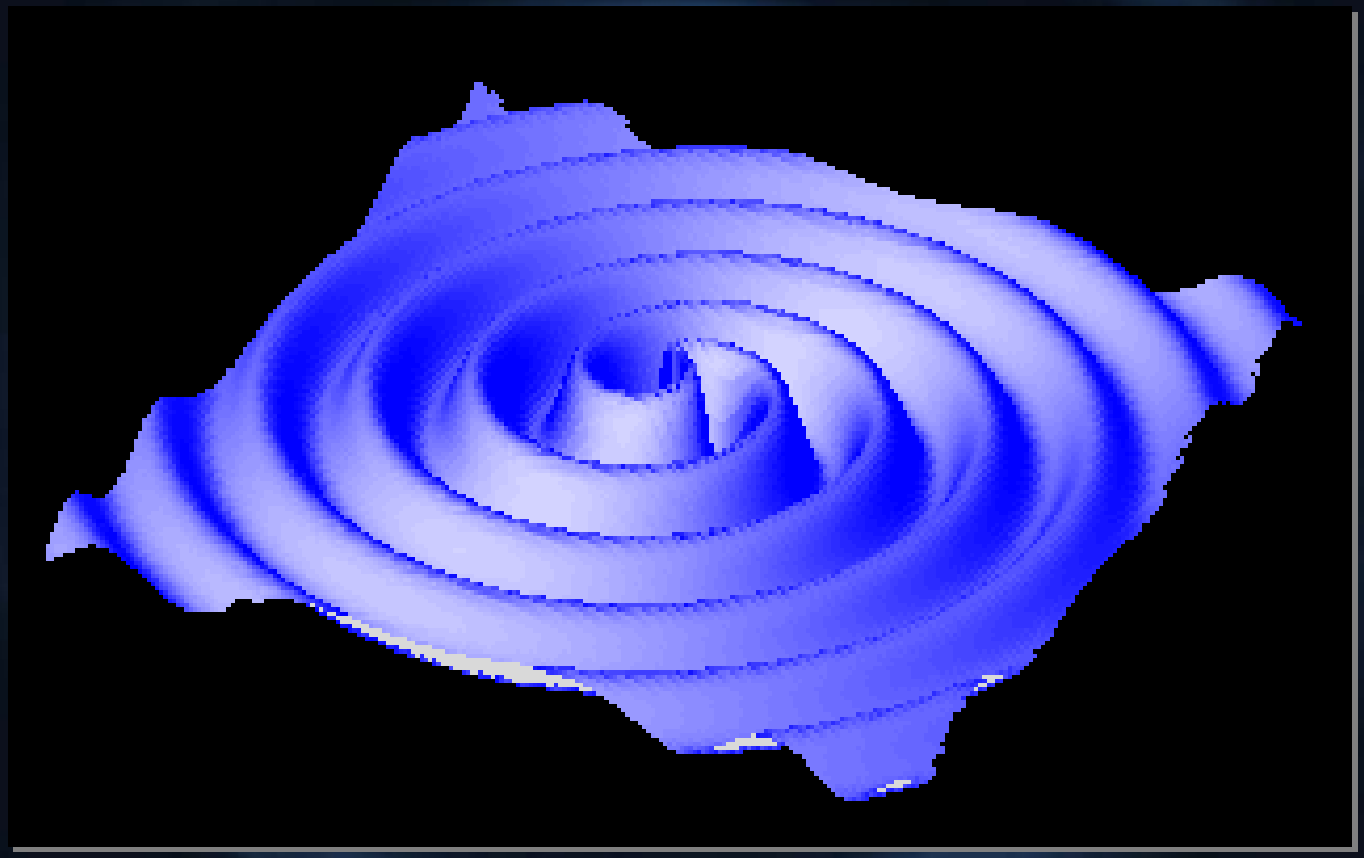
Laser Interferometer Space Antenna (LISA)

