LISA

An experiment in charge management

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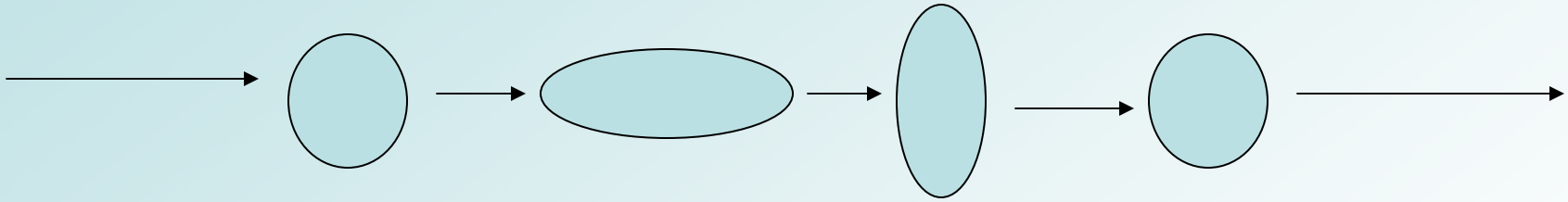
The search for gravitational waves

Gravitational waves: new way to observe the Universe!

- Gravitational waves - ripples in space-time that affect any type of matter they encounter.



•The motion is small, but measurable with today's technology.

•Like any wave, gravitational waves carry information about the matter that created them.

•Because gravitational waves travel (in essence) unaffected by matter, sensitive detectors would enable us to detect waves made billions of years ago, despite their weak signals.

