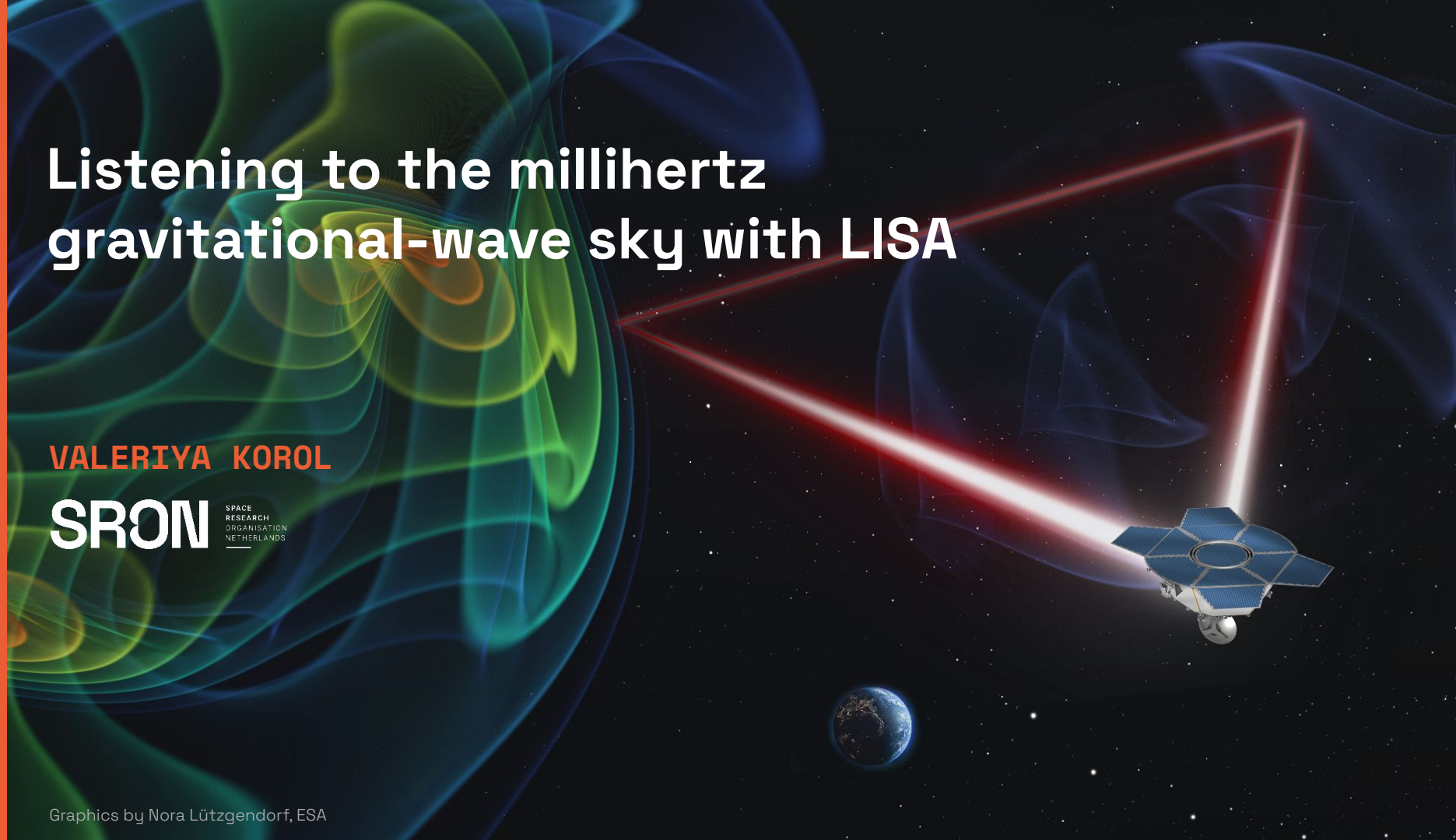
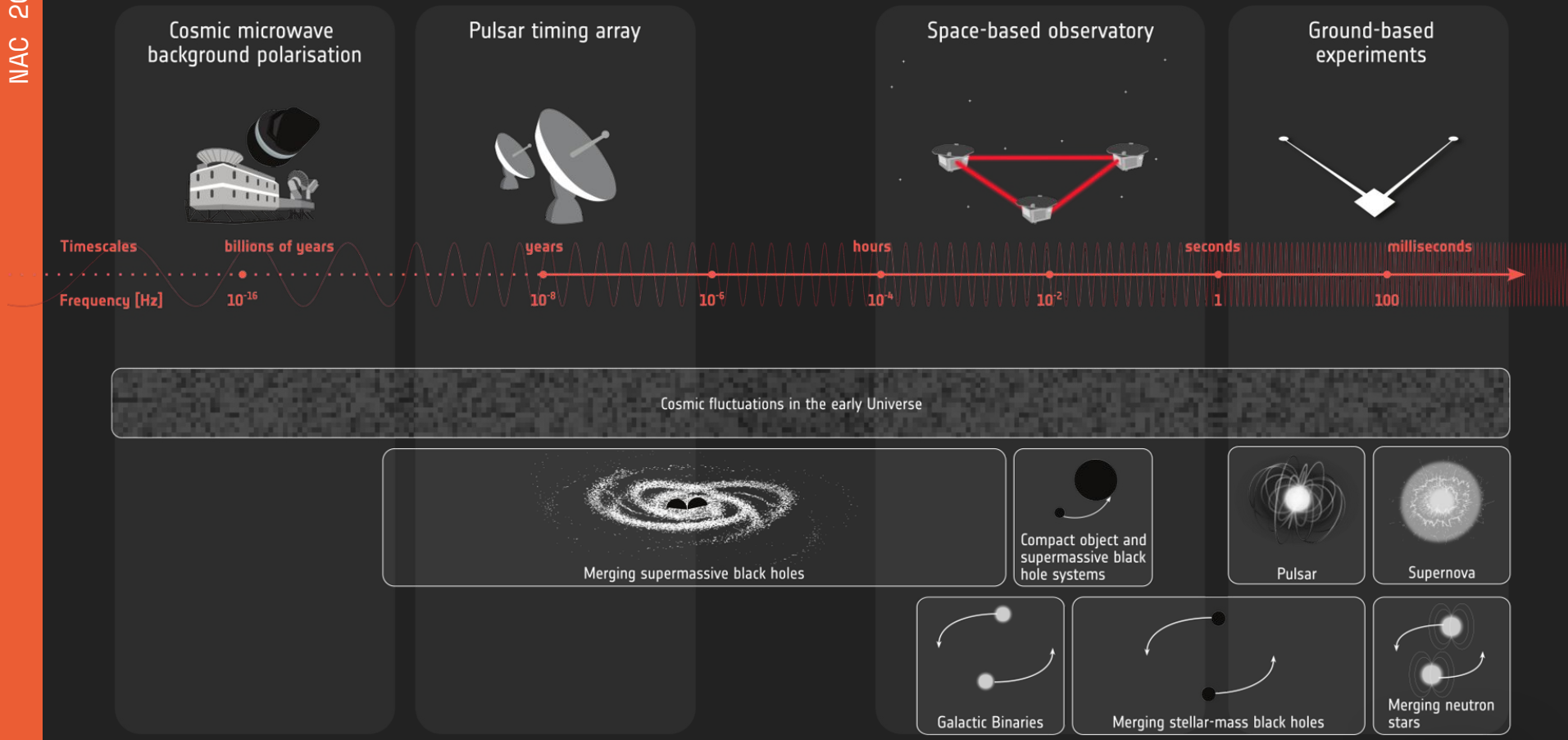
Listening to the millihertz gravitational-wave sky with LISA