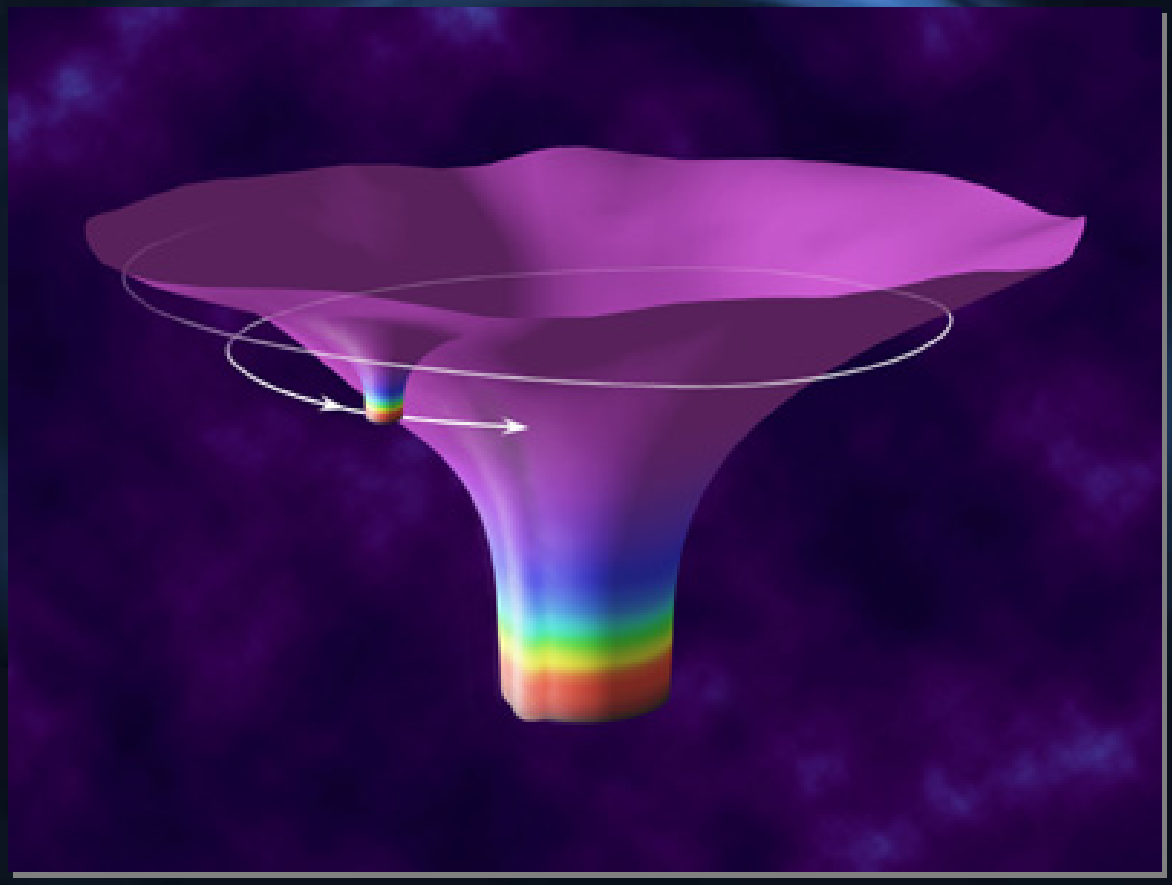
Detects Gravitational Waves

- Ripples in space-time caused by the movement of massive bodies in space.
- First predicted by Einstein
- Most powerful sources of GW's emit at low frequencies
- Travel through space essentially unaffected by intervening matter