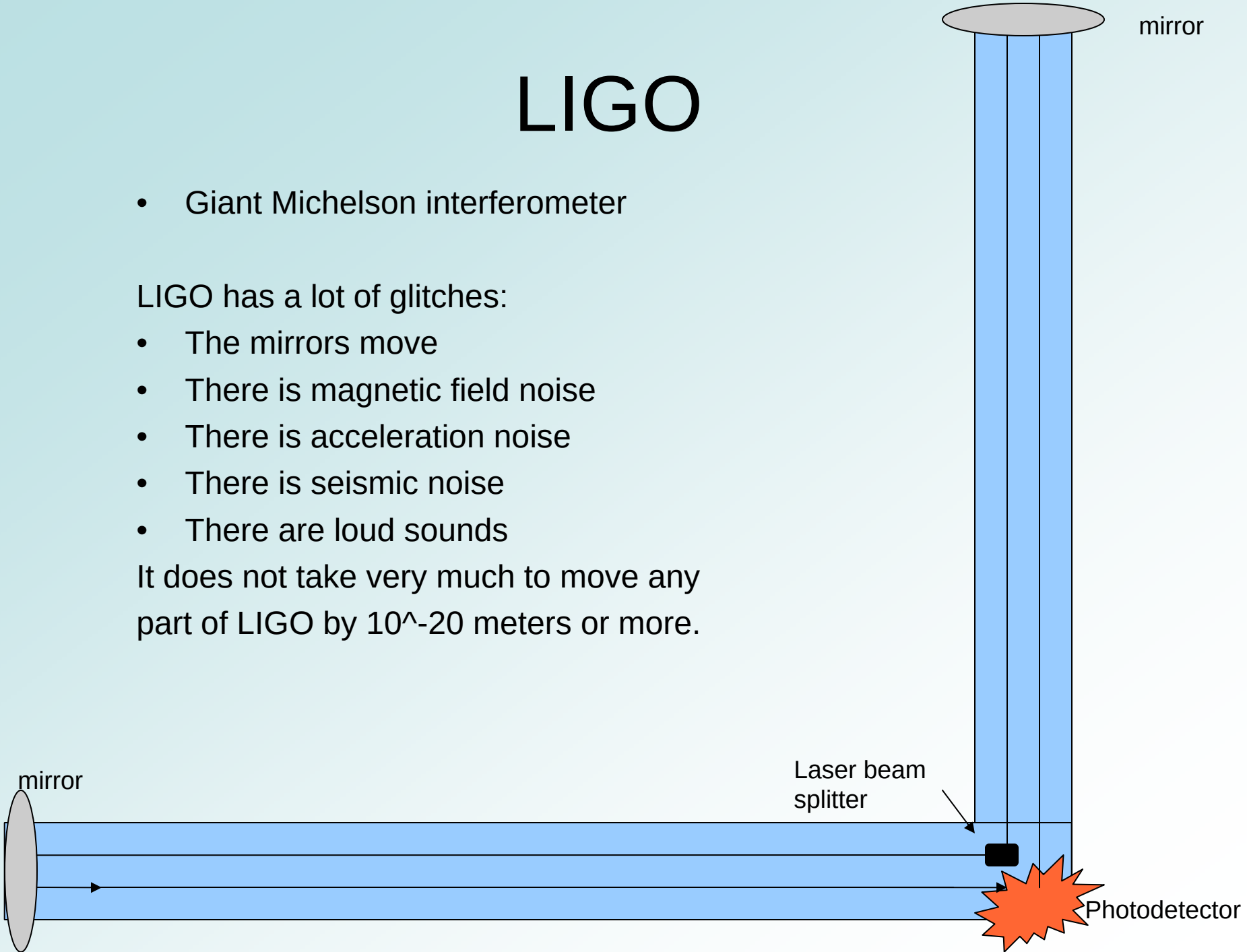
LIGO

- Giant Michelson interferometer

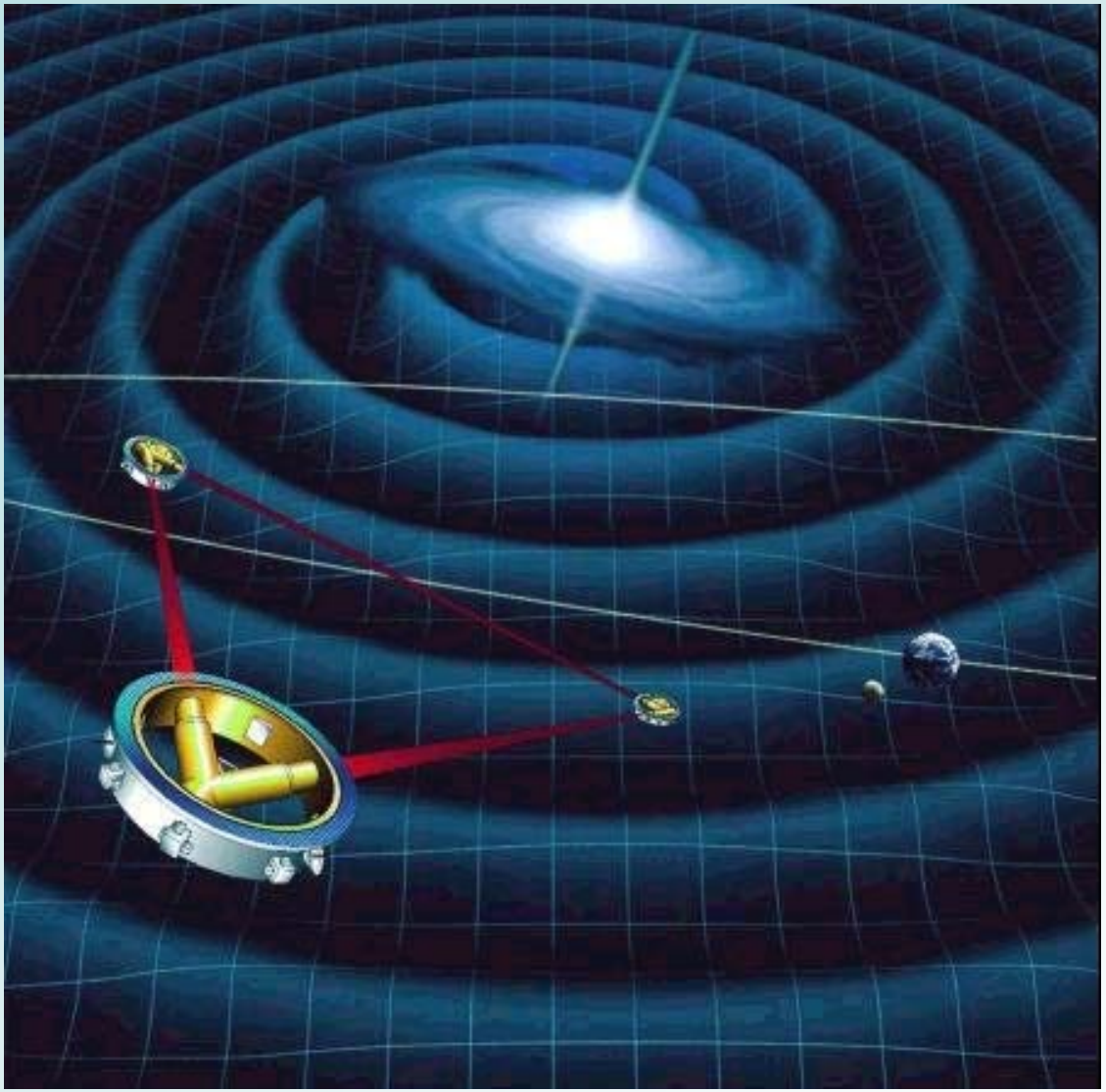
LIGO has a lot of glitches:

- The mirrors move
- There is magnetic field noise
- There is acceleration noise
- There is seismic noise
- There are loud sounds

It does not take very much to move any part of LIGO by 10^-20 meters or more.



