



APC Laboratory's



Gravitation Group

« Spacetime tells matter how to move;
matter tells spacetime how to curve. »

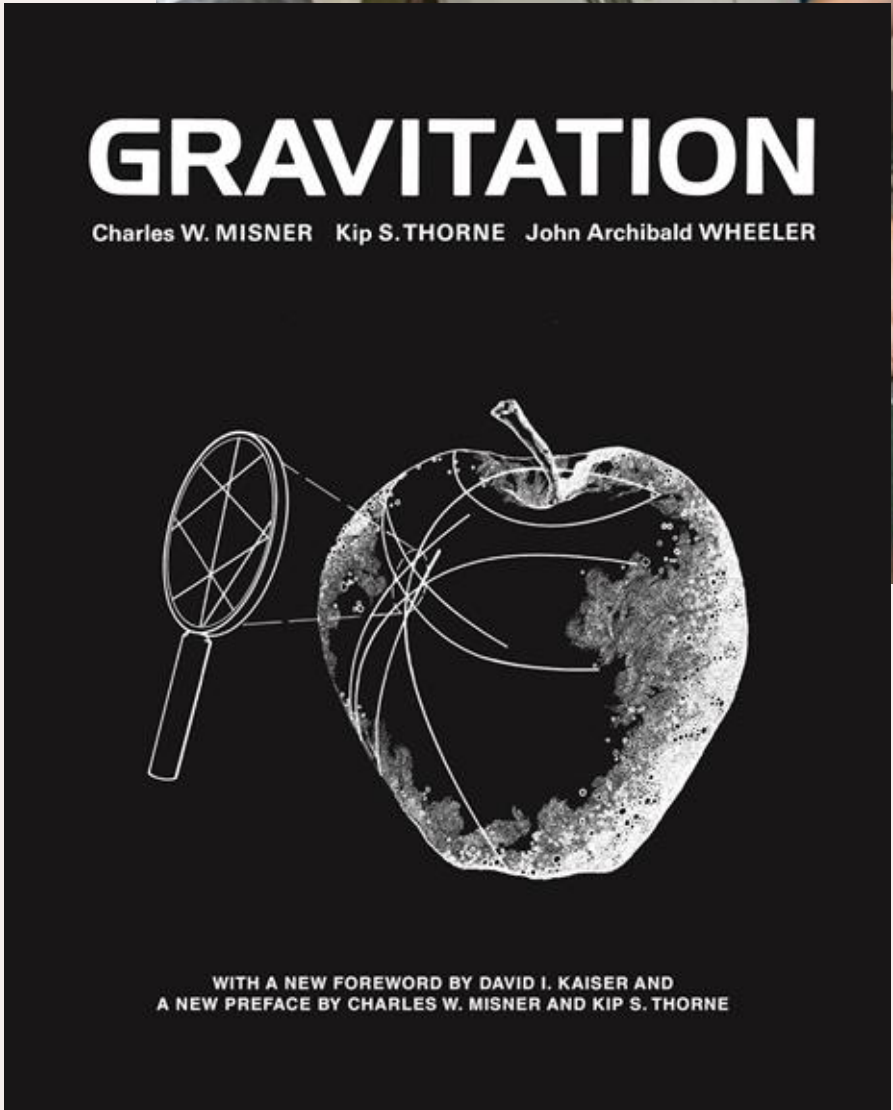
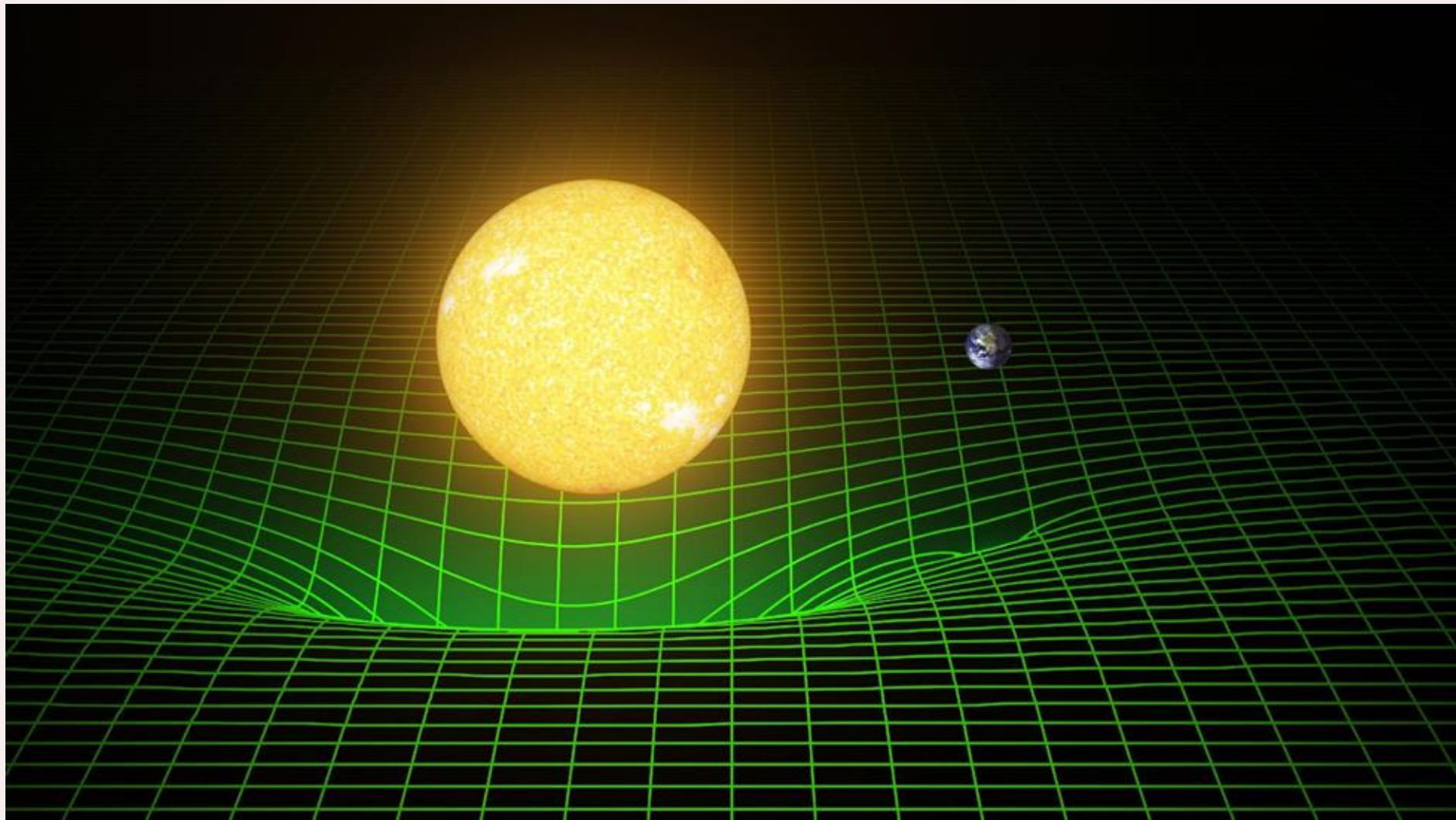
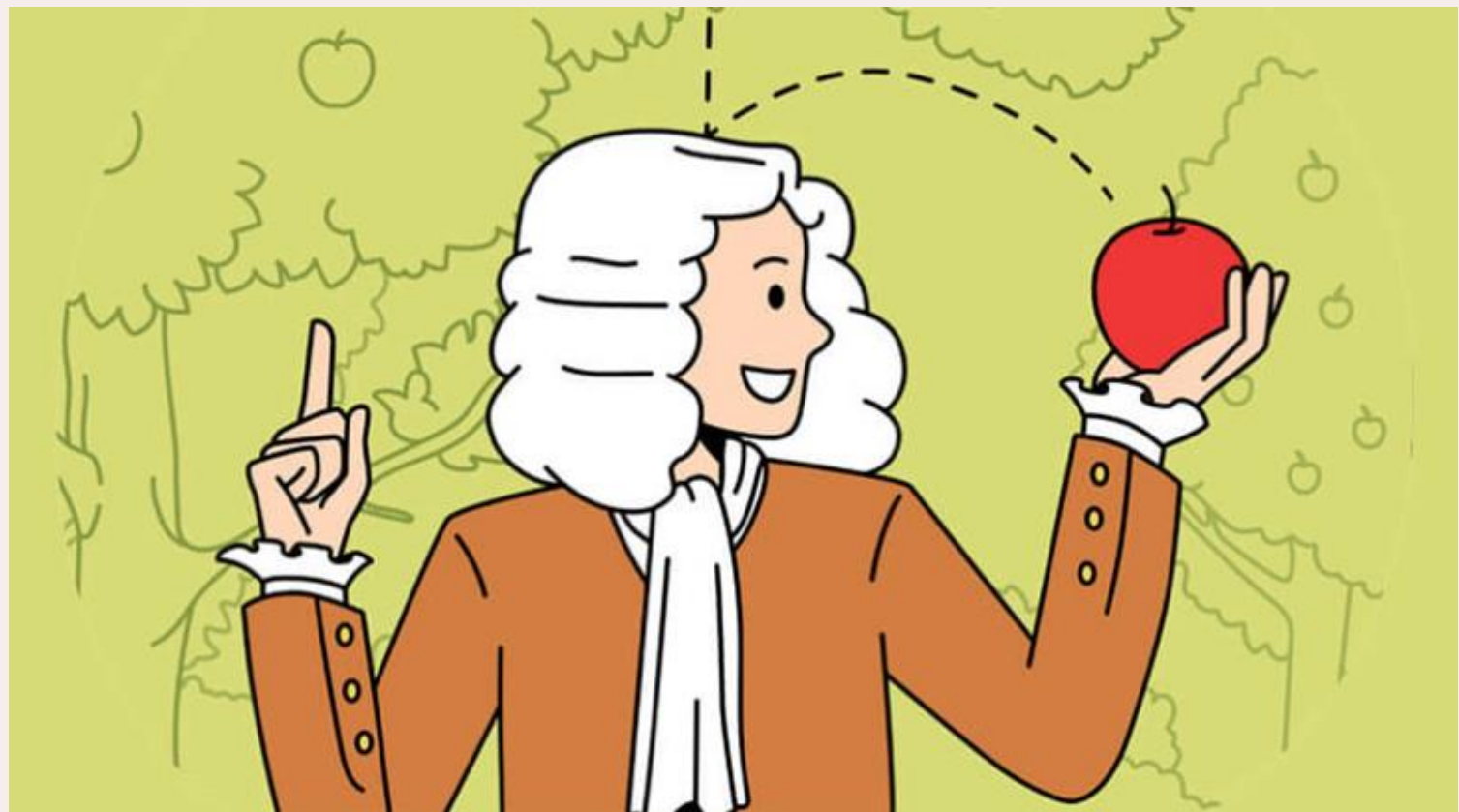
John Archibald Wheeler, Gravitation, 1973

