National Space and Aeronautics Administration

LISA's first year

Promises and Challenges of LISA Science

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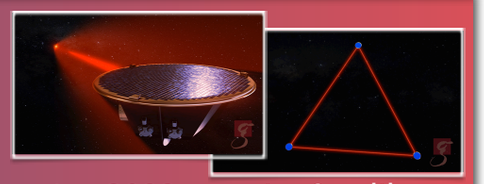
The NASA–ESA mission LISA will measure gravitational waves with frequencies of 0.1 mHz–0.1 Hz. LISA sources include massive-BH mergers, the inspirals of compact objects into central galactic BHs, the binaries of compact stars in our Galaxy, and possibly GW relics from the Big Bang.

Oct 2020*: launch! — cruise (14 months) →

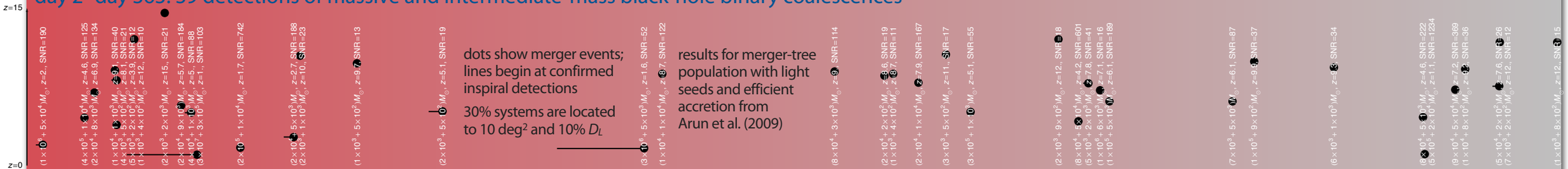
The three LISA spacecraft orbit the Sun in a 5-million-km triangular formation. LISA measures GWs using laser interferometry to monitor the distance fluctuations between freely falling test masses, which are protected from external disturbances by the drag-free control of the spacecraft.



→ Jan 2022: acquire & calibrate

1 Apr 2022: begin science operation → end year 1 (four more years!)

day 2–day 363: 39 detections of massive and intermediate-mass black-hole binary coalescences



dots show merger events; lines begin at confirmed inspiral detections

30% systems are located to 10 deg² and 10% D_L

results for merger-tree population with light seeds and efficient accretion from Arun et al. (2009)

day 1–day 365: 23,000 detections of known and and unknown Galactic binaries

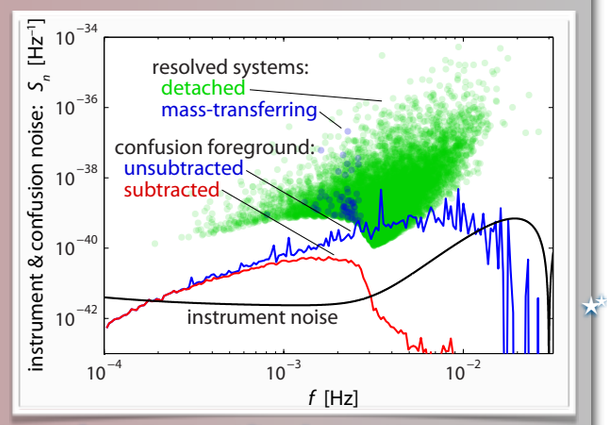
at least 6 known AM CVn's and one cataclysmic variable

RX J0806.3 HP Lib AM CVn — EI Psc — V803 Cen — V407 Vul — ES Cet

several more known systems have uncertain GW luminosities or will be detected in the next four years

results for SDSS-calibrated Galactic binary population with He-star mass-transferring systems from Nissanke et al. (2011)

detected sources are subtracted from the dataset, resulting in a much lower confusion foreground

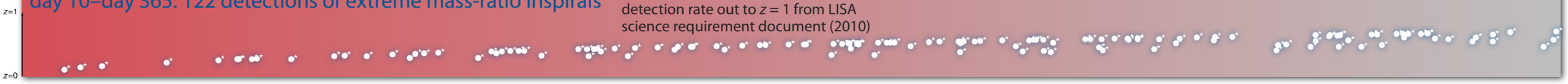


59 previously undetected mass-transferring systems; 248 after Galactic foreground subtraction

9,816 previously undetected detached systems (173 on day 1); 22,643 after foreground subtraction

day 10–day 365: 122 detections of extreme mass-ratio inspirals

detection rate out to $z = 1$ from LISA science requirement document (2010)



Massive black-hole binaries

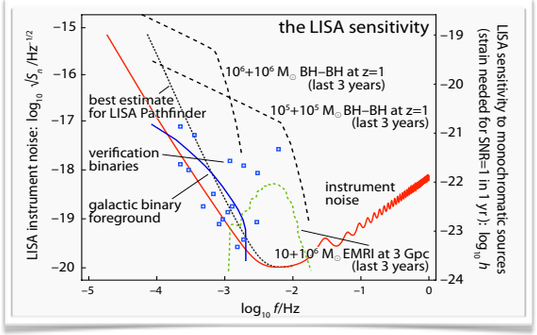
- study the galaxy-MBH coevolution
- measure accurate distances of high-z objects to determine cosmology
- test GR in the nonlinear regime

Challenge: produce accurate, efficient inspiral–merger–ringdown templates

Galactic binaries

- study the astrophysics of binary stellar evolution, including the common envelope phase

Challenge: design the probabilistic representation and querying of the source catalog



Extreme mass-ratio inspirals

- study MBHs and their environment in the dense nuclei of galaxies
- map BH spacetimes, test no-hair theorem and cosmic censorship

Challenge: develop accurate and efficient signal templates

Cosmic-string bursts and stochastic backgrounds

- look for new physics from the early Universe and string theory

Challenge: characterize space of models and theories