VALERIYA KOROL

SRON SPACE RESEARCH ORGANISATION NETHERLANDS



Graphics by Nora Lützgendorf, ESA



Graphics by ESA

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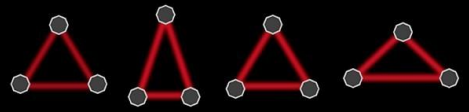
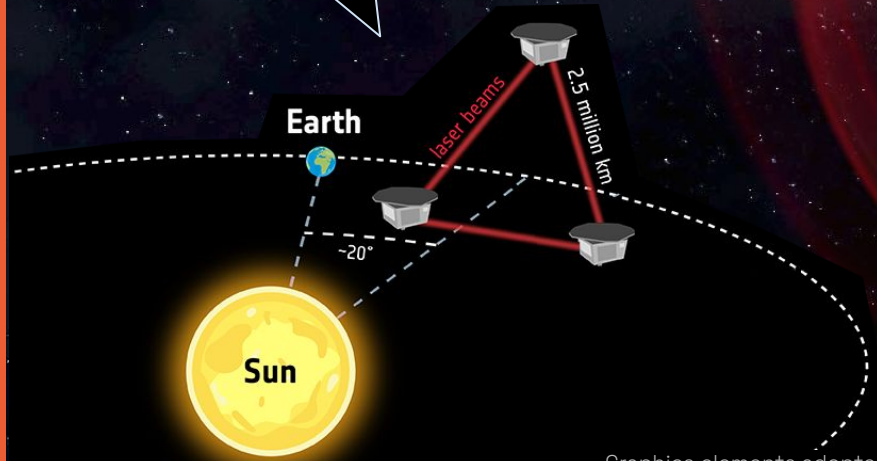
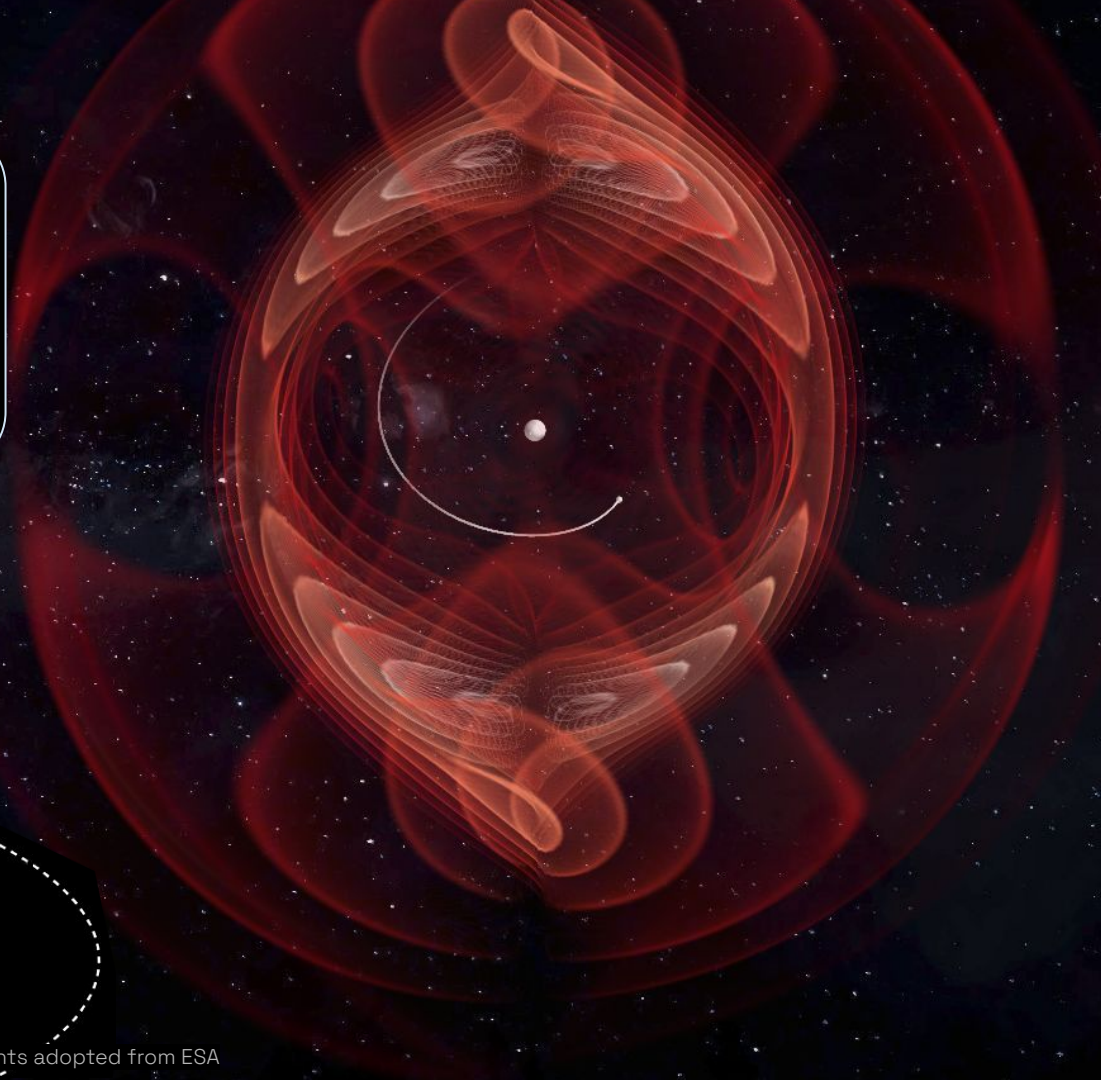
Mission concept

Laser interferometry in space

As a gravitational wave passes, it slightly changes the distance between LISA's spacecraft. LISA will detect these tiny shifts by measuring changes in the separation across its 2.5 million kilometre arms.