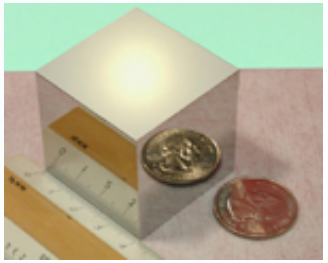
LIGO… in space!



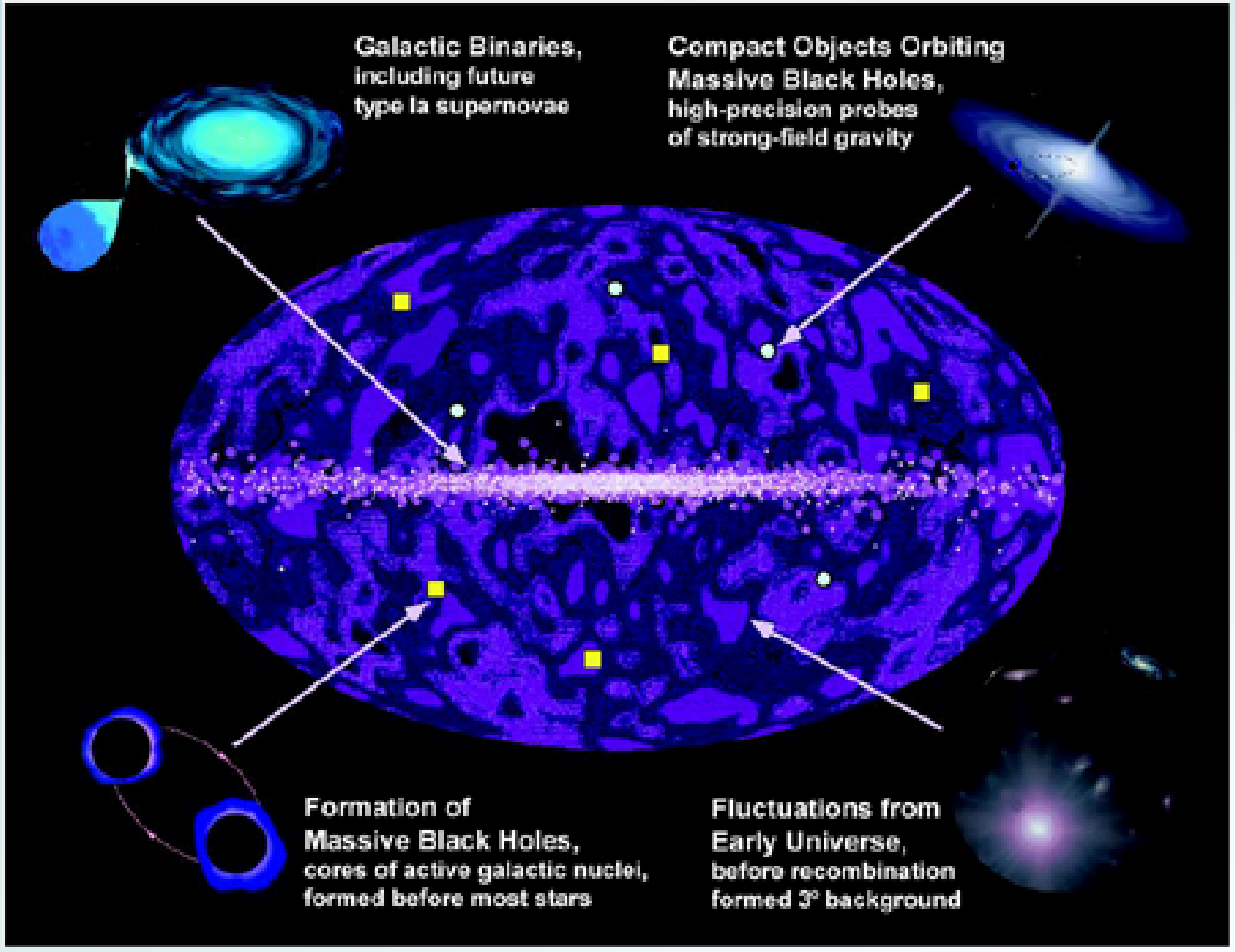
Images source: http://lisa.jpl.nasa.gov/gallery/lisa-waves.html