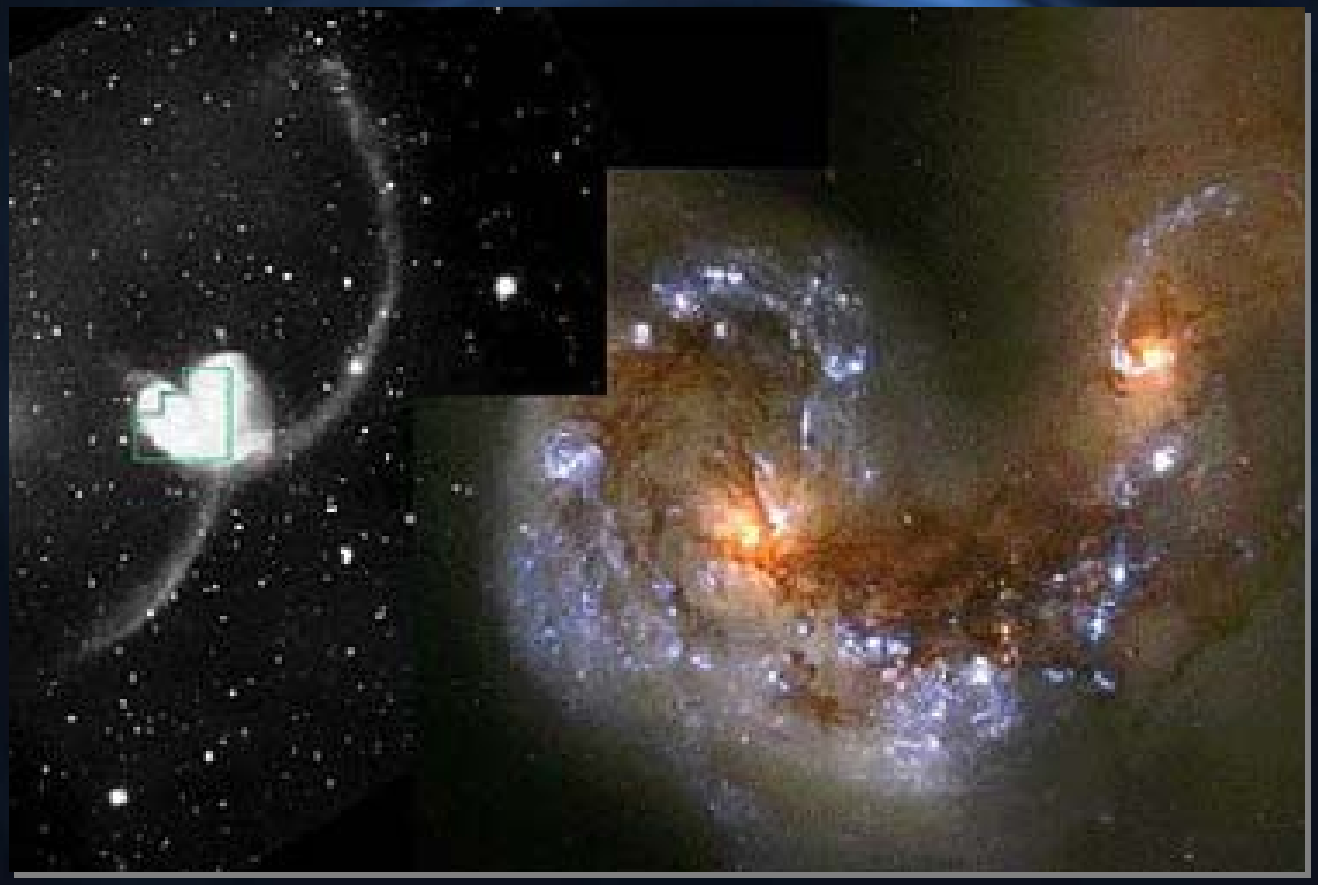


Binary Systems

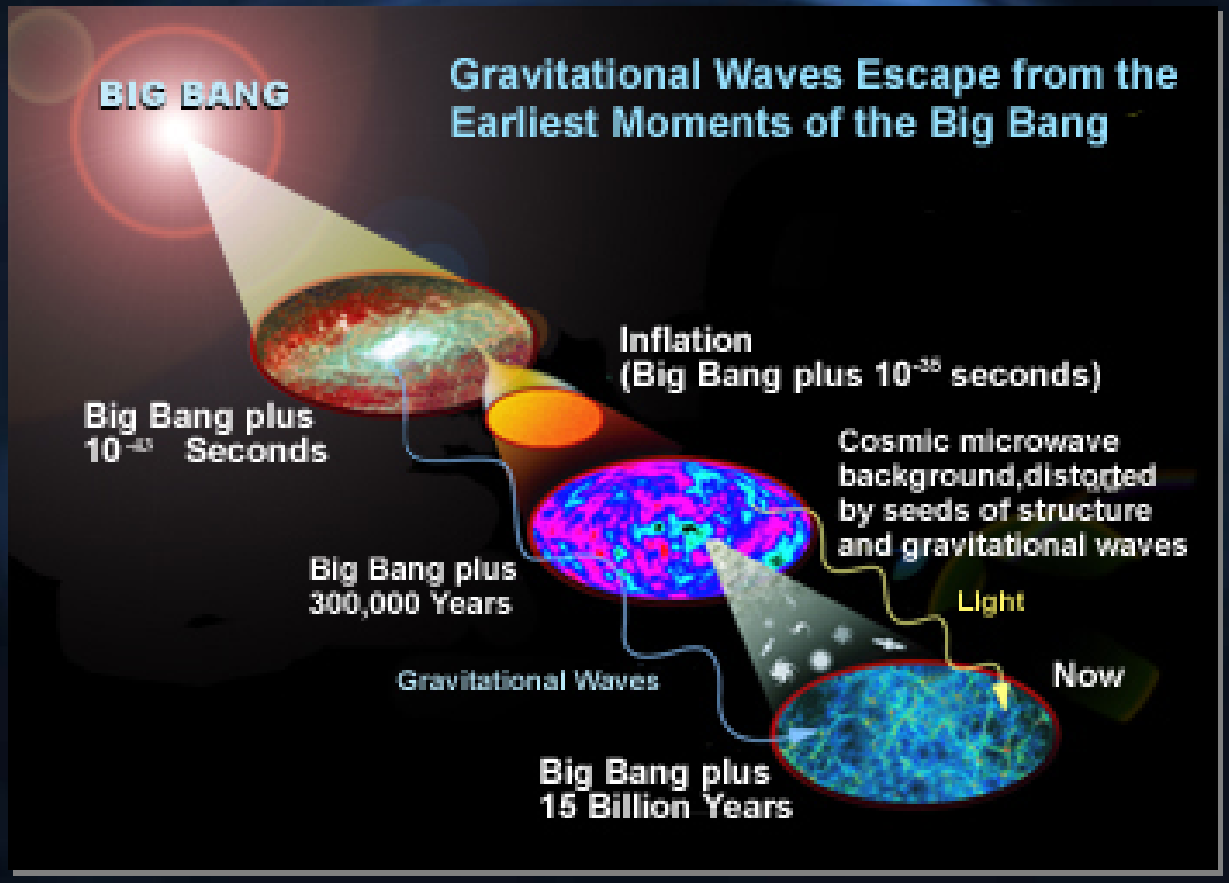
Death Spirals of Stars



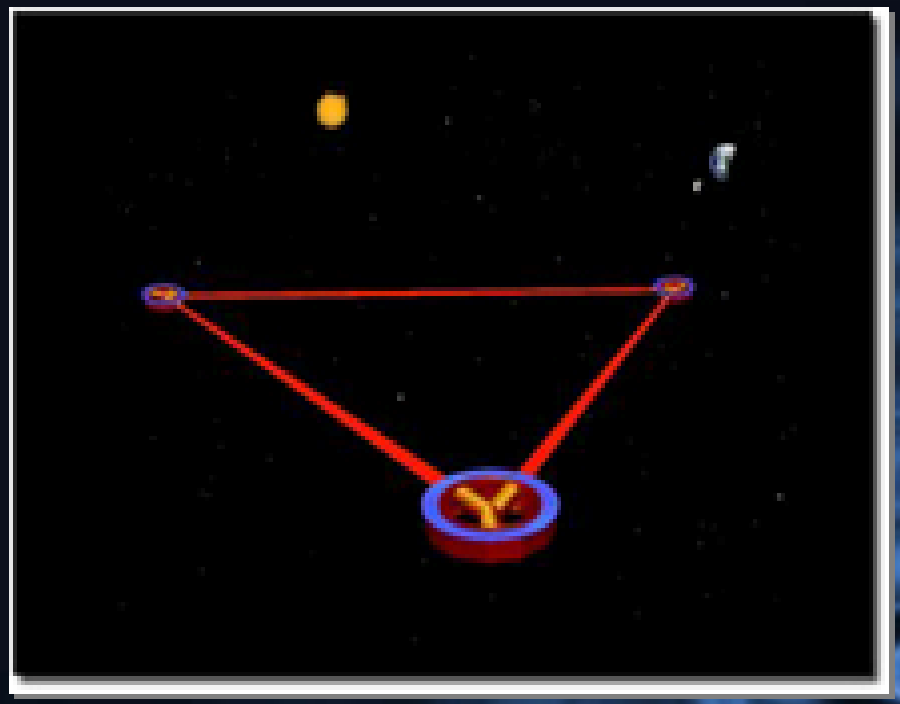