Hubert HALLOIN

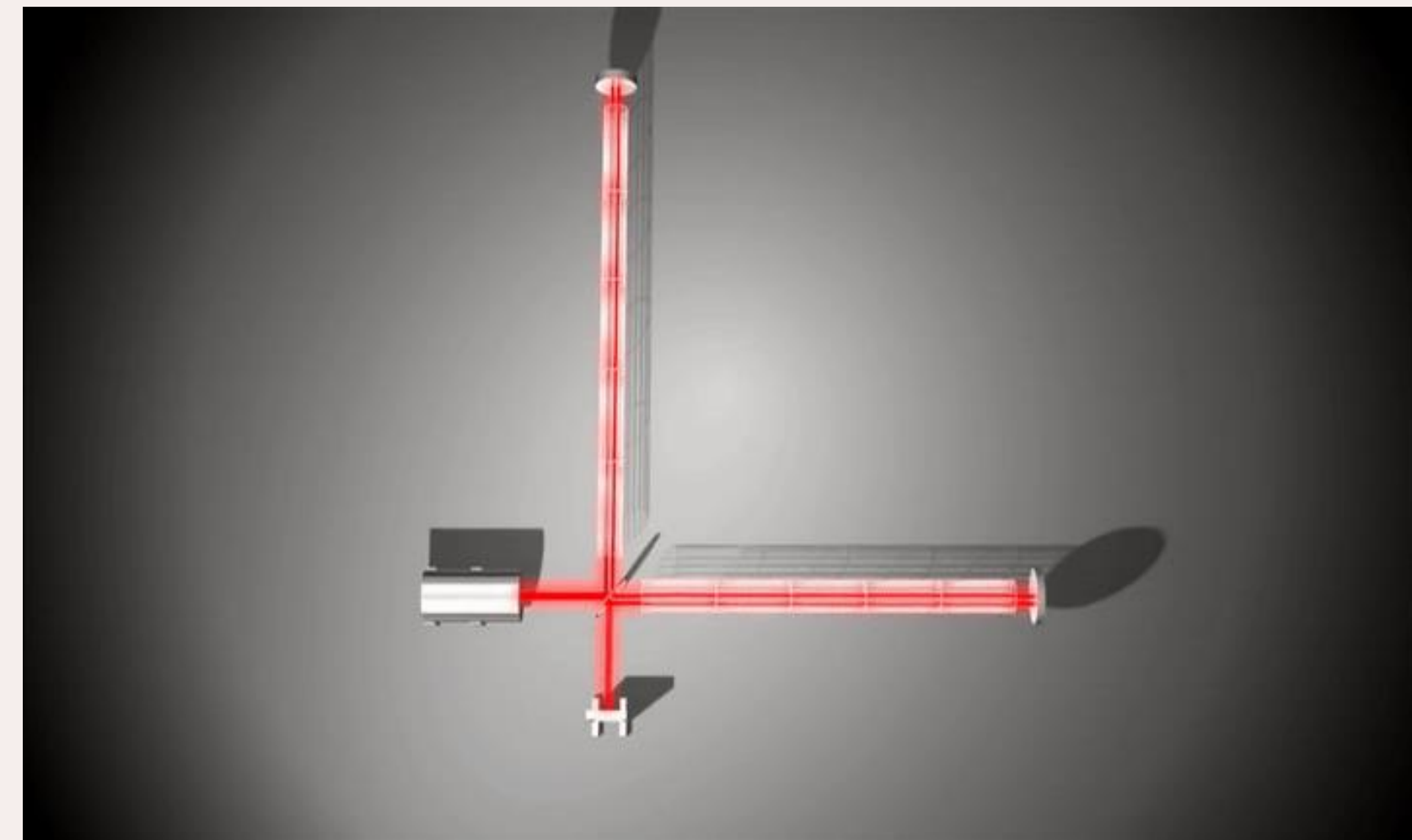
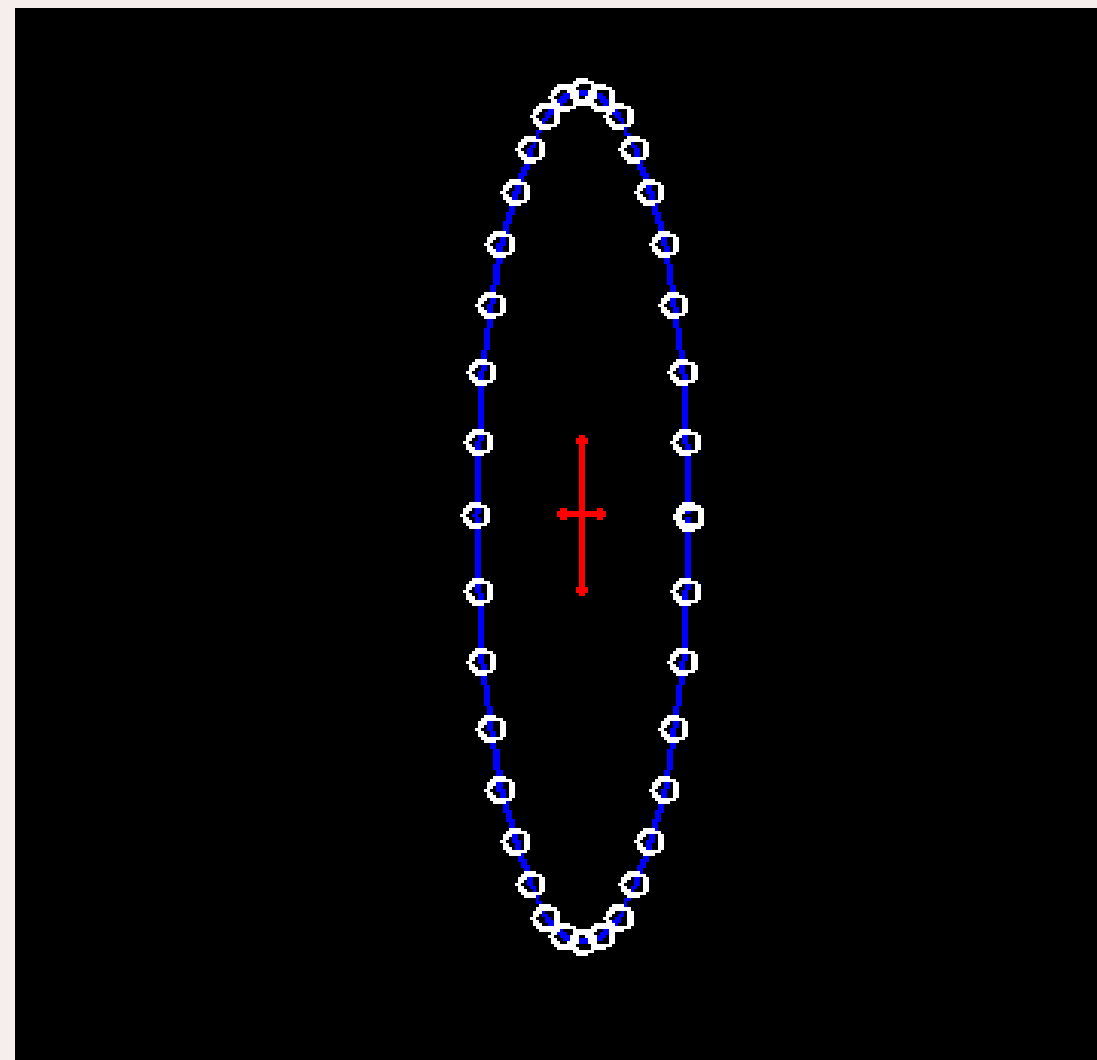
