Gravitational-Wave Mission Study

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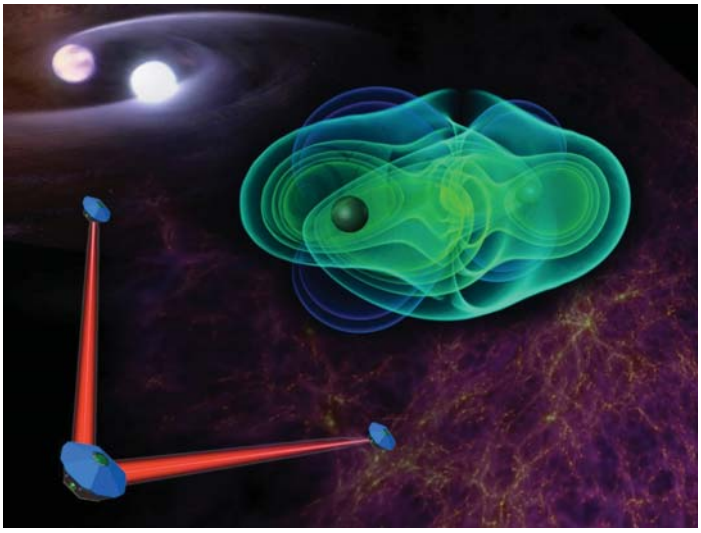
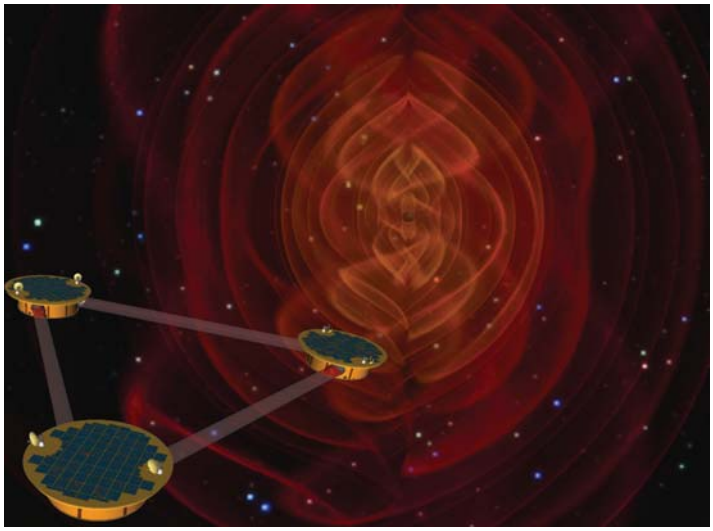
eLISA



SGO Mid



Overview

In November 2013, ESA selected the science theme, the "Gravitational Universe," for its third large mission opportunity, known as L3, under its Cosmic Vision Programme. The planned launch date is 2034. ESA is considering a 20% participation by an international partner, and NASA's Astrophysics Division has indicated an interest in participating. We have studied the design consequences of a NASA contribution, evaluated the science benefits and identified the technology requirements for hardware that could be delivered by NASA.

The European community proposed a strawman mission concept, called eLISA, having two measurement arms, derived from the well studied LISA (Laser Interferometer Space Antenna) concept. The US community is promoting a mission concept known as SGO Mid (Space-based Gravitational-wave Observatory Mid-sized), a three arm LISA-like concept. If NASA were to partner with ESA, the eLISA concept could be transformed to SGO Mid by the addition of a third arm, augmenting science, reducing risk and reducing non-recurring engineering costs. The characteristics of the mission concepts and the relative science performance of eLISA, SGO Mid and LISA are described. Note that all results are based on models, methods and assumptions used in NASA studies.

Comparison of Concept Characteristics

Parameter	eLISA	SGO Mid	Classic LISA
Measurement arm length	1 x 10^6 km	1 x 10^6 km	5 x 10^6 km
Number & type of spacecraft	1 corner (2 optical assemblies), 2 end (single optical assembly)	3 corner (2 optical assemblies)	3 corner (2 optical assemblies)
Constellation configuration	Vee	Triangle	Triangle
Interferometer configuration	2 arms, 4 links	3 arms, 6 links	3 arms, 6 links
Gravitational-wave polarization measurement	Single instantaneous polarization, second polarization by orbital evolution	Two simultaneous polarizations continuously	Two simultaneous polarizations continuously
Orbit	Heliocentric, earth-trailing, drifting-away 9°- 21°	Heliocentric, earth-trailing, drifting-away 9°- 21°	22° heliocentric, earth-trailing
Trajectory	Launch to Geosynchronous Transfer Orbit, transfer to escape, 14 months	Direct injection to escape, 18 months	Direct injection to escape, 14 months
Duration of science observations	2 years, extendable to 4 years	2 years, extendable to 4 years	5 years, extendable to 8.5 years
Launch vehicle(s)	Two Soyuz	Single Medium EELV (e.g., Atlas 551)	Single Medium EELV (e.g., Falcon Heavy)
Optical bench	Low-CTE material, hydroxy-catalysis construction	Low-CTE material, hydroxy-catalysis construction	Low-CTE material, hydroxy-catalysis construction
Laser	2 W, 1064 nm, frequency and power stabilized	1 W, 1064 nm, frequency and power stabilized	2 W, 1064 nm, frequency and power stabilized
Telescope	20 cm diameter, off-axis	25 cm diameter, on-axis	40 cm diameter, on-axis
Gravitational Reference Sensor	46 mm cubical test mass - Au:Pt alloy, electrostatically controlled, optical readout	46 mm cubical test mass - Au:Pt alloy, electrostatically controlled, optical readout	46 mm cubical test mass - Au:Pt alloy, electrostatically controlled, optical readout

Comparison of Science Performance

Number of Sources Observed	eLISA	SGO Mid	Classic LISA
Massive Black Hole Binaries/Mergers	40-47	41-52	108-220
Detected z > 10	1-3	1-4	3-57
Both mass errors < 1%	13-30	18-42	67-171
One spin error < 1%	3-10	11-27	49-130
Both spin errors < 1%	<1	<1	1-17
Distance error < 3%	3-5	12-22	81-108
Sky location < 1 deg^2	1-3	14-21	71-112
Sky location < 0.1 deg^2	<1	4-8	22-51
Extreme-Mass-Ratio-Inspirals	12	35	800
Resolved Compact White Dwarf Binaries	3,900	7,000	40,000
Interacting	50	100	1,300
Detached	5,000	8,000	40,000
Sky location < 1 deg^2	1,000	2,000	13,000
Sky location < 1 deg^2, distance error < 10%	500	800	8,000
Stochastic Background Sensitivity (relative to LISA	0.15	0.2	1

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