Merging Black Holes



“Echoes” from the Big Bang



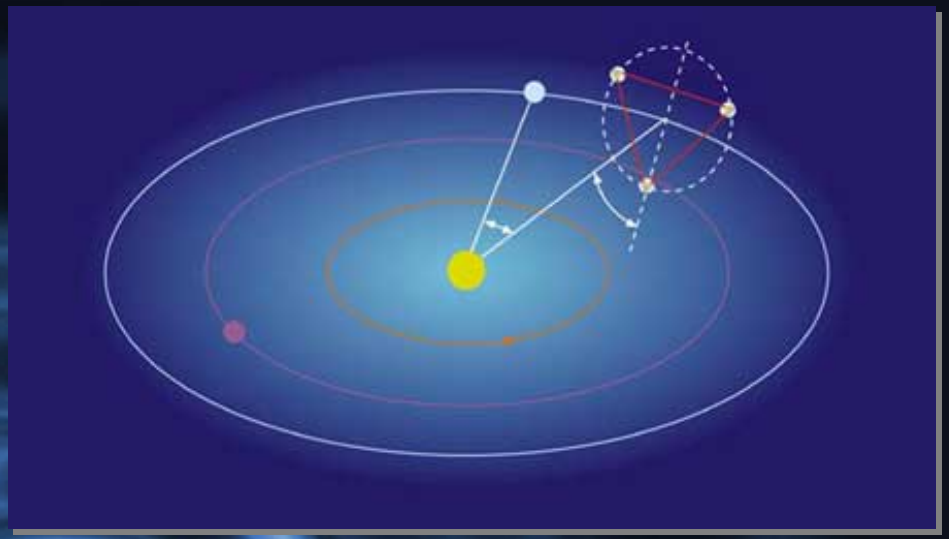
- Production was planned to begin in 2004
- Planned launch was in 2015