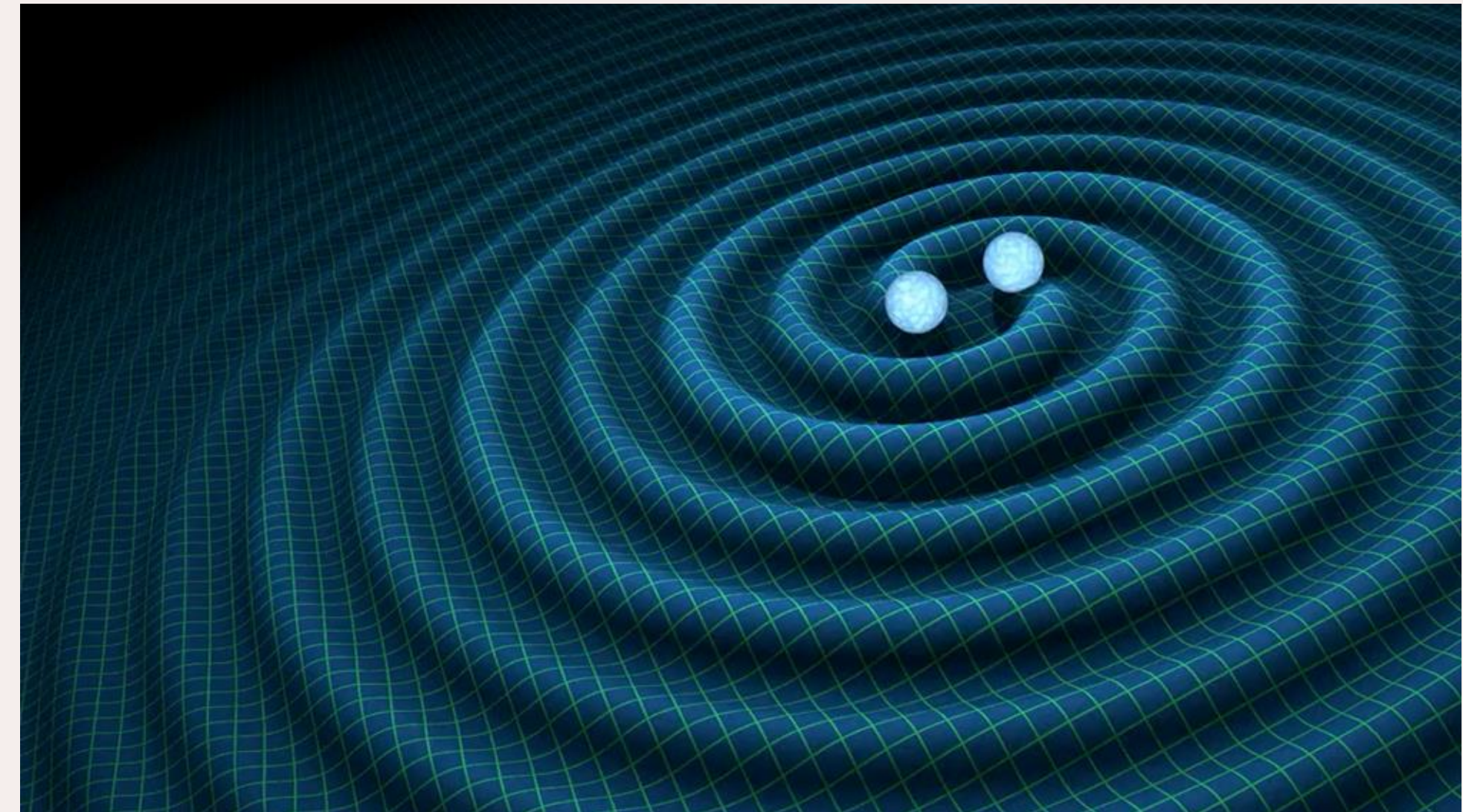
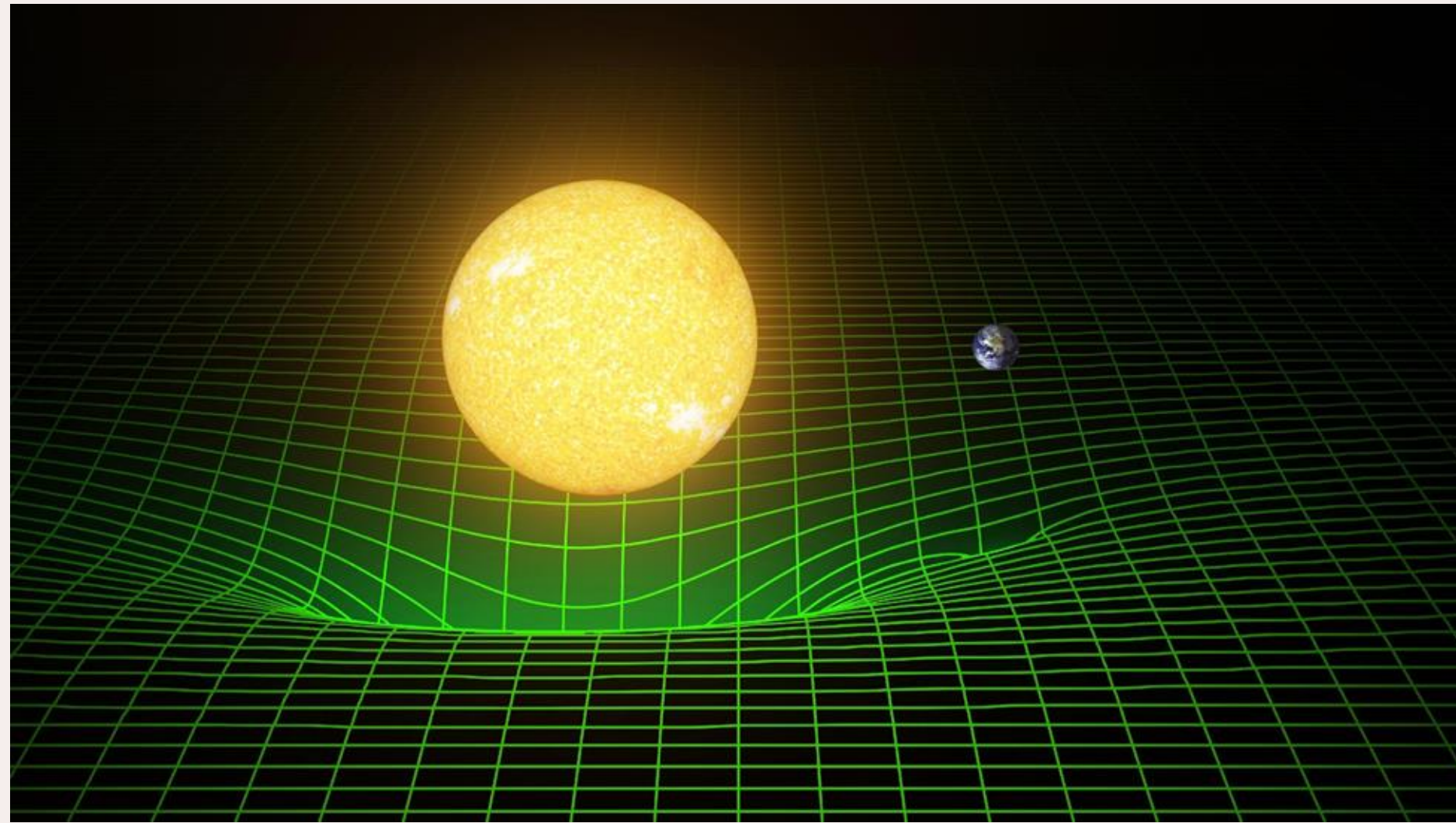
14.10.2026