Graphics elements adopted from ESA

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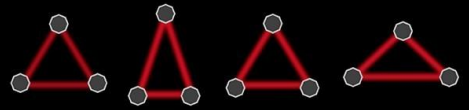
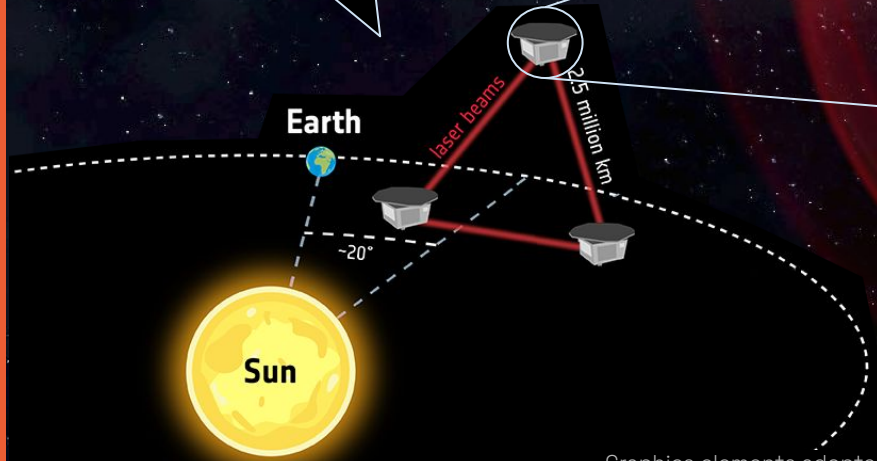
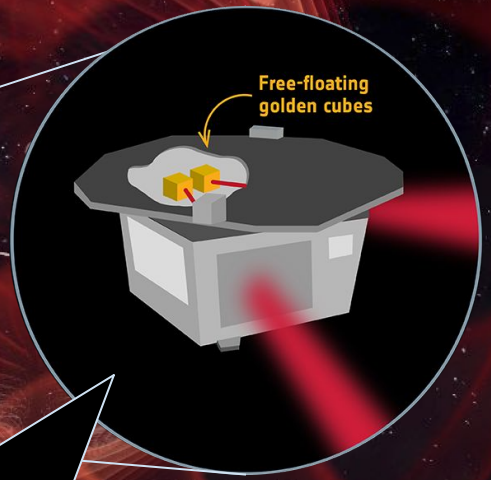






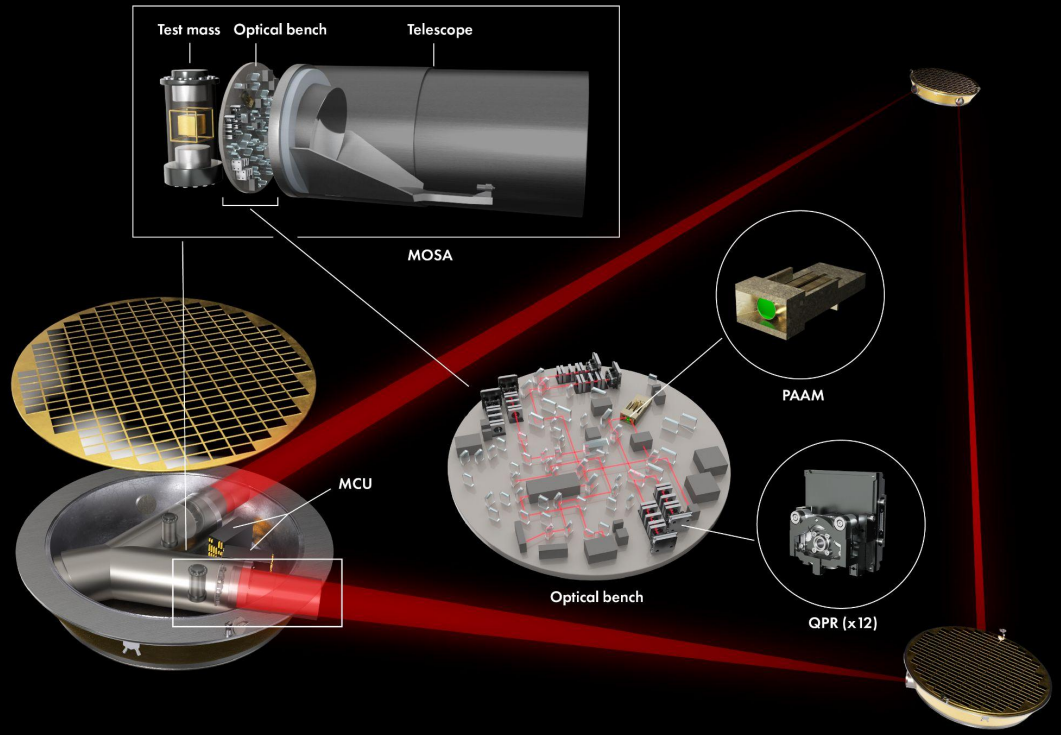
Drag-free control

Each LISA spacecraft carries two test masses kept in free fall. The spacecraft continuously adjusts its position to stay centred on the mass, shielding it from external forces like solar radiation and micrometeorites.

✔ **Tested with the LISA Pathfinder mission (2015-2017)**

Graphics elements adopted from ESA

Dutch hardware contribution



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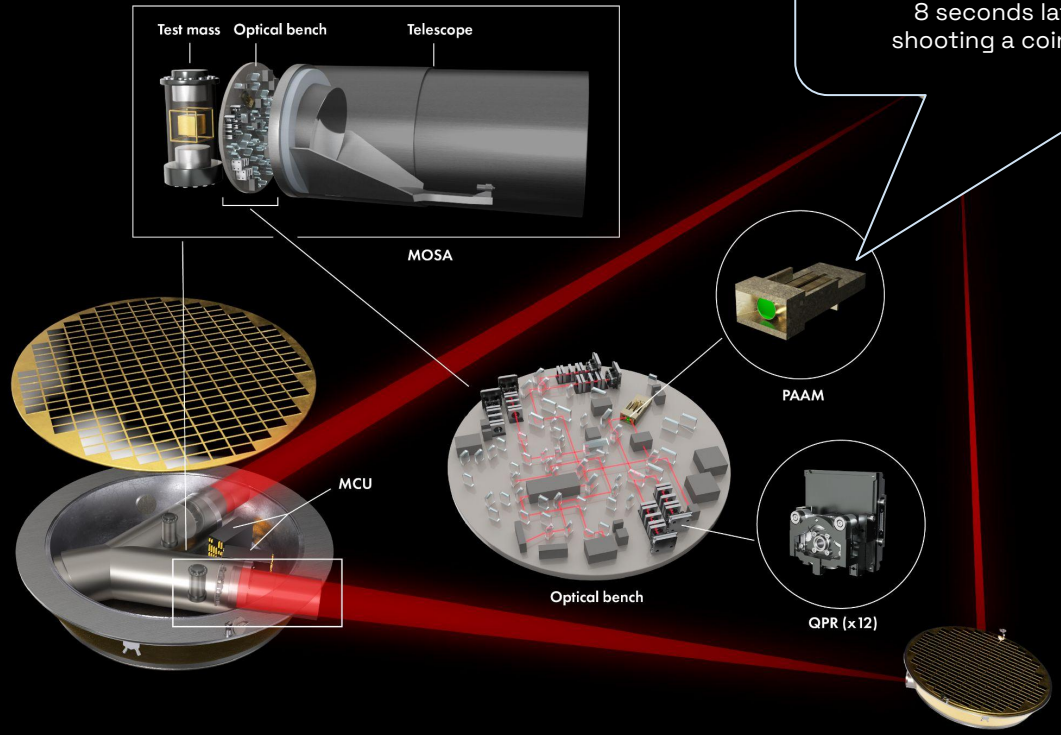
Dutch hardware contribution