- Planned duration of operation is 5 years

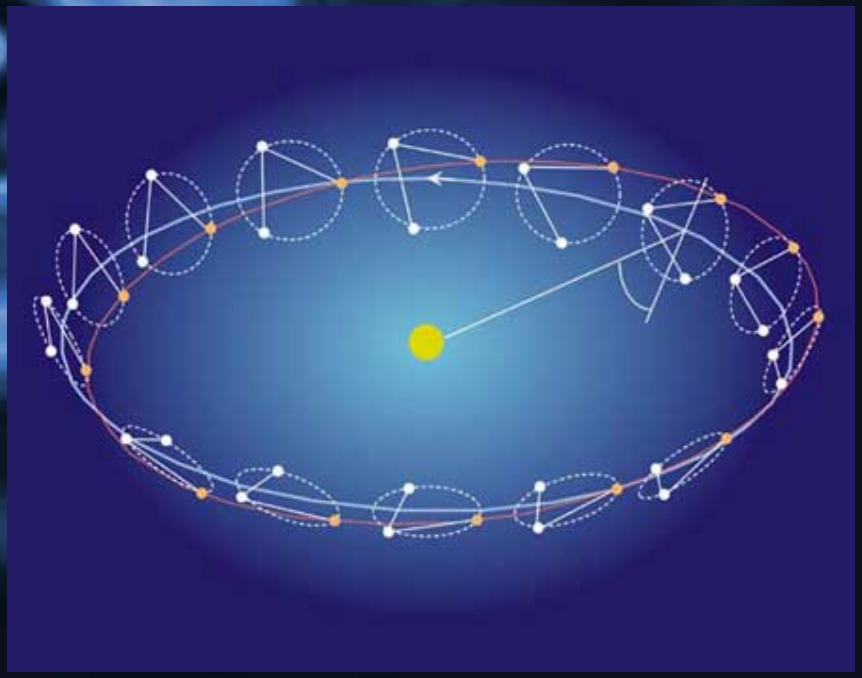


-Made up of 3 cylindrical spacecrafts spaced 5 million kilometers apart forming an equilateral triangle