AADC Visit

Gravitation in a nutshell/1



Gravitational waves in a nutshell/2

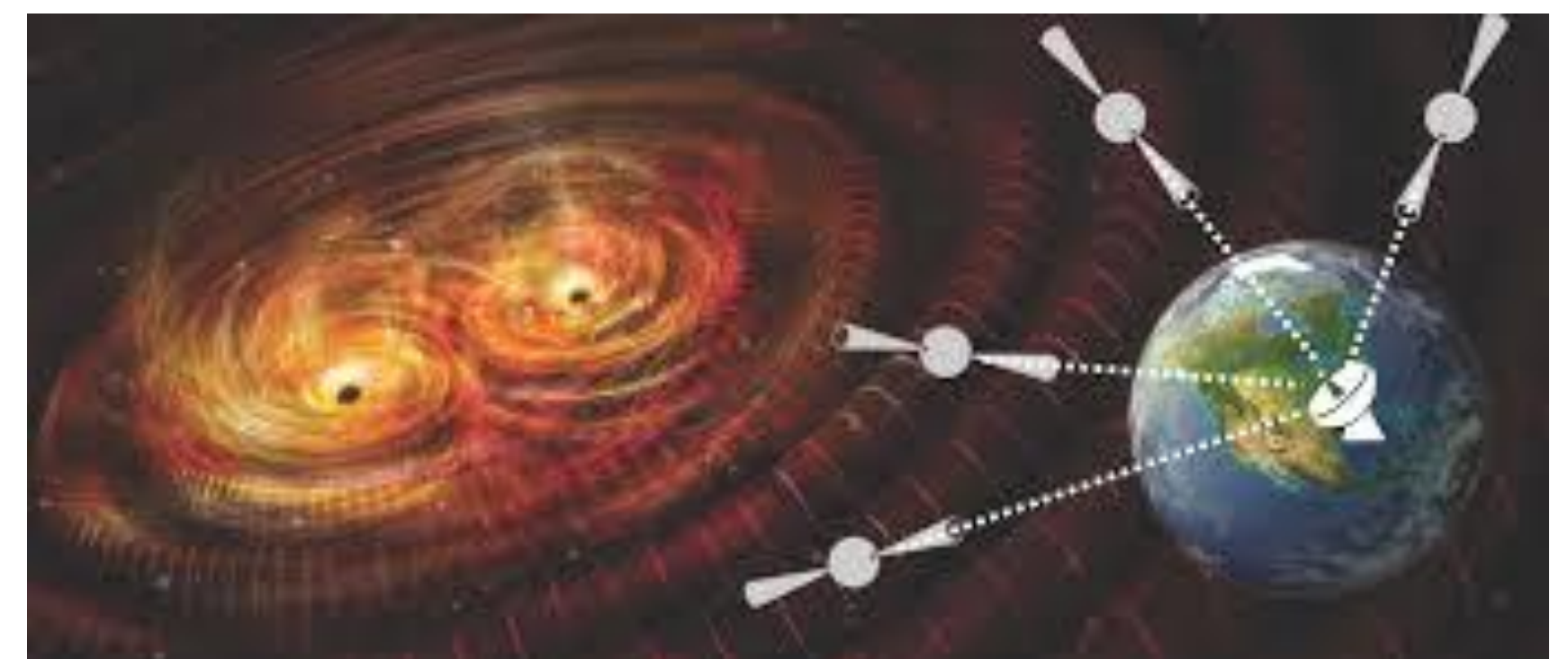
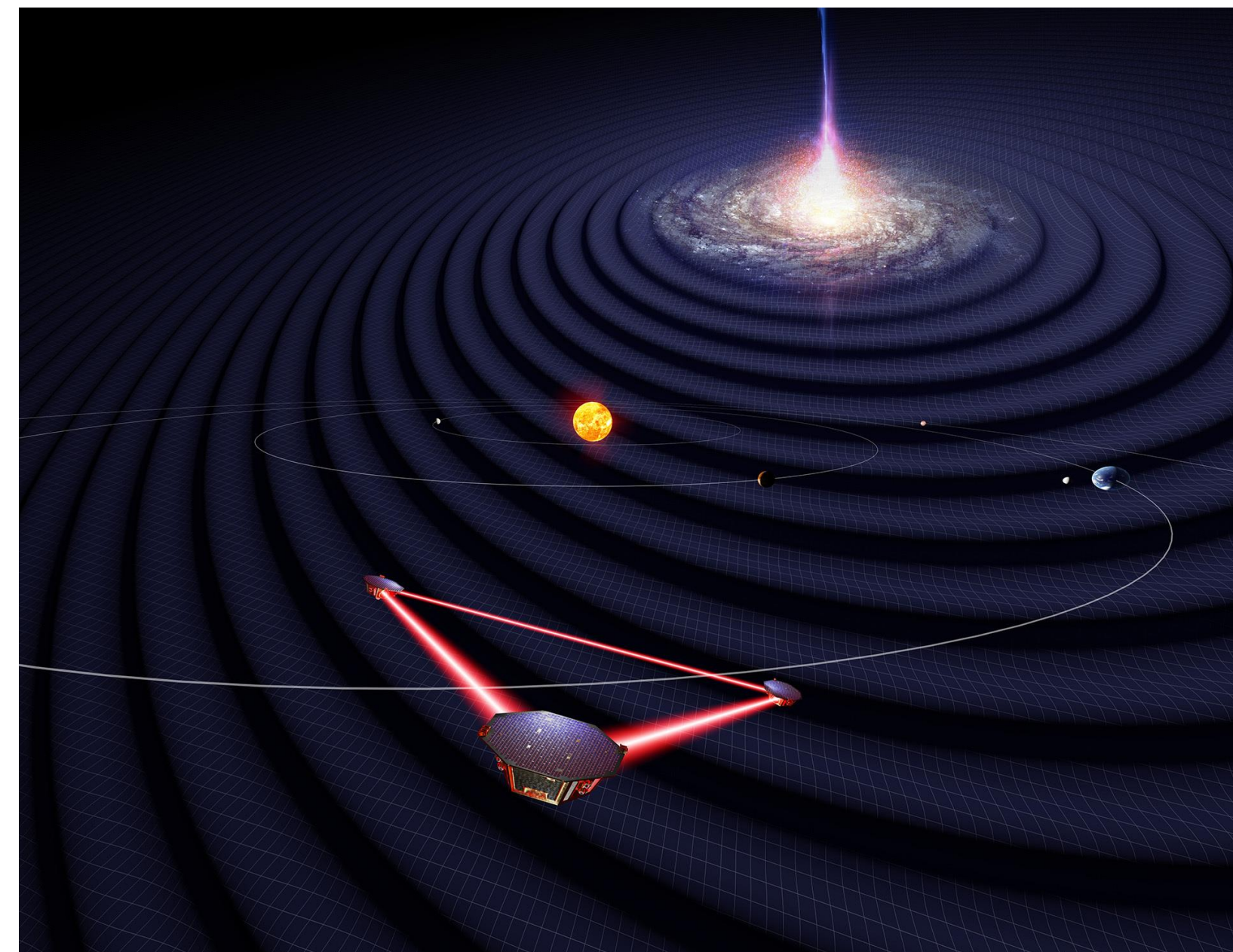
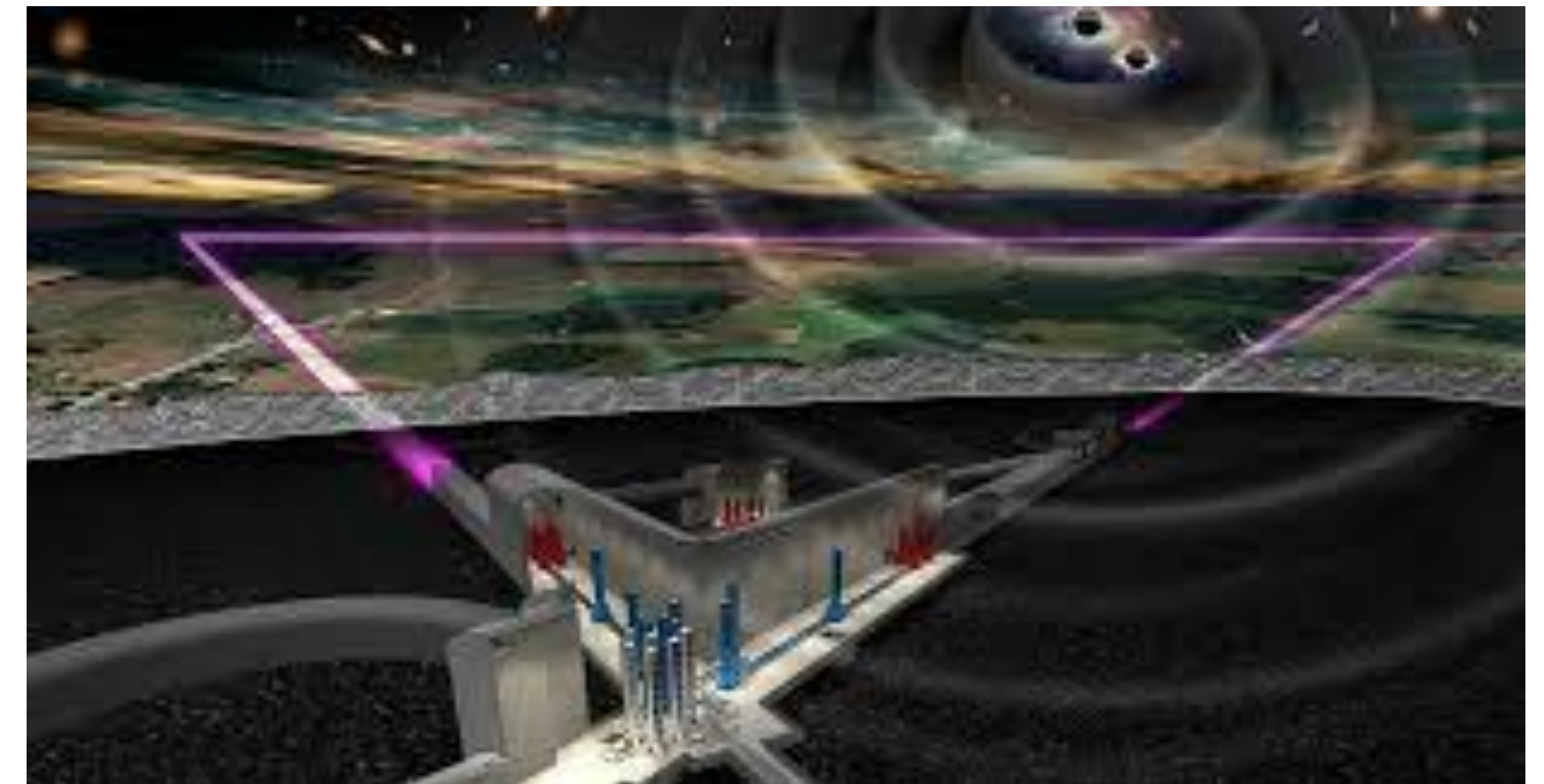