Point-Ahead Angle Mechanism (PAAM)

For the laser to hit the moving spacecraft 2.5 million km away, it must be aimed ahead - to where the other spacecraft will be 8 seconds later. The pointing needs to be as precise as shooting a coin on the Eiffel Tower from the Netherlands!

- by TNO



SRON

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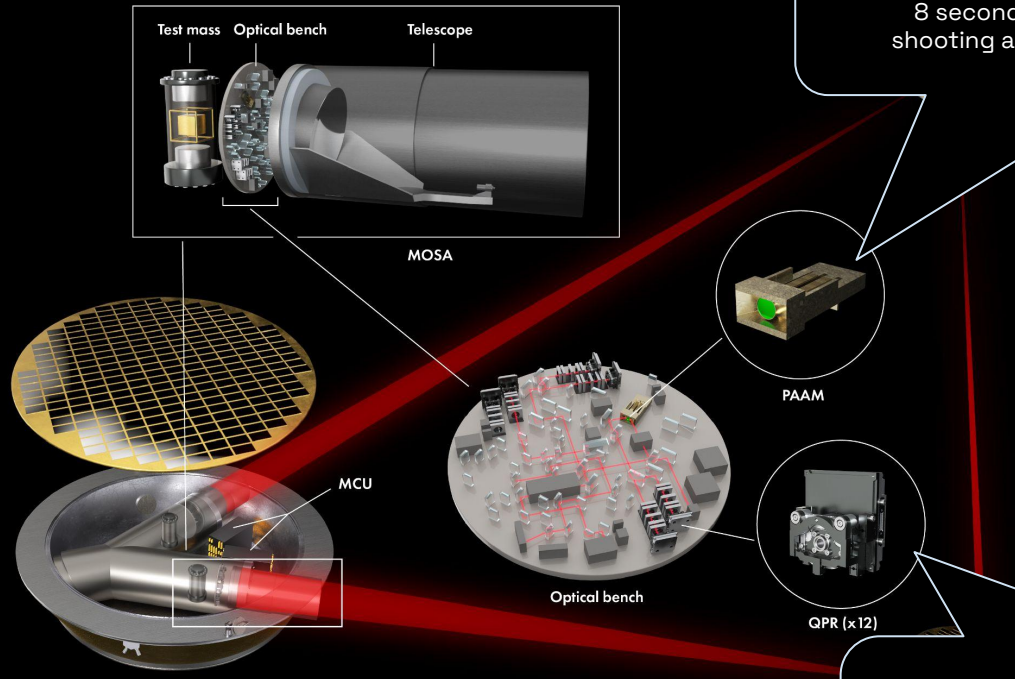

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Quadrant Photo Receivers (QPRs) or "*LISA's eyes*"
Designed to catch the faint laser light and to measure its interference pattern with local reference laser
- by Nikhef & SRON

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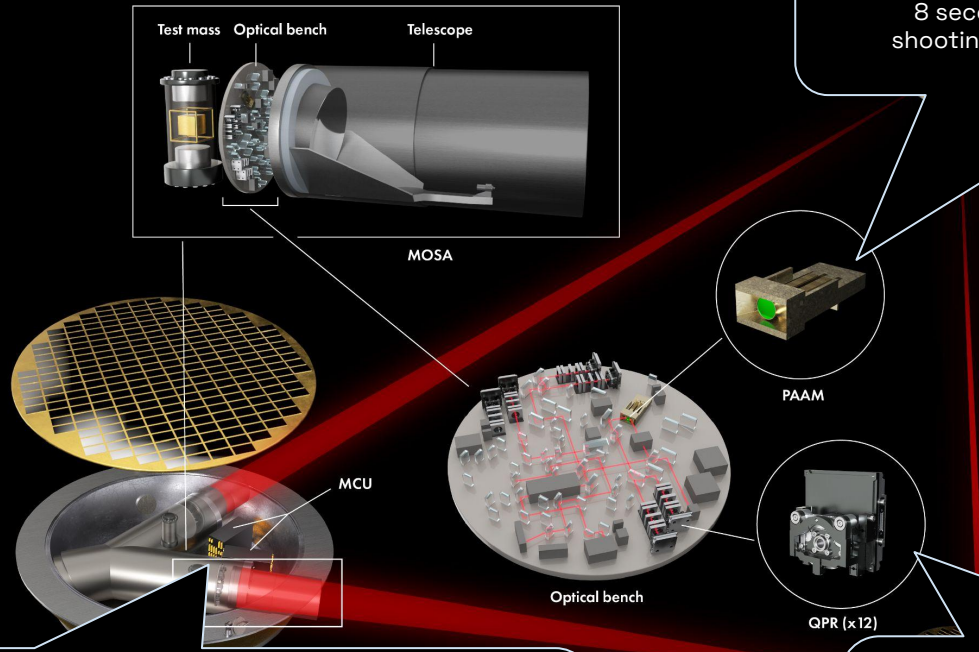

Mechanism Control Unit (MSU)
LISA's optical bench contains several adjustable mechanisms that steer laser beams, move their position, or switch optical paths. The MCU is the "*electronic brain*" that coordinates them.
-by SRON

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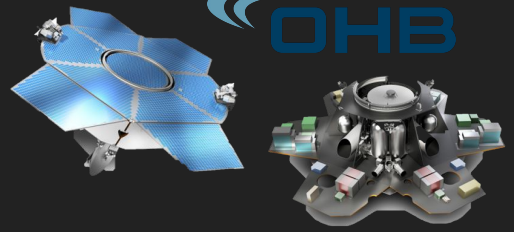
Mission status



Adoption
2024

Payload PDR

S/C Preliminary Design Review
2027

Flight Acceptance Review
2035

Here we build it!