LISA uses the same principles as LIGO except:

- Arm length is 5 million km, which will allow observation in the frequencies of the more interesting sources.
- Uses 3 separate interferometers
- Distances are measured between freely floating test masses that act as end mirrors



Why LISA is important and what it will see



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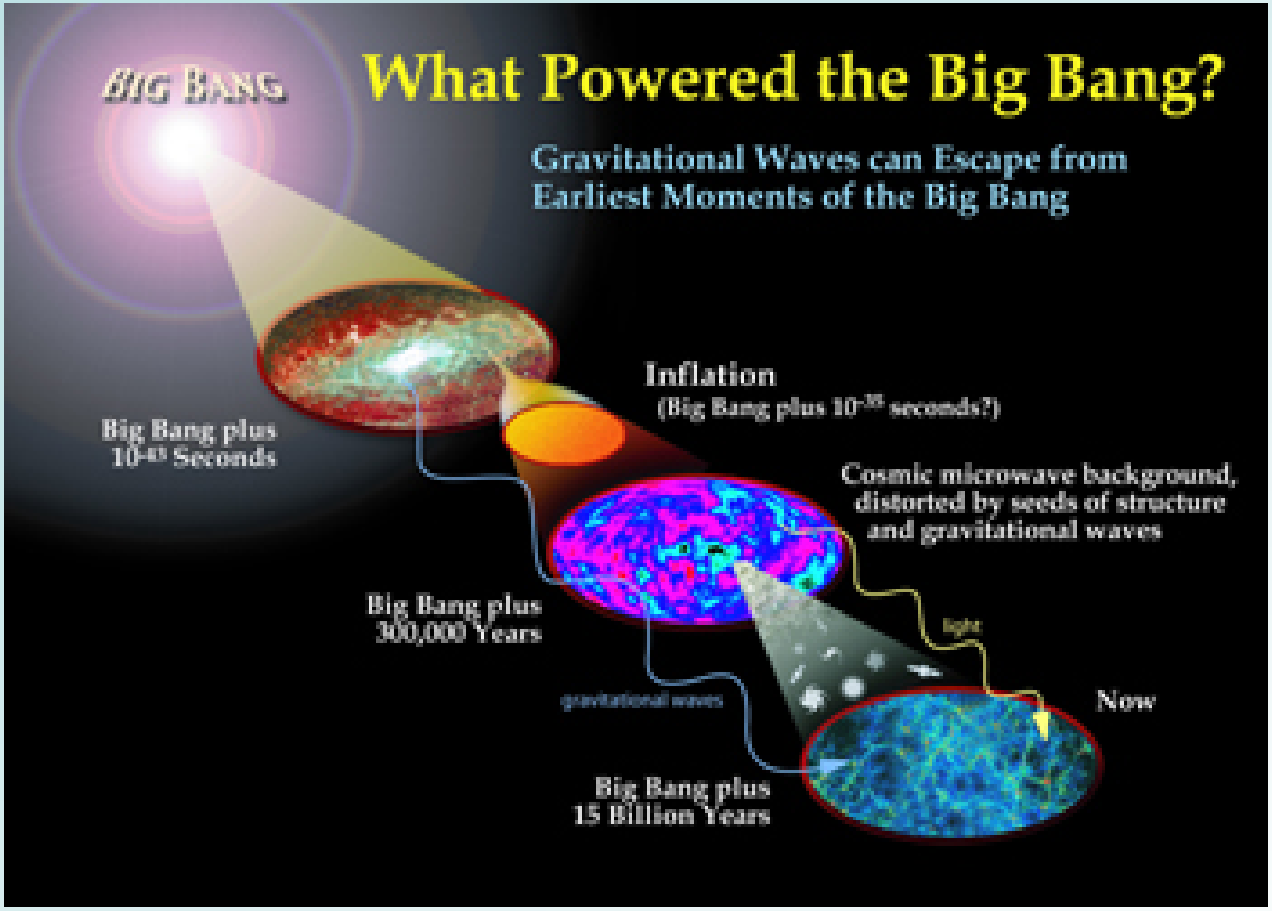
- Testing relativity
- Observing enormous amounts of gravity wave sources
- Directly detecting merging super massive black holes
- Investigating acceleration of the Universe
- Shedding light on dark energy's nature



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- Detection of gravitational waves from the early Universe would be “the most fundamental discovery that LISA could make.”
- For scale, the Cosmic Microwave Background allows us to see back to less than 300,000 years after the Big Bang. LISA will search for gravitational wave emission from up to one second after the Big Bang.