How gravitational waves are addressing the “big questions” ?

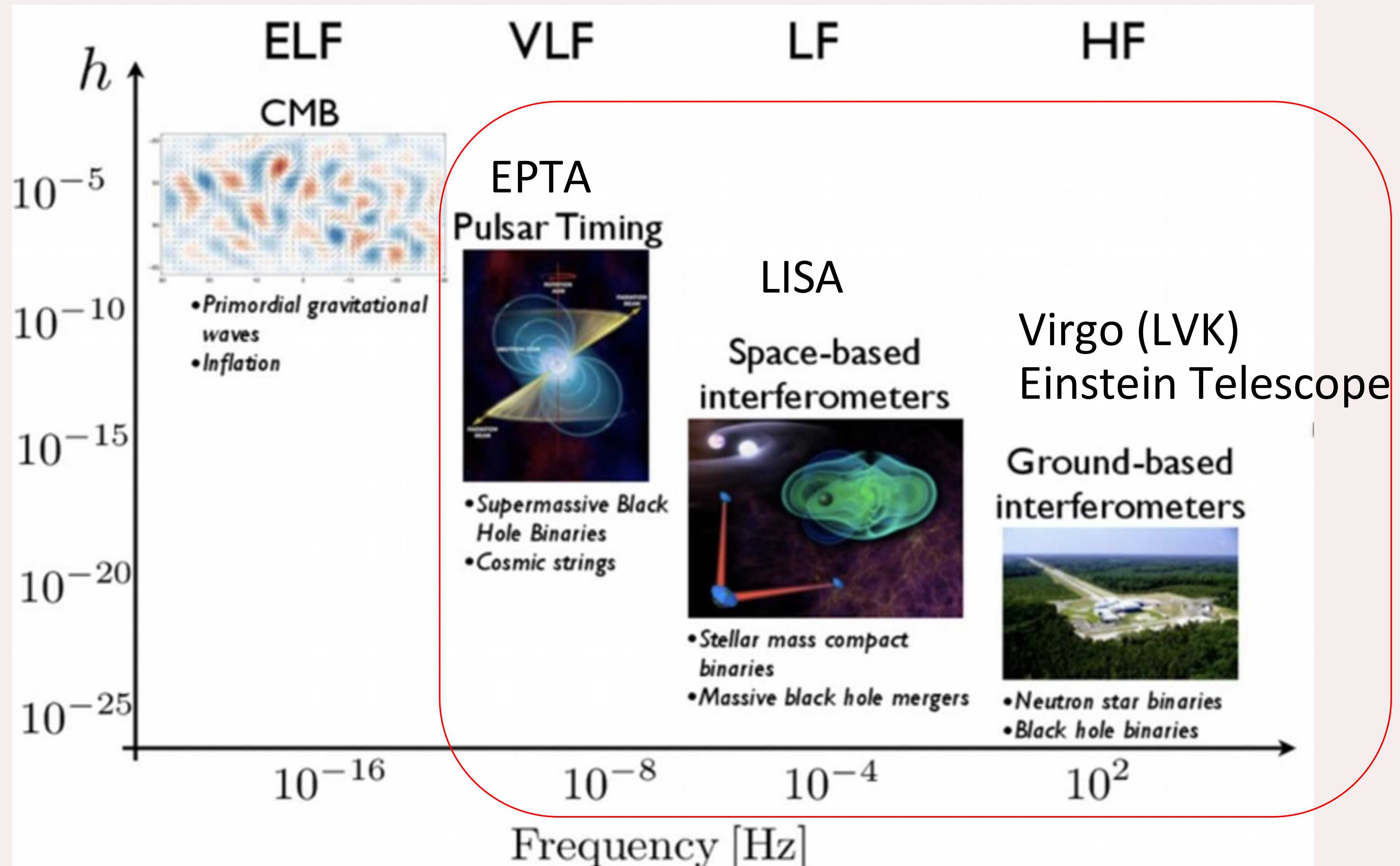
- . **Nature of gravity:** quantum gravity? Validity of general relativity?
 - . Consistency of Gravitational-wave waveforms with General Relativity (generation, propagation and the nature of the remnant (post-merger) object
 - . Testing behavior near the horizon
- . **Black-holes and Compact objects:** nature of black-holes ? Distribution and evolution of black-holes through cosmic history? Role of super-massive black-holes in the formation/evolution of galaxies?
 - . Formation and properties of GW sources: black-holes (full spectrum of masses) and neutron stars
- . **Inflation and origin of structures:** which mechanism generate the structures? Can we test the early universe using gravitational-waves?
 - . Detection (or upper limits) of a cosmological gravitational-wave background
- . **Dark matter:** test of dark matter candidates
 - . Detection (or upper limit) of exotic gravitational-wave sources, dark matter around massive black holes
- . **Dark energy and cosmological constant:** is gravity correct at large scales? Why is the vacuum energy so small?
 - . Measurement of Hubble constant and other cosmological parameters through gravitational-waves
- . **Bonus: Multi-messenger revolution!**

