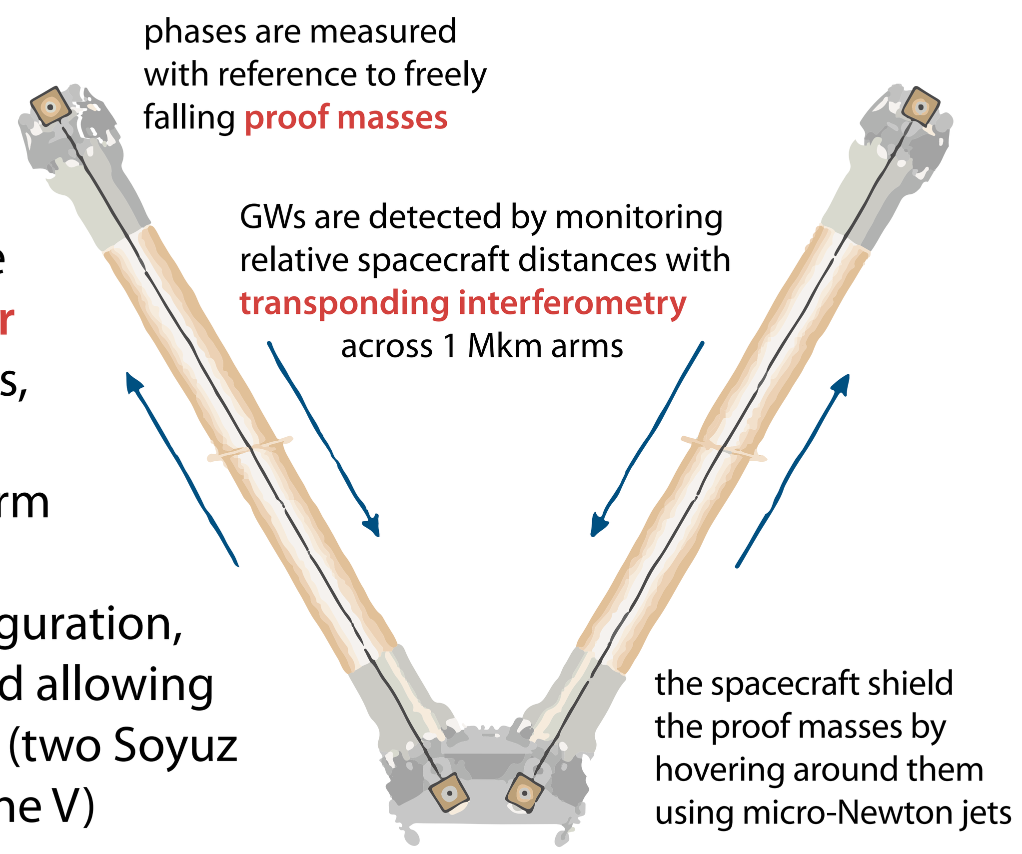
National Aeronautics and Space Administration

Low-frequency gravitational-wave astronomy with eLISA

Michele Vallisneri
(Jet Propulsion Laboratory)
for the **eLISA science task force**

eLISA is Europe's gravitational-wave space observatory, redesigned to fit the ESA Cosmic Vision budget and timeline constraints

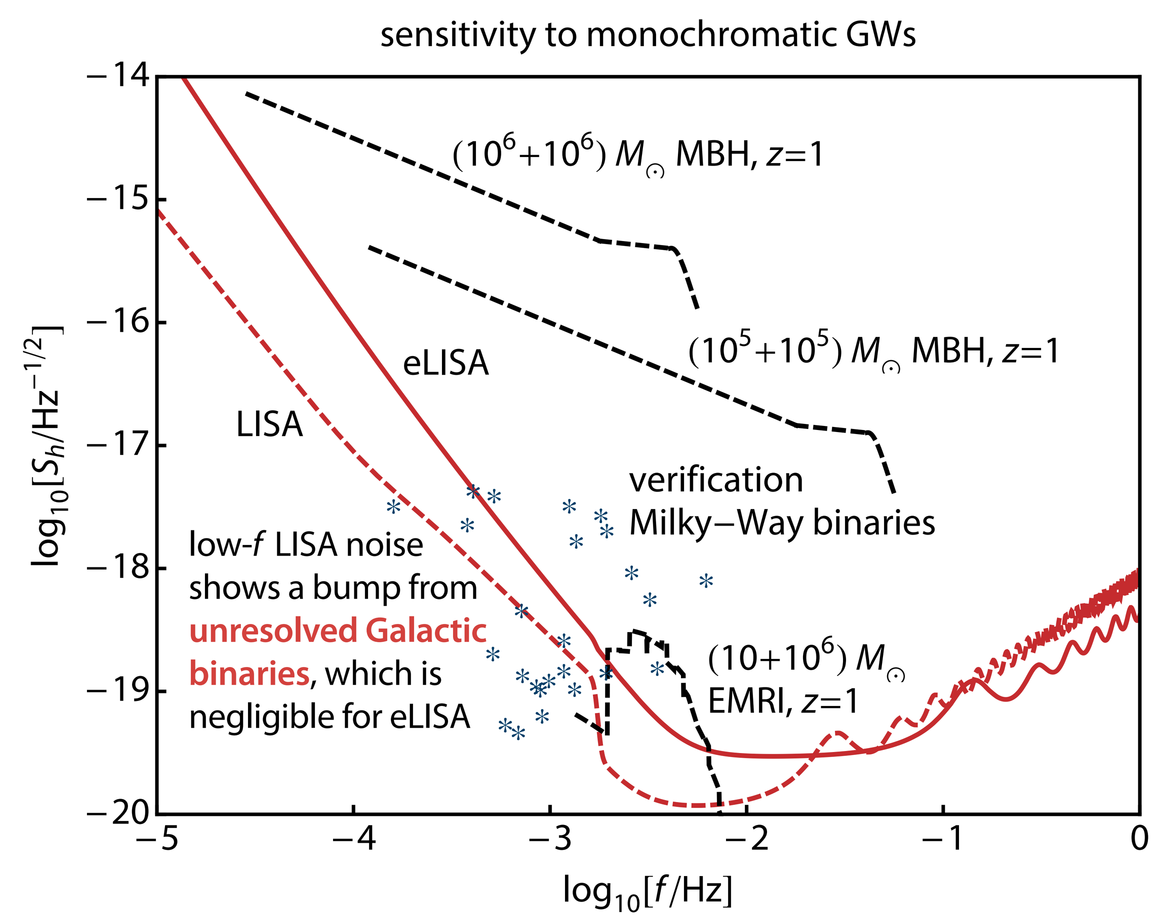
cost savings compared to LISA are obtained with extensive reuse of **LISA Pathfinder hardware**, simpler orbits, shorter arms, smaller telescopes, and a two-arm (rather than three-arm) mother–daughter configuration, making for less mass and allowing cheaper launch options (two Soyuz rockets or a shared Ariane V)