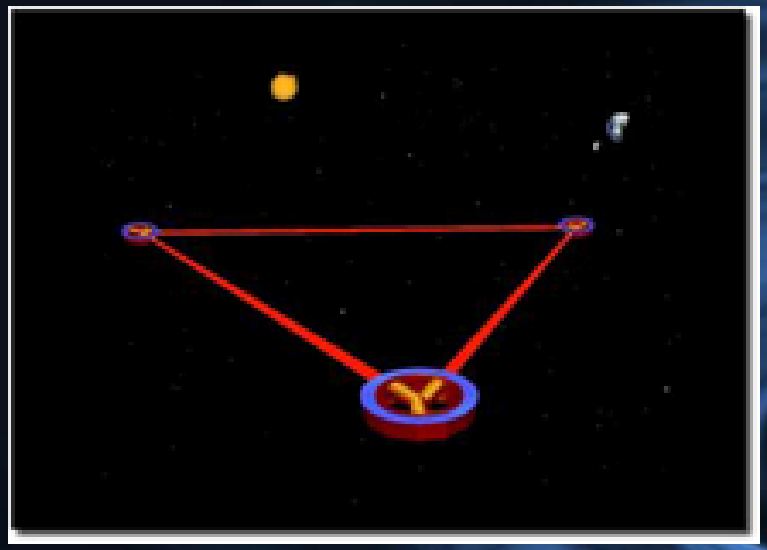
-Each spacecraft cylinder is 1.8 m in diameter and .48 m tall

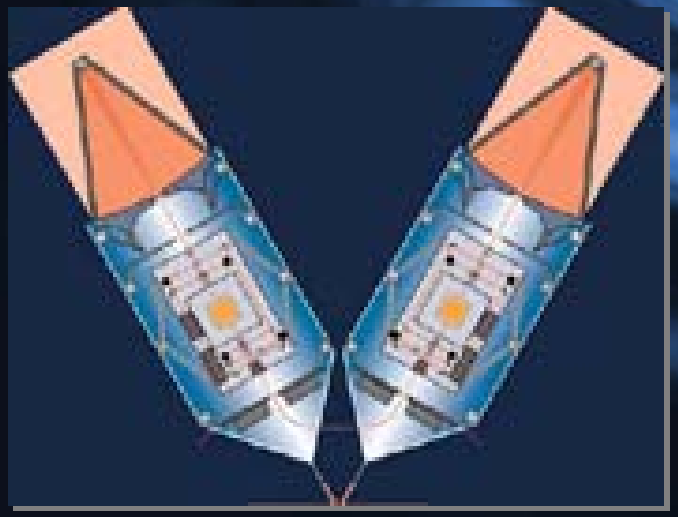
- LISA will travel 20 degrees behind the Earth as it orbits around the Sun





How does it work?