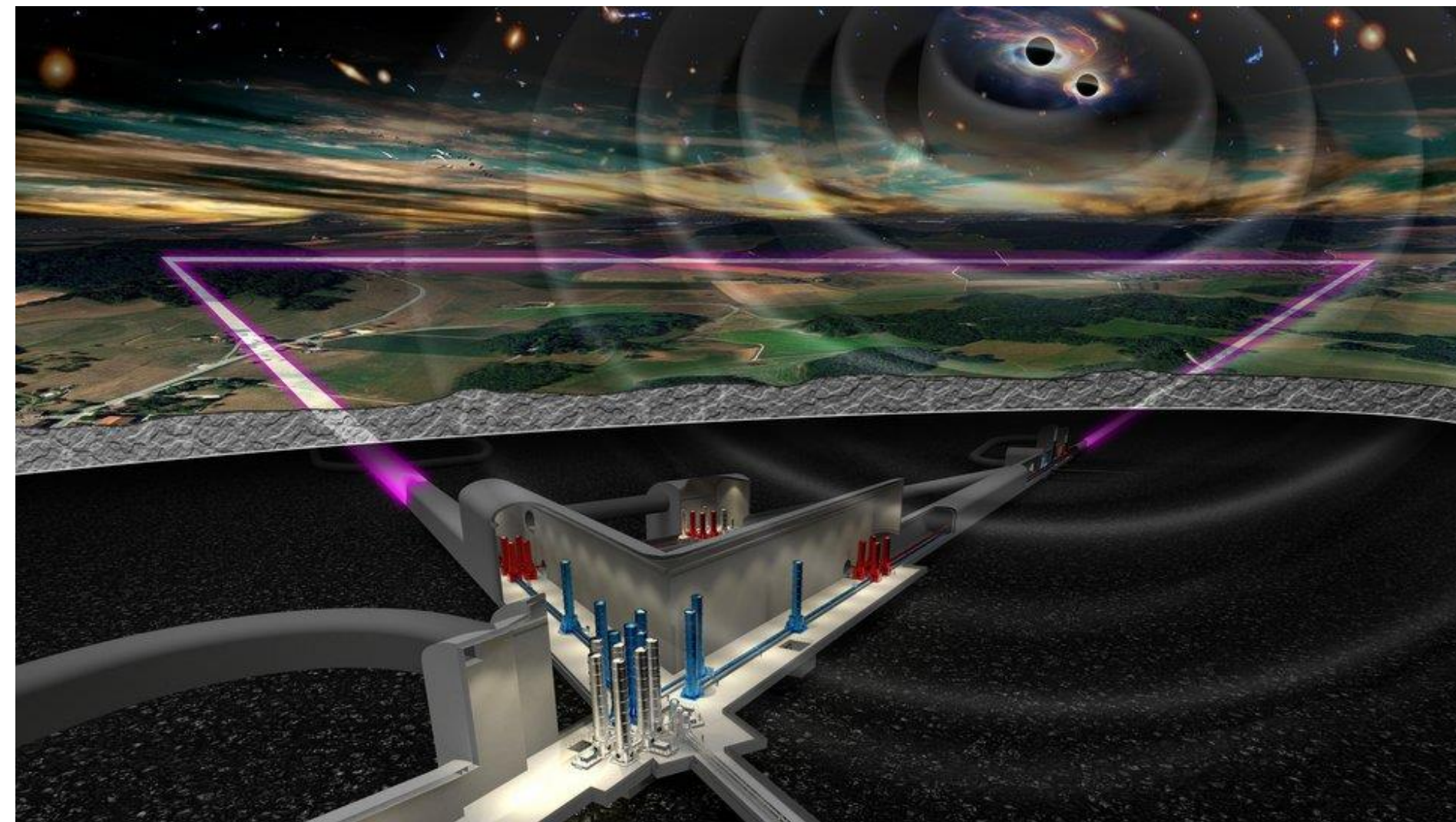
Our Projects

- Advanced VIRGO and Einstein Telescope (ET)
- LISA (Laser Interferometer Space Antenna)
- Pulsar Timing Array