B1 | B2 | C | D | E1

Preliminary Definition

Detailed Definition

Qualification & Production

Invitation to Tender

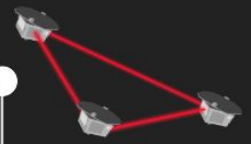
2025

Prime Contractor Kickoff

2031

S/C Critical Design Review

S/C Delivery



Launch

AUG 2035

Graphics by Nora Lützgendorf, ESA

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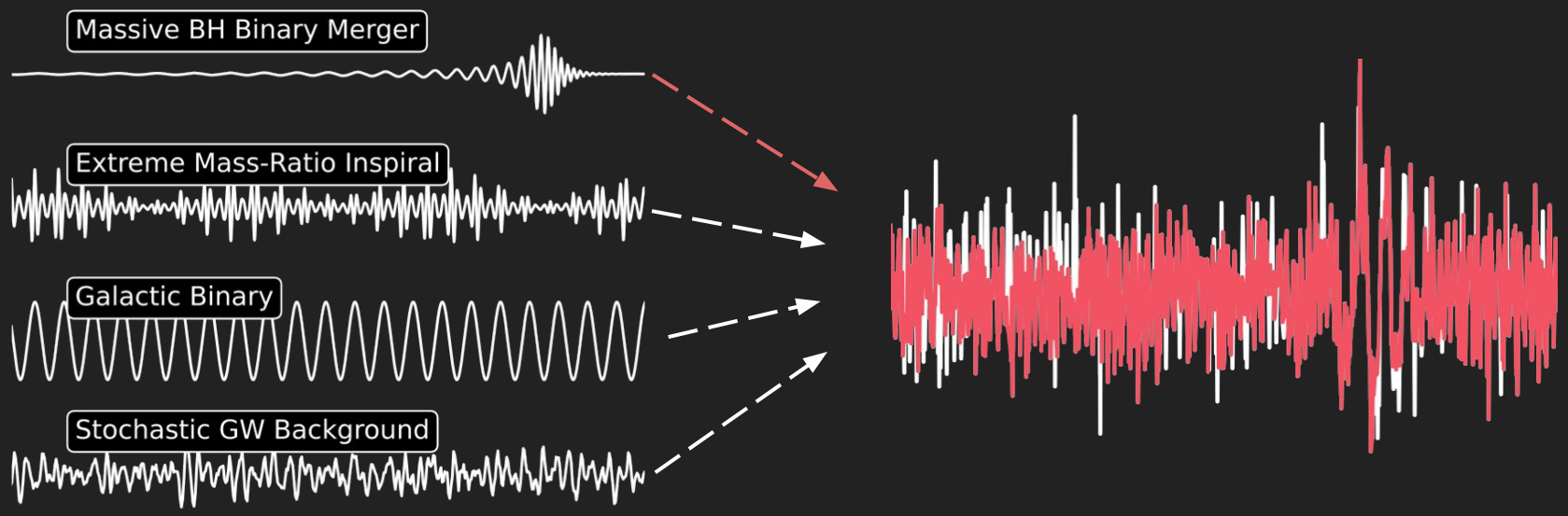
What will LISA “hear”?



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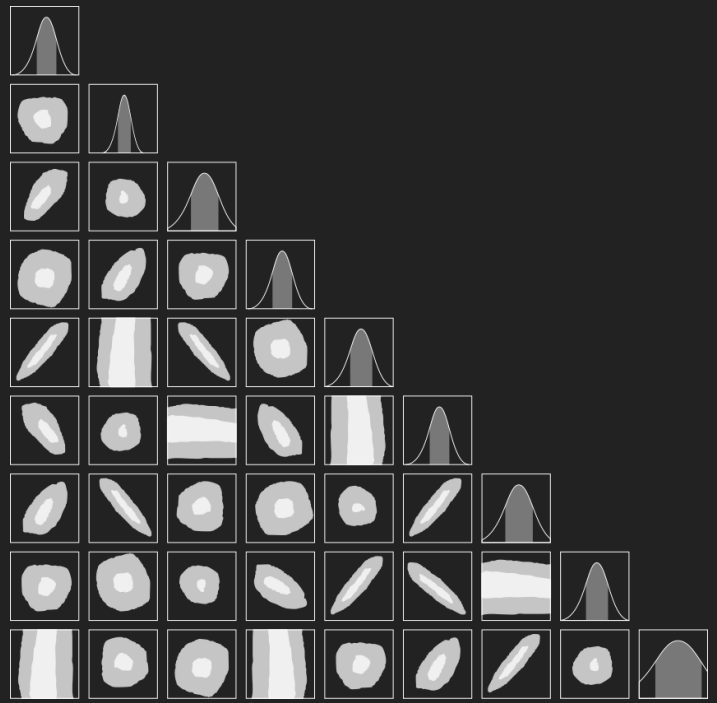
Output from the LISA global fit



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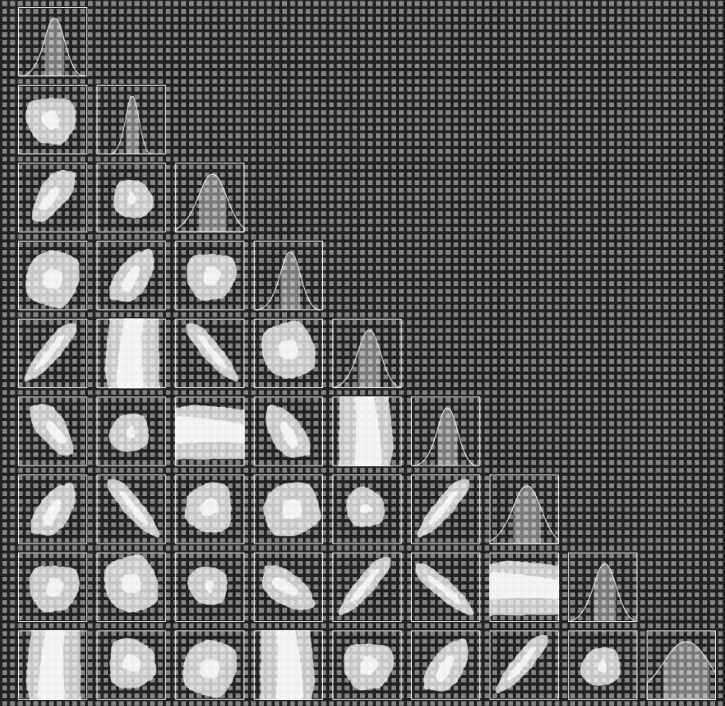

> 60 000 parameters after 1 year!