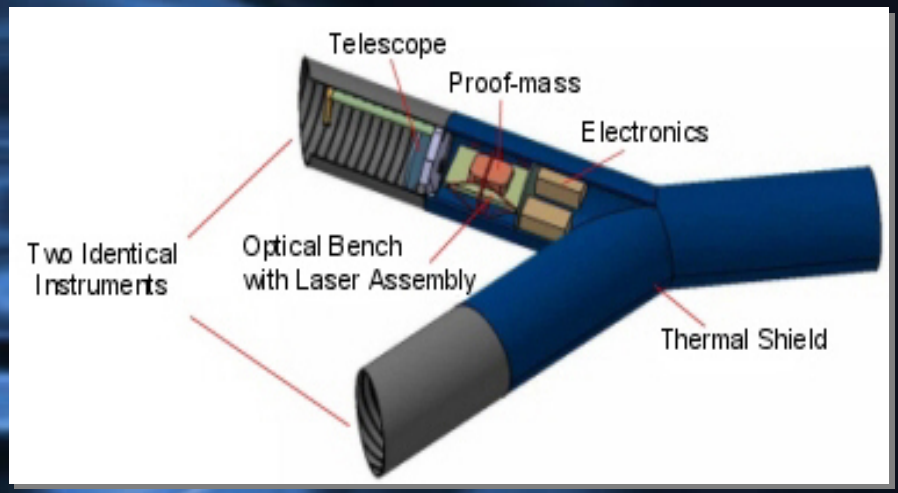


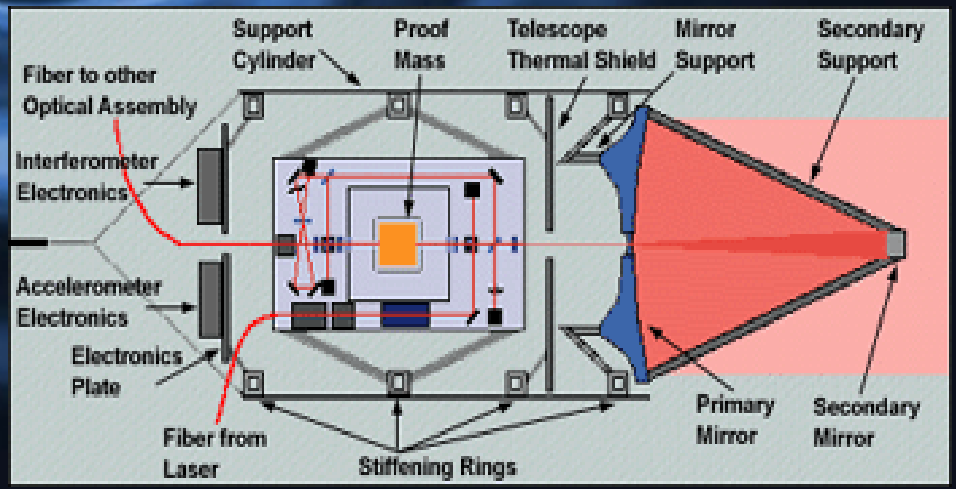


-Each spacecraft contains a y-shaped tube that contains two identical instruments, each one pointing at another spacecraft

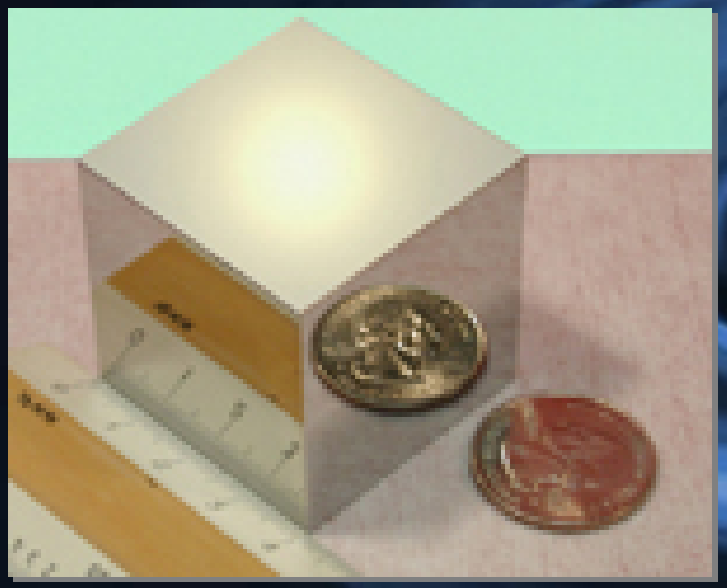
How does it work?

- Lasers used to tell where the spacecrafts are in relation to each other
- Cassegrain telescope in each instrument receives light from other spacecraft
- Each instrument contains a test mass (yellow box in the middle of the bottom picture)





How does it work?

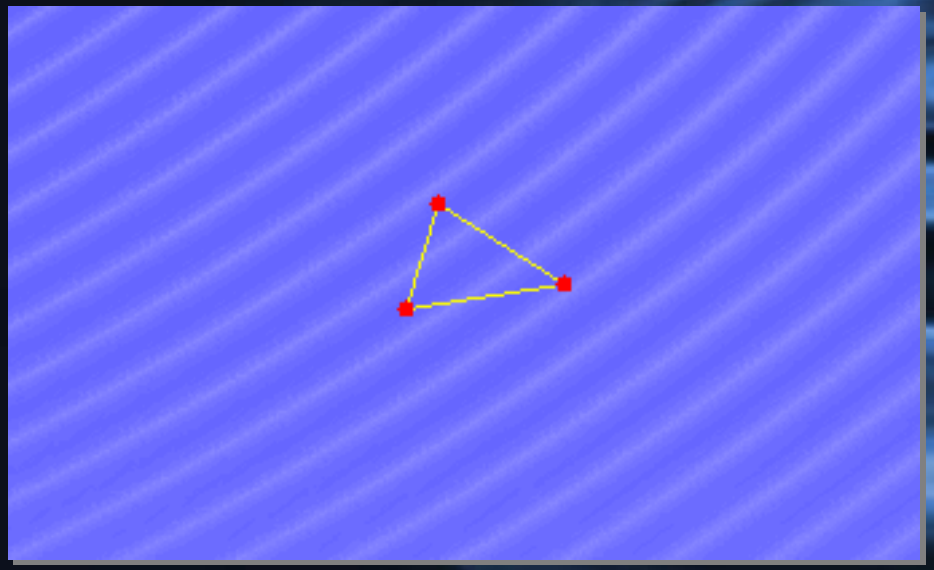


-Test masses are highly polished 4 cm cubes

-Freely floating in the “heart” of each instrument

-Protected from all external and internal disturbances, only affected by gravity

How does it work?



