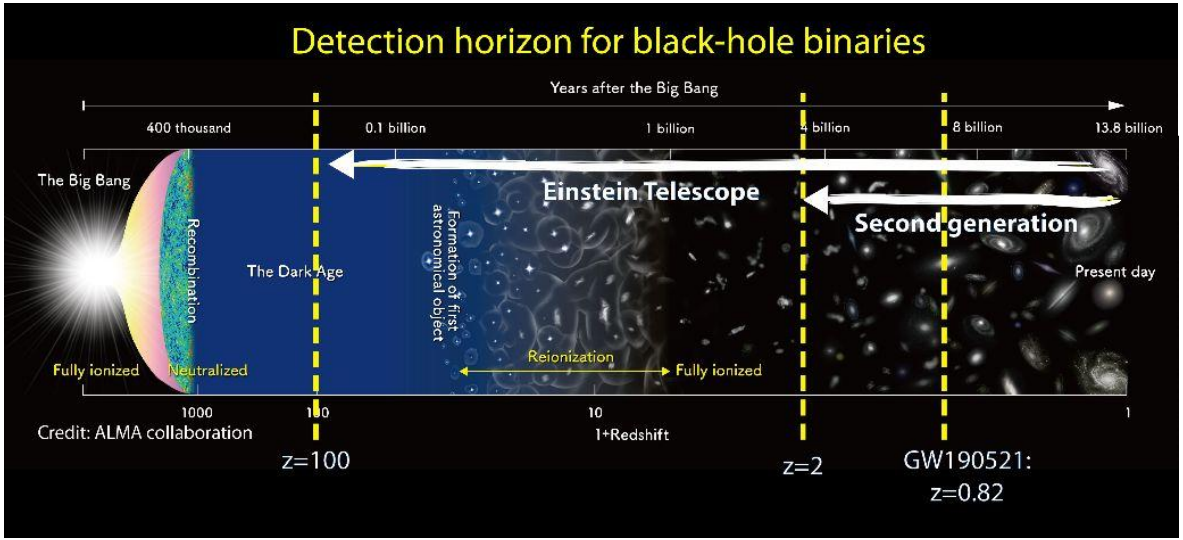
ET sensitivity

- 10 × current detectors
- Low-freq improvement

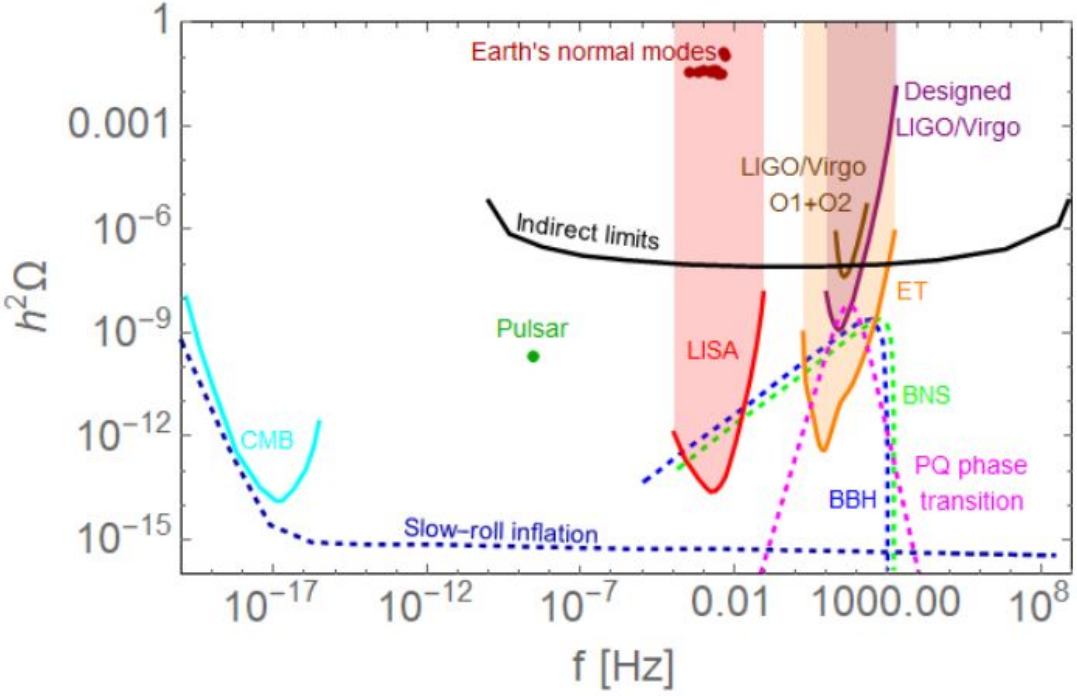


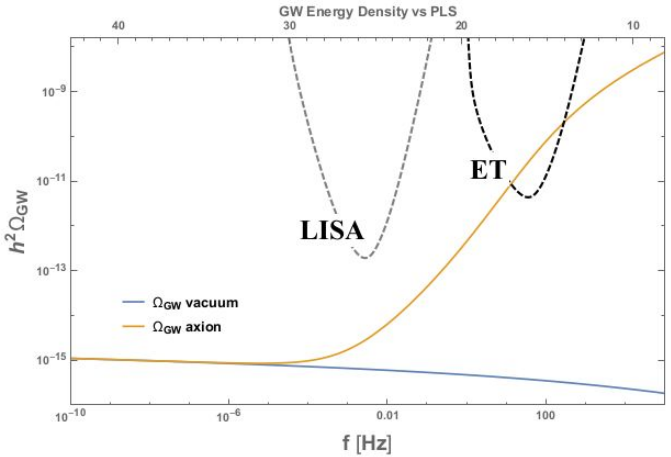
ET detection capability: binary mergers





ET detection capability: GW background





Topological defects, phase transitions ...

ET science

- Black hole properties: origin (stellar / primordial), evolution, demography
- Near-horizon physics, probing the nature of compact objects
- Neutron star properties: strongly coupled matter, QCD, exotic matter
- Multimessenger astronomy
- Dark matter: primordial black holes, axion clouds, ...
- Dark energy and modifications of gravity at cosmological scales
- New sources: supernovae, isolated neutron stars, stochastic background!

From: ET Design Report 2020 Update ET-0007B-20

ET Observational Science Board

Formed in Nov 2021 with a mandate to:

- Investigate science case for ET
- Produce ET blue book (summer 2024)
- Develop analysis tools required for science extraction
- Release a series of mock data challenges
- Develop data analysis platform and computational infrastructure
- Foster relations with other GW experiments
- Foster relations with the external EM/neutrino communities

ET Observational Science Board

10 Divisions:

- Fundamental physics
- Cosmology
- Population studies
- Multimessenger observations
- Synergies with other GW observatories
- Nuclear physics
- Stellar collapse and isolated neutron stars
- Waveforms
- Common tools
- Data analysis platform

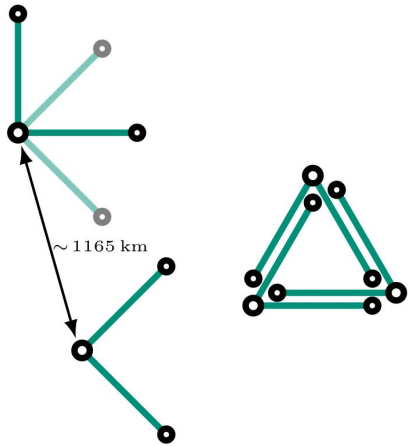
Comparison of different designs: CoBA

- Separated detectors better for compact binary science
- 2L 45° suboptimal for the stochastic background
- A single L is not a viable alternative

- Null stream in the Δ configuration
  - PSD characterization
  - Glitch identification and unmodelled searches

- Correlated noise for co-located detectors
  - Magnetic, seismic, and Newtonian noise
  - Problem at low frequencies

Janssens+ 2022



Journal of Cosmology and Astroparticle Physics
An IOP and SISSA journal