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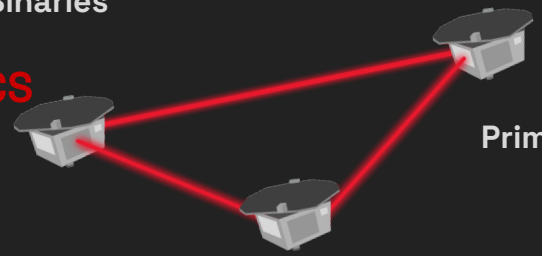
Gravitational waves for everyone

Milky Way's stellar distribution
Thermonuclear supernovae
Expansion of the Universe
Spectral shape
Exoplanets
Binary interactions
Dark sirens
Bright sirens
Anisotropies
Binary Evolution
Stochastic GW backgrounds
Tidal Disruption Events
Galactic Binaries
Stellar-mass Black Hole Binaries
COSMOLOGY
Large-scale anisotropies
Primordial Black Holes
Extreme Mass-Ratio Inspirals
ASTROPHYSICS
Primordial Universe
Inflation
Massive Black Hole Binaries
Intermediate-mass Black Holes
Phase Transitions
TeV-scale particle physics
Scale of Grand Unification
Origin and formation
Sgr A*
Structure of Black Holes
FUNDAMENTAL PHYSICS
Dark matter
Black Holes' environments
Merger history
GW propagation properties
Nature of Gravity
Cosmic strings
Compact object equation of state
Tests of the no-hair theorem
Beyond GR emission channels
Matter-antimatter asymmetry
Tides in strong gravity
Dark sector objects
Modified gravity



LISA Definition Study Report (Red book) Colpi et al. /w Korol (2024), arXiv:2402.07571

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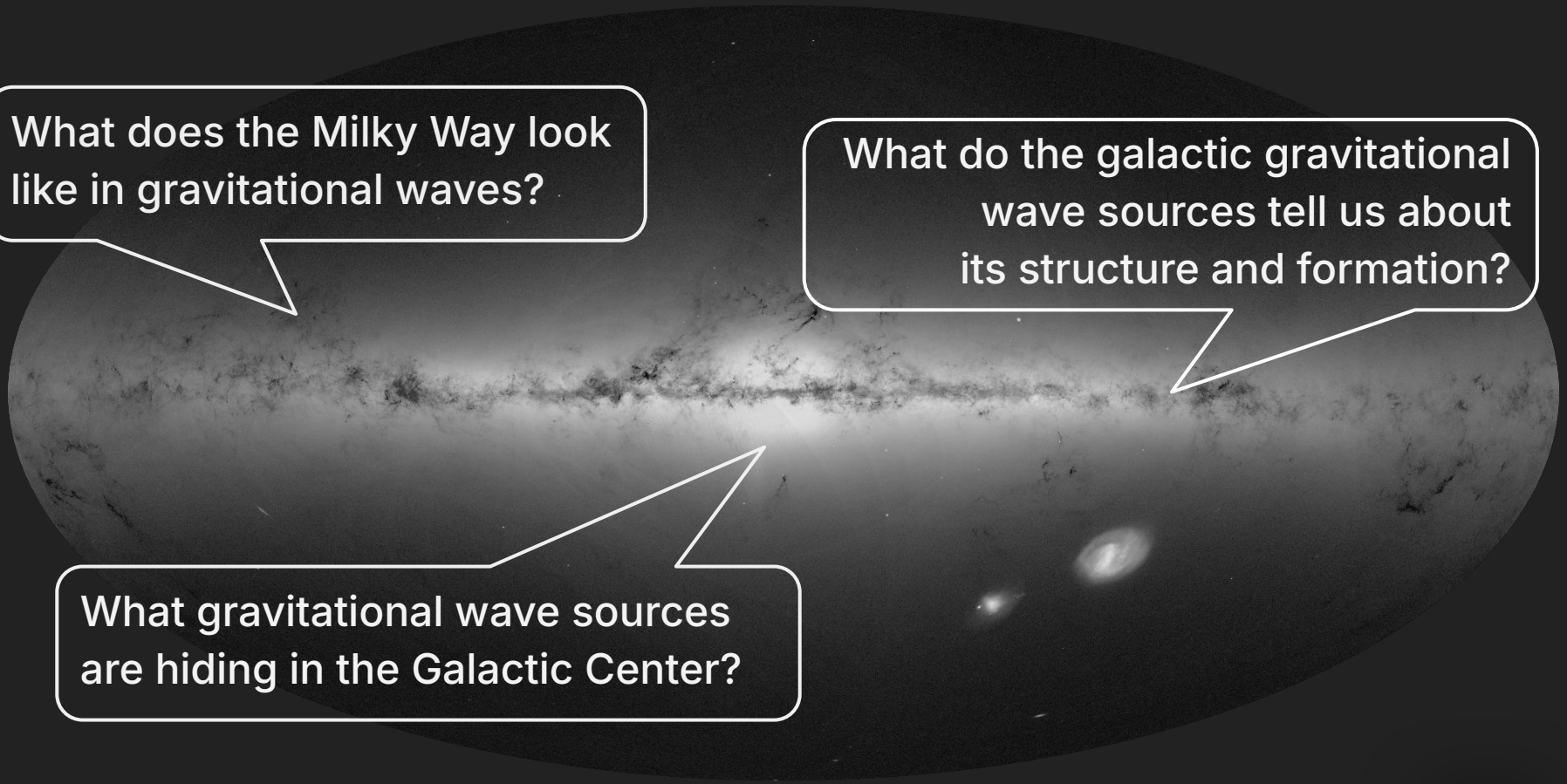

What does the Milky Way look like in gravitational waves?

What do the galactic gravitational wave sources tell us about its structure and formation?

What gravitational wave sources are hiding in the Galactic Center?