-Spacecrafts sense movement of test masses

-Change in distances between test masses measured by free-falling gravitational reference sensor to detect gravity waves

Advantages

-In space, LISA won't be affected by "noise" on the Earth from earthquakes, tides, weather, and variations in the Earth's own gravitational field

-Spacecrafts can be placed much farther apart from each other

-Will be able to detect frequencies as low as 1 millihertz whereas ground-based observatories can only detect above 1 hertz

-Will compliment ground-based resonant-mass and laser-interferometry detectors

Disadvantages

External Disturbances

-Pressure from the light of the sun

-Variable solar magnetic field

-Distortion of the spacecraft array due to the gravitational forces of the Earth and Moon

Internal Disturbances

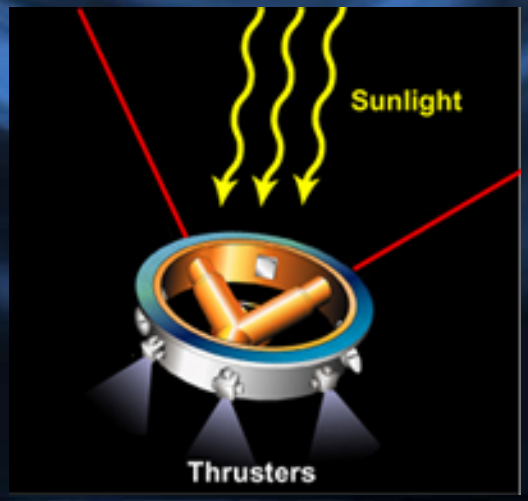
-Interaction between electrical field generated by spacecraft computer and test masses

-Effects from residual gas pressure near test masses

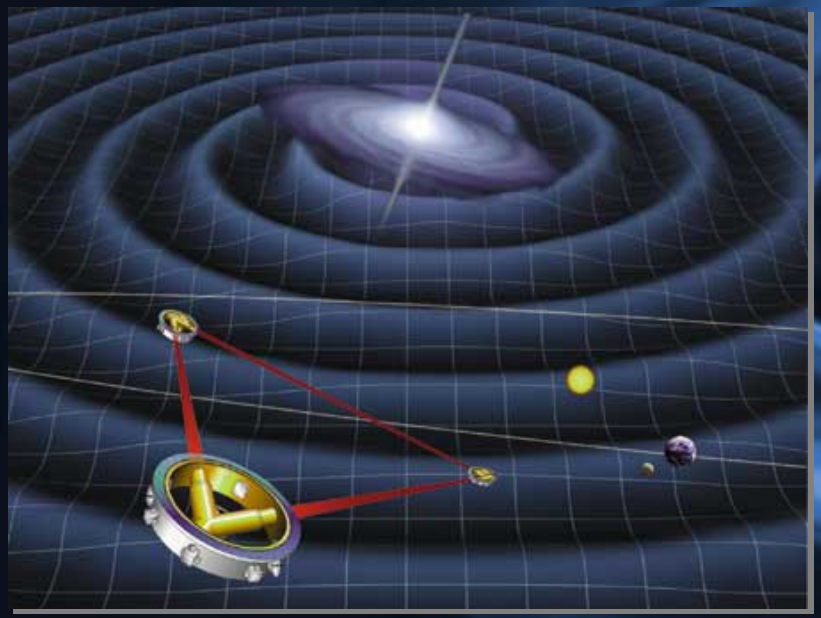
-Thermal radiation from the electrodes used to measure the spacecraft's position

Counteracting Disturbances

- Spacecraft will act as a shield to protect the test masses from solar disturbances
- LISA's orbital position will protect it from any gravitational forces from Earth or Moon
- Micronewton thrusters counteract movement of spacecraft from disturbances to maintain a distance from the test masses accurate to 10 nm



Goals



- -Directly detect gravitational waves
- -Test Einstein's theory of relativity
- -Study the roles of massive black holes in the evolution of galaxies
- -Observe gravitational waves emitted from the early universe
- -Pave the way for future missions involving multiple spacecrafts flying in formation