eLISA will achieve a large portion of the LISA science, detecting thousands of individual GW sources in the 10^{-4}–10^{-1} Hz low-frequency band

sensitivity is plotted so that the height of a monochromatic source (such as the verification binaries in the Galaxy) with respect to the LISA/eLISA noise curves gives the detection SNR

chirping sources (such as MBH binaries) are plotted so that their height relative to the noise curves gives the rms SNR per log frequency interval



eLISA is a candidate for ESA's "L2" mission, with start in 2015, launch in the late 2020s; NASA may provide a sensitivity upgrade as minor partner

for more information:

a review of the science case for eLISA
bit.ly/elisa-science

the pan-European eLISA consortium committed to building the mission with ESA
bit.ly/elisa-consortium

NASA's 2012 study of low-cost LISA alternatives
bit.ly/nasa-pcos

LISA Pathfinder (launch 2014), the technology mission that will test drag-free operation in space
bit.ly/esa-lpf

my homepage, with links to LISA/eLISA papers and tools
vallis.org

including:

inspiral–merger–ringdowns of massive black-hole binaries

eLISA will detect 10–100 coalescence events out to $z = 15$ in 2 years, measuring masses to 0.5% and spins to 1%

These observations will:

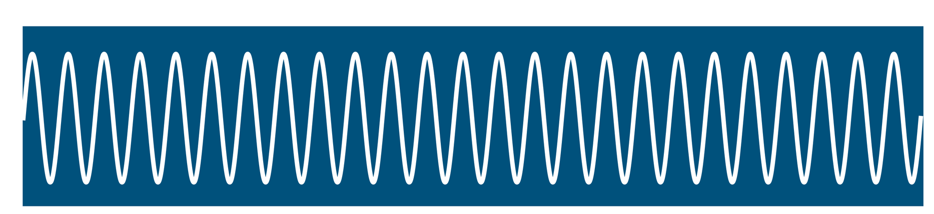
- provide a census of "light" (10^4–$10^7\,M_\odot$) MBHs in binaries and of their spins
- discriminate among models of MBH formation and growth (light vs. heavy seeds, efficient vs. chaotic accretion) and of galaxy evolution
- test strong-field general relativity, by comparing merger waves with the predictions of numerical relativity

EMRIs: stellar-mass black-hole inspirals into nuclear black holes

eLISA will detect tens of these captures out to $z = 0.7$, measuring MBH masses and spins to 0.1%, and quadrupoles to 1%

These observations will:

- probe populations of MBHs and nuclear compact objects
- find intermediate-mass BHs if they exist
- test the no-hair theorem ("all BHs are Kerr") and look for other violations of general relativity



compact white-dwarf binaries in the Galaxy

eLISA will study ~ 20 known *verification binaries* and discover thousands more detached and mass-transferring systems

These observations will:

- constrain binary evolution and common-envelope processes
- shed light on mass transfer and tides in interacting binaries
- enhance the results from GAIA and other surveys with orbital inclinations and accurate distances

gravitational-wave bursts from cosmic-string cusps

eLISA will search for individual instances of cosmic strings, as predicted by GUTs and string-theory–inspired models

These observations will:

- find these objects if they exist in sufficient numbers
- improve existing bounds on cosmic-string parameters (tension and reconnection probability)

stochastic backgrounds from the early Universe

eLISA will search for relic radiation from new physics at 0.1–1000 TeV, probing bulk motions 10^{-18} to 10^{-10} s after the Big Bang

These observations may:

- discover first-order transitions resulting in bubble collisions and turbulence
- probe the size of the extra dimensions required by superstring theory
- detect networks of cosmic strings