Background image: ESA/Gaia/DPAC

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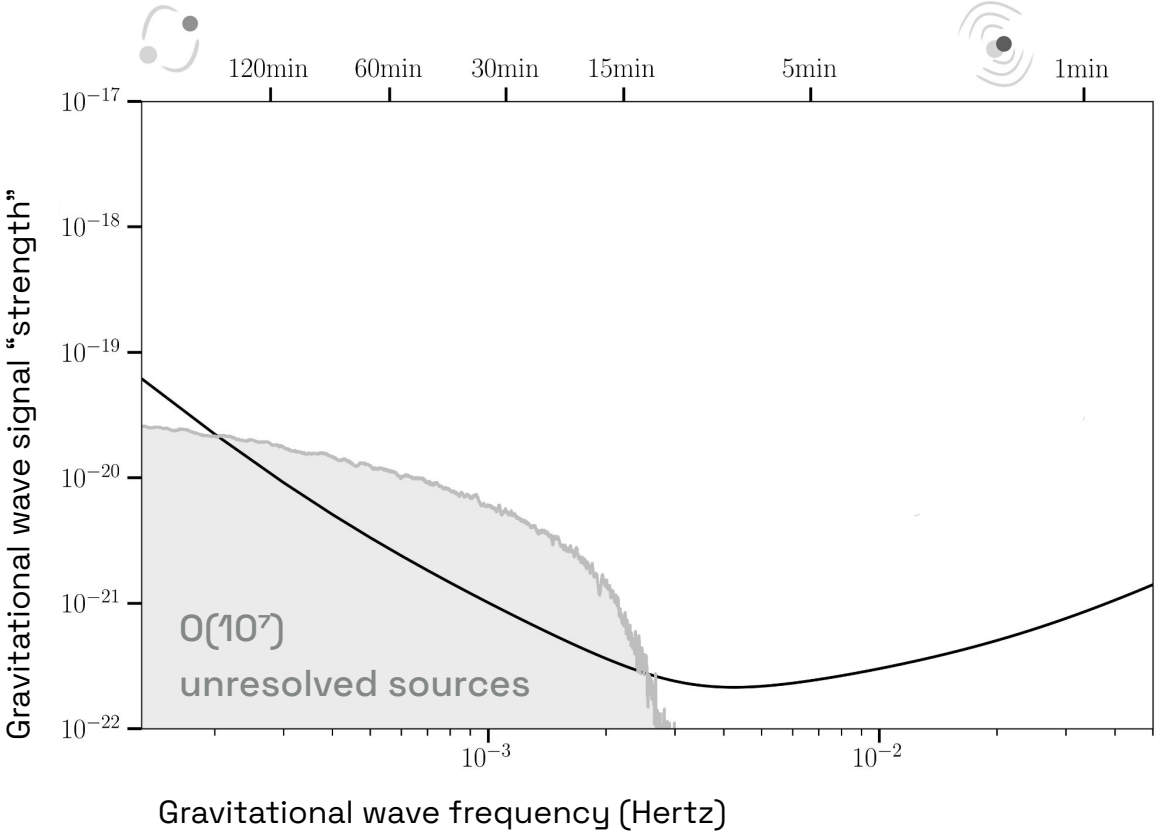
Galactic astrophysics with LISA



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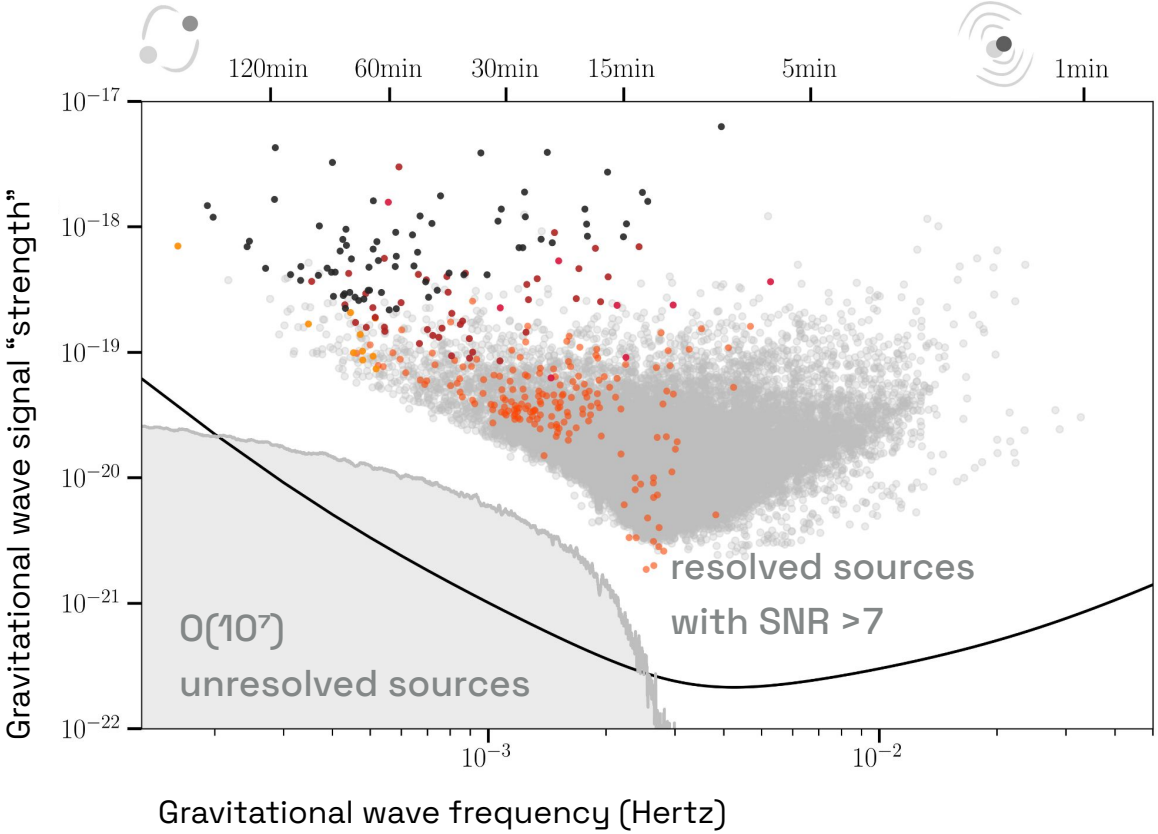
Galactic astrophysics with LISA