Projects: detection of GW across the whole frequency spectrum





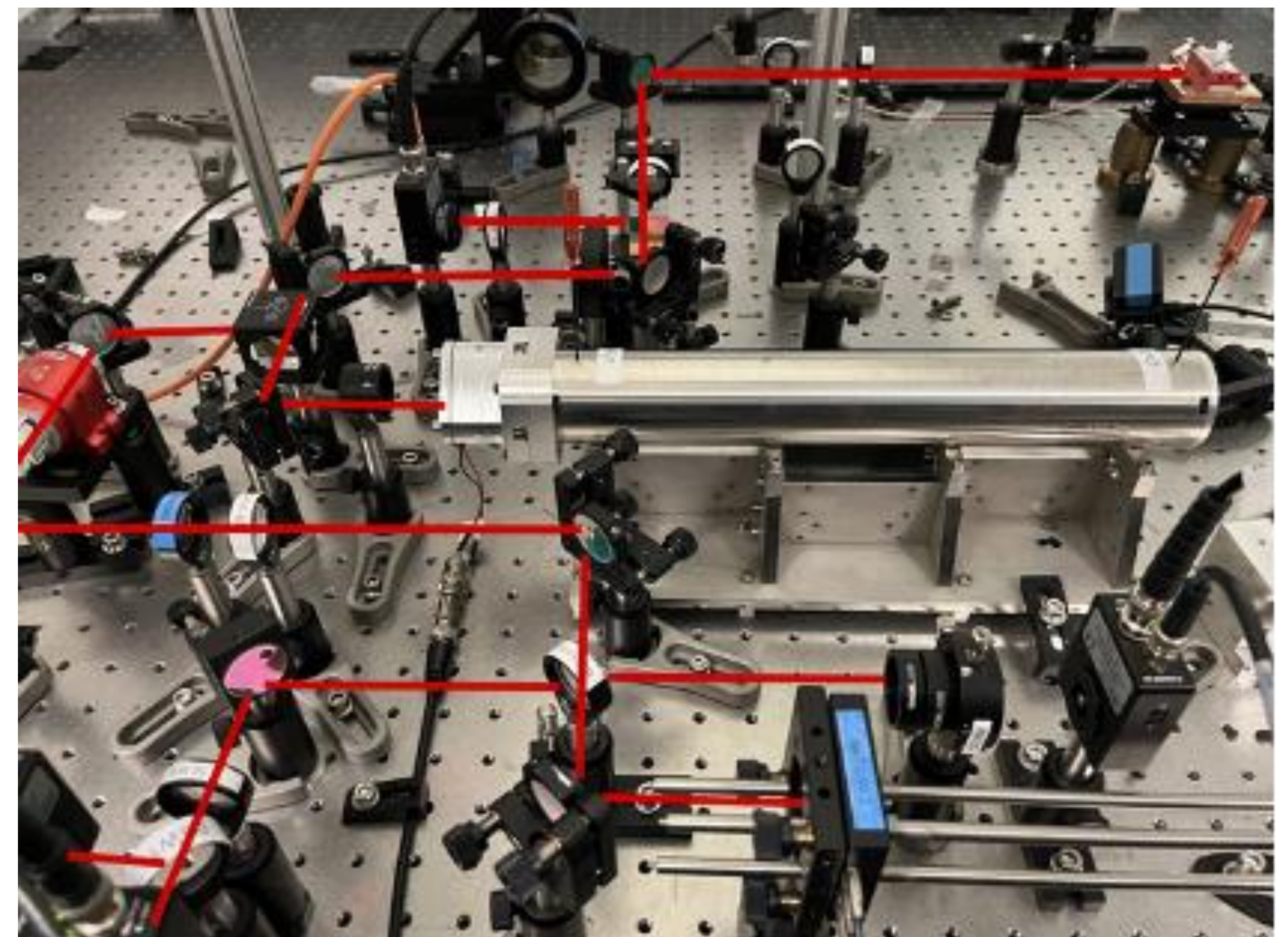
AdVirgo and ET

ground-based detectors

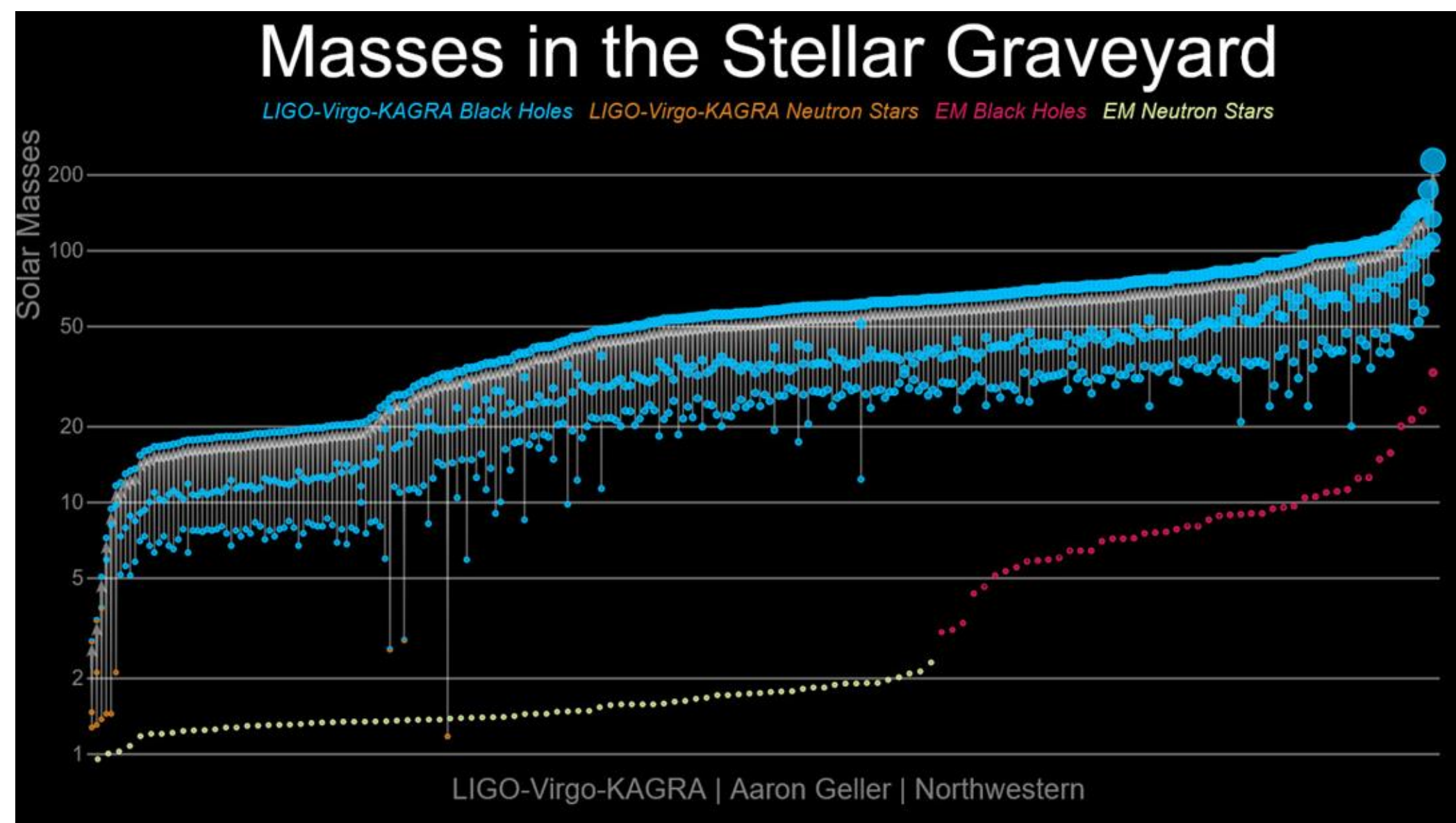
AdVirgo and ET activities

- I. Data Analysis :
Interpretation of GW observations within LVK/IGWN — testing GR with ring-down part of the CBC signal (O4A data).

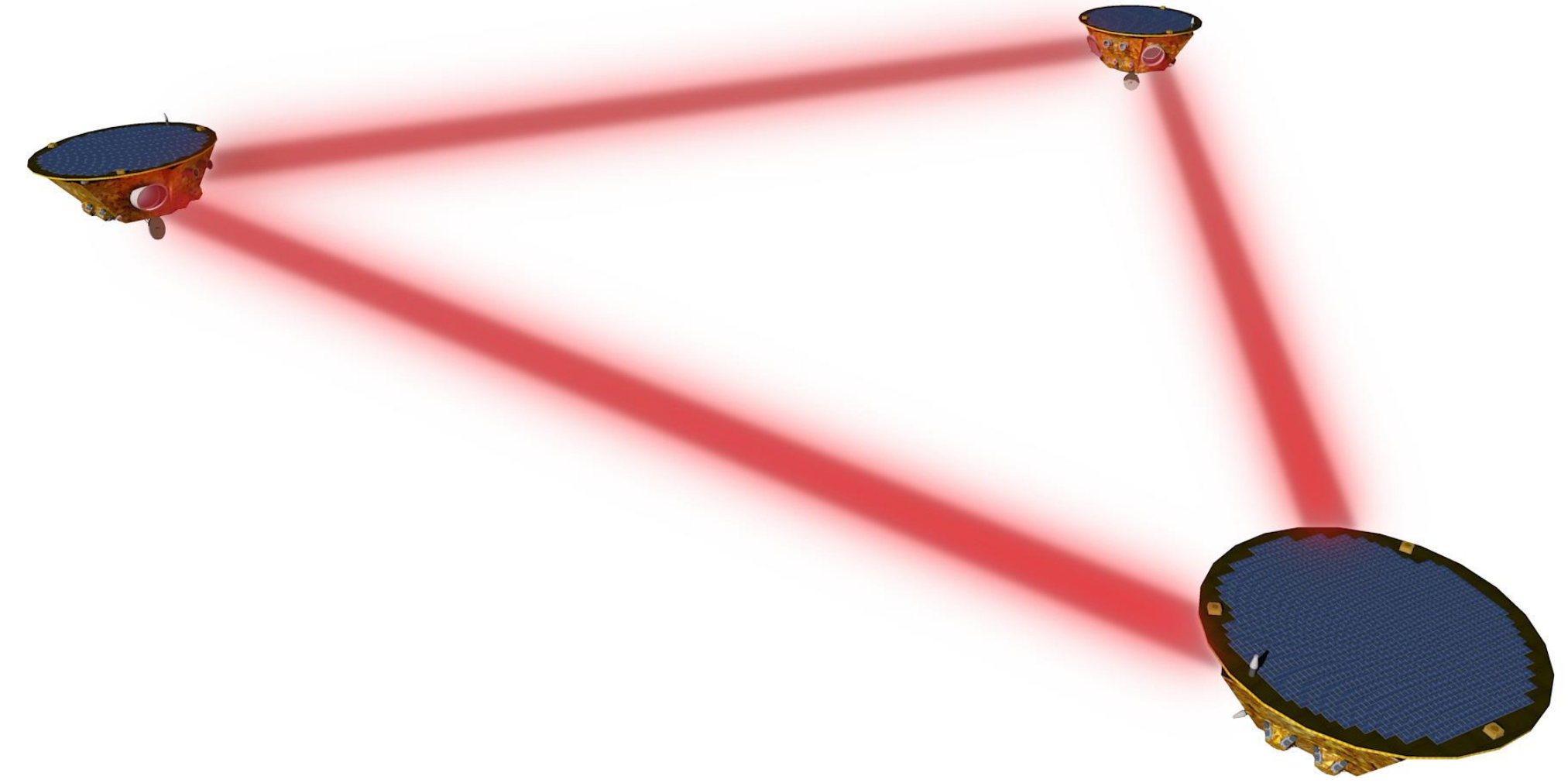
R&D — model-free and ML-based reconstruction of GW polarisations



