The Einstein Telescope

Status

Harald Lück
Leibniz Universität Hannover
Institut für Gravitationsphysik
and
Albert Einstein Institute
Max-Planck Institute for Gravitational Physics
The advanced GW Network

Advanced LIGO
Hanford, 2015

Advanced LIGO
Livingston, 2015

Advanced Virgo
2016

GEO600, 2011

Advanced LIGO
INDIA, 2024

KAGRA, 2018
LVK Observation runs

<table>
<thead>
<tr>
<th>Year</th>
<th>O1</th>
<th>O2</th>
<th>O3</th>
<th>O4</th>
<th>O5</th>
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<tr>
<td>2015</td>
<td>80 Mpc</td>
<td>100 Mpc</td>
<td>110-130 Mpc</td>
<td>160-190 Mpc</td>
<td>Target 330 Mpc</td>
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<td>2016</td>
<td>30 Mpc</td>
<td>50 Mpc</td>
<td>90-120 Mpc</td>
<td>150-260 Mpc</td>
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<td>2017</td>
<td>8-25 Mpc</td>
<td>25-130 Mpc</td>
<td>130+ Mpc</td>
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<td>2018</td>
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O3a detector range

- Median BNS Range [Mpc]
- Time [days] from April 01, 2019

**LIGO**
- Hanford
- Livingston
- Virgo

**Virgo**
- Hanford
- Livingston
- Virgo

**KAGRA**
- Hanford
- Livingston
- Virgo

**LIGO-India**
- Hanford
- Livingston
- Virgo
Coalescing binaries observed so far O1 – O3a

LIGO-Virgo Black Holes

LIGO-Virgo Neutron Stars

GWTC-2 plot v1.0

LIGO-P2000061-v10 LIGO-Virgo | Frank Elavsky, Aaron Geller | Northwestern
More sources out there...

Supernova

CBCs

Pulsars

Star quakes

Stochastic GW background
Limiting noise sources:

- High frequencies
  - Shot noise
- Mid frequencies
  - Shot + Rad.Pres. noise
- Low frequencies
  - Radiation pressure
  - Seismic
  - Suspension thermal
  - Newtonian
  + Control Noise
Detector Subsystems

Colours for subsystems:
- Core optics, coatings
- Light sources
- Quantum Enhancements
- Auxiliary optics
- Sensing and Control
- Seismic Isolation & Suspensions
- Cryogenics
Between the observation runs → stepwise upgrades → A+ the advanced Plus Detectors

Infrastructure will reach an end of lifetime and a limit in performance (self noise, size) → New infrastructures
Updated Documents

http://www.et-gw.eu

Relevant ET Documents

- Einstein Telescope: Science Case, Design Study and Feasibility Report
- Science Case for the Einstein Telescope
- ET cost book
- Socio-economic impact of the Einstein Telescope
- Einstein Telescope: An assessment of its economic, social and environmental impact in Sardinia
- Management structure of the ET Collaboration
Cosmic Explorer will have 40 km arms \( \rightarrow \) gain a factor 10 w.r.t. advanced LIGO

**THE SIZE**

**Einstein Telescope 10 km**

Advanced LIGO
4 km

3 Interferometers resolve polarisation
**ET - Xylophone Concept**

**ET - LF**
- low-power, cryogenic low-frequency detector

**ET – HF**
- high-power, room-temperature high-frequency detector

**ET-HF:**
- High power laser
- High circulating light power
- Thermal compensation
- Large test masses
- New coatings
- Frequency dependent squeezing

**ET-LF:**
- Cryogenics
- Seismic suspensions
- Silicon (Sapphire) test masses
- Large test masses
- New coatings
- New laser wavelength
- Frequency dependent squeezing, Filter cavities

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**Diagram Notes:**
- Optical element, Fused Silica, room temperature
- Optical element, Silicon, cryogenic
- Laser beam 1550nm
- Laser beam 1064nm
- Squeezed light beam

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**300 K**

**10 – 20 K**
ET Xylophone Sensitivity

ET-LF

ET-HF
Cosmic Explorer
The 3G GW Network (2035→)

ET EINSTEIN TELESCOPE

Cosmic Explorer

aLIGO+

3G south/ NEMO

aLIGO +

AdV+

aLIGO+

INDIA

KAGRA
Sensitivities in the 3G era
Hearing the „whole universe“...

CBC Sources throughout the universe

Credit: E. Hall (MIT)
Gravitational wave astronomy
In the late 30's