Living Review LISA Astro Working Group /w Korol et al. 2023



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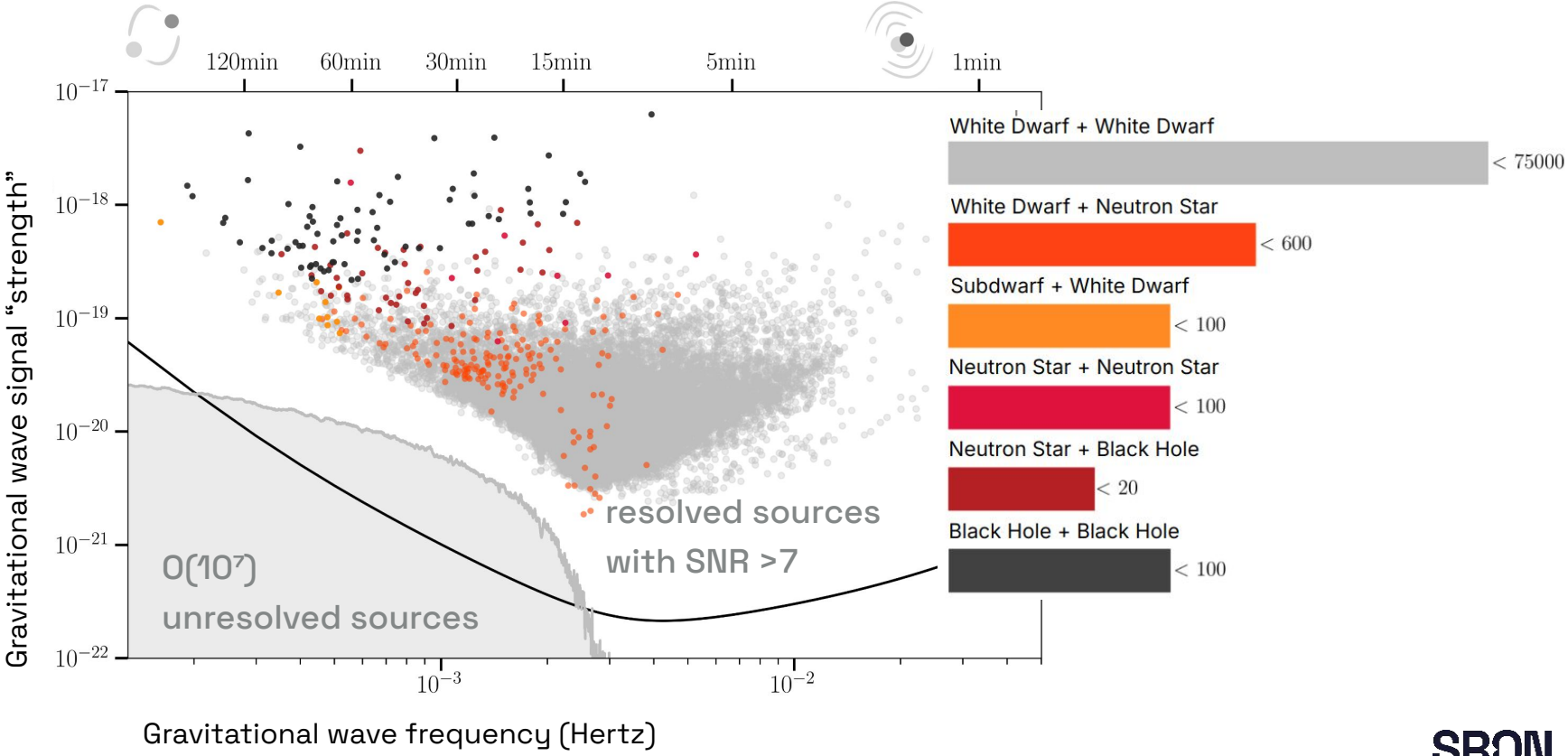

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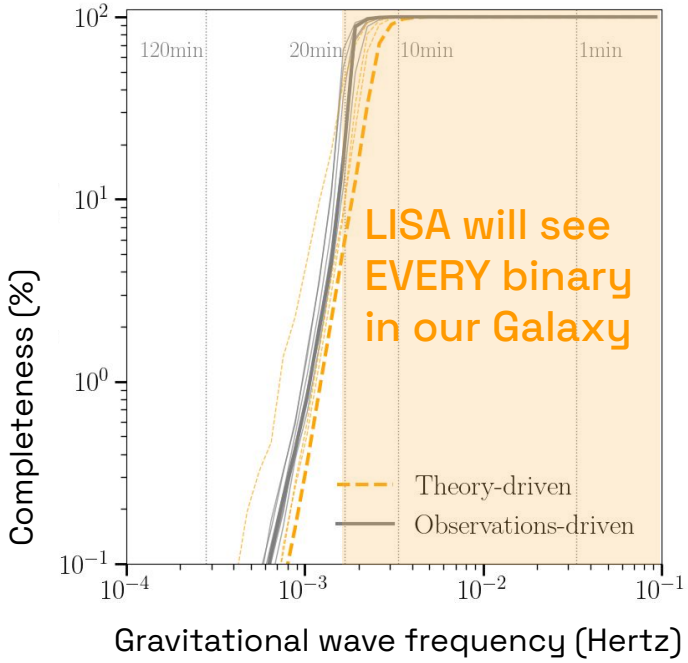

Korol et al. 2024

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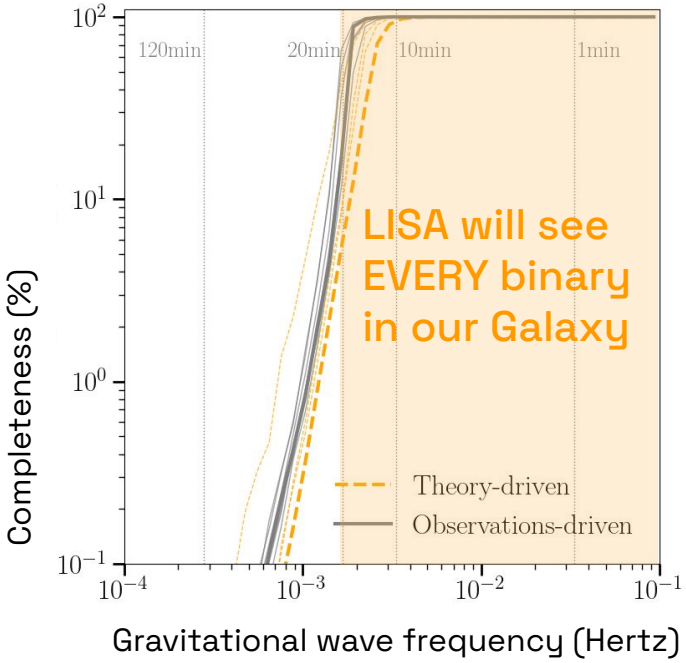

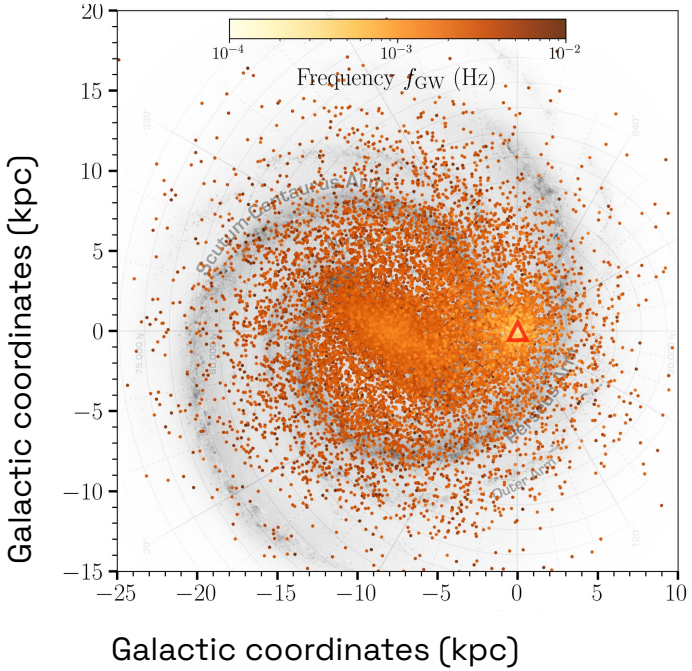

Korol et al. 2024

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6 Oct 2026: Join LISA-NL Community Day @ SRON!

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