Science with the Einstein Telescope: a comparison of different designs

Marica Branchesi,[1,2,*] Michele Maggiore,[3,4,*] David Alonso,[5]
Charles Badger,[6] Biswajit Banerjee,[1,2] Freija Beirnaert,[7]
Enis Belgacem,[3,4] Swetha Bhagwat,[8,9] Guillaume Boileau,[10,11]

Recent data analysis highlights

- Overlapping signals [Samajdar+ PRD **104** 044003 (2021); Janquart+ arXiv: 2211.01304; Janquart+ MNRAS 523 (2023)]
- Speeding up CBC PE for long signals: relative binning, factorization of the parameter space, machine learning based approaches [a huge body of work]

- Utilization of the null stream [Goncharov+ PRD **105** 122007 (2022)]
- Correlated seismic and Newtonian noise [Janssens+ PRD **106** 042008 (2022)]
- Correlated magnetic noise [Janssens+ PRD **107** 022004 (2023)]
- Likelihood in the presence of correlated noise [Cireddu+ arXiv:2312.14614]
    - In certain situations having co-located detectors can lead to improved CBC parameter estimation!

ET Observational Science Blue Book

- *The* reference for describing science achievable by ET
- Update and enlarge science cases: previous and original work
- Target: scientists, diverse backgrounds

- Chapter per division listed above
- 50-100 pages per chapter written in most cases: editing remains
- Timeline: end of summer 2024

ET Observational Science MDC

Aims:

- Provide a common dataset for comparison of analysis methods
- Find out the limitations of current methods
- Encourage the community to develop new tools
- Assess the potential for astrophysics, fundamental physics and cosmology with ET
- Assess the requirements for computing infrastructure

Topics:

- Searches in the 3G era
- Parameter Estimation for high SNR, long duration, and overlapping signals
- Exploiting the ET null stream
- Cosmological and population inference with 3G data
- Characterising the astrophysical stochastic background
- Estimating computational requirements

ET Data Analysis Platform

- Common data analysis algorithms (similar to LSCSoft)
- Common standards and practices
- Integration with e-Infrastructure