- II. Instrumental Activities :
Noise reduction — frequency squeezing for quantum noise, study of acoustic and atmospheric newtonian noise



AdVirgo+ (O5) — design and testing of an optical bench for stable recycling cavities



LISA

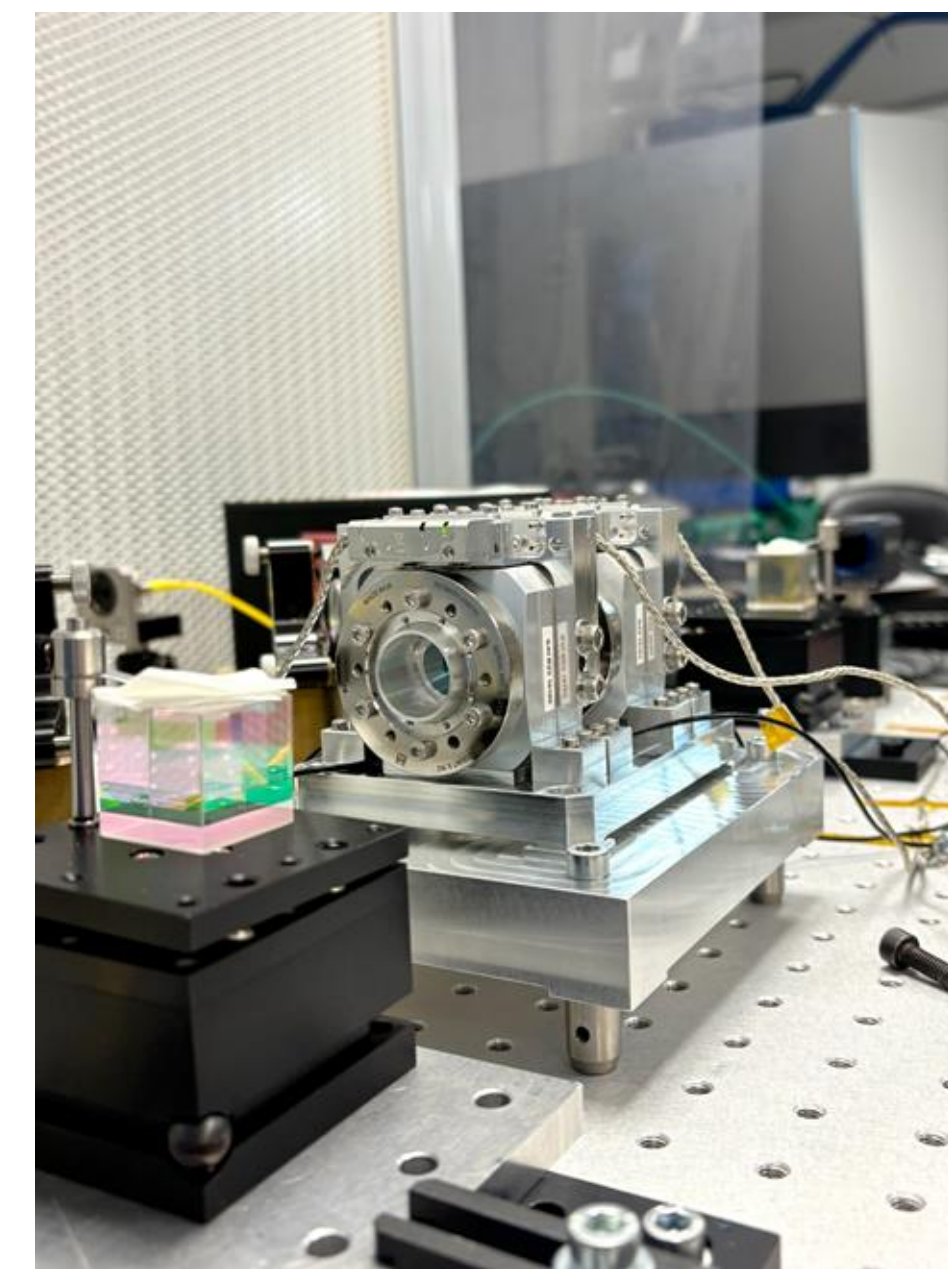
space-based detector

LISA activities

I. Data Analysis : Building of LISA Global Fit and source cataloging

Interpretation of GWs — in astrophysics
(models) and fundamental physics (testing
GR, dark matter)

Use of ML in data analysis

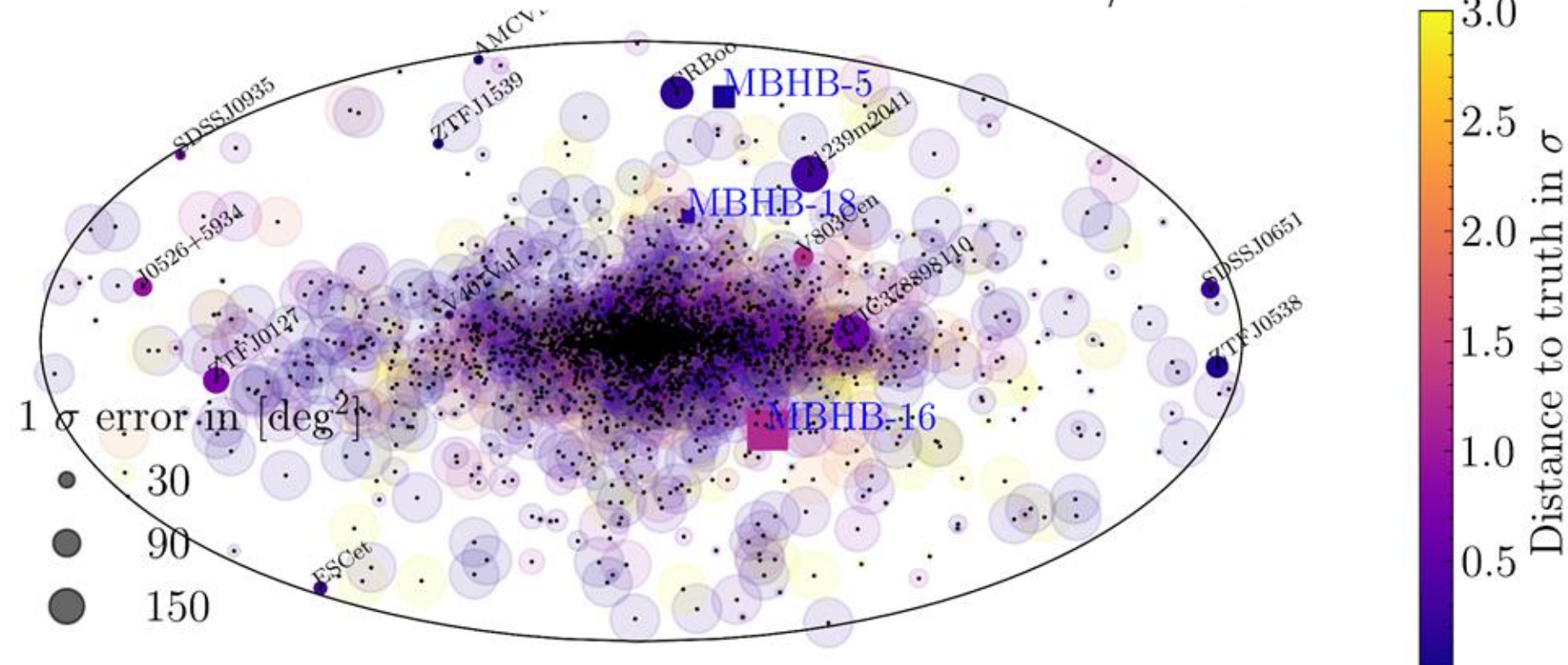


II. Instrumental Activities : Verification of interferometer core with optical bench prototypes

Development of ultra stable optical systems
for testing LISA prior to launch

Performance modelling of the detection
system

9 months of observation. 3310 binaries recovered / 3590





Pulsar Timing Array

PTA activities

Data Analysis :

Search, modelling and analysis of resolvable in spiraling SMBHB binaries

Interpretation of the stochastic GW background (Early Universe, SMBHBs)

Modelling of pulsar noise

Building continuous data analysis pipeline (overlap with LISA)