How LISA works

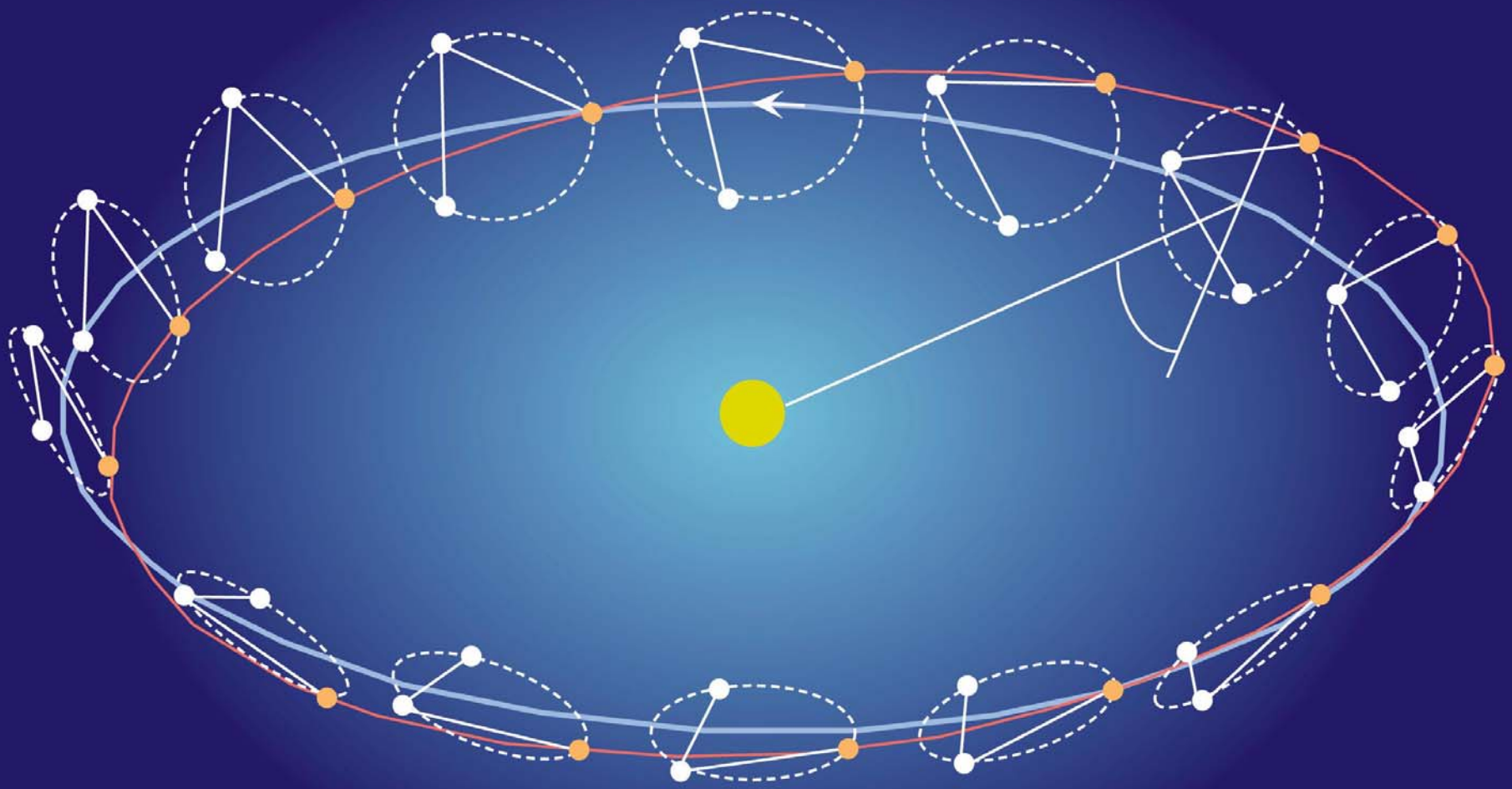


Image source:http://lisa.nasa.gov/STRATEGY/getThere.html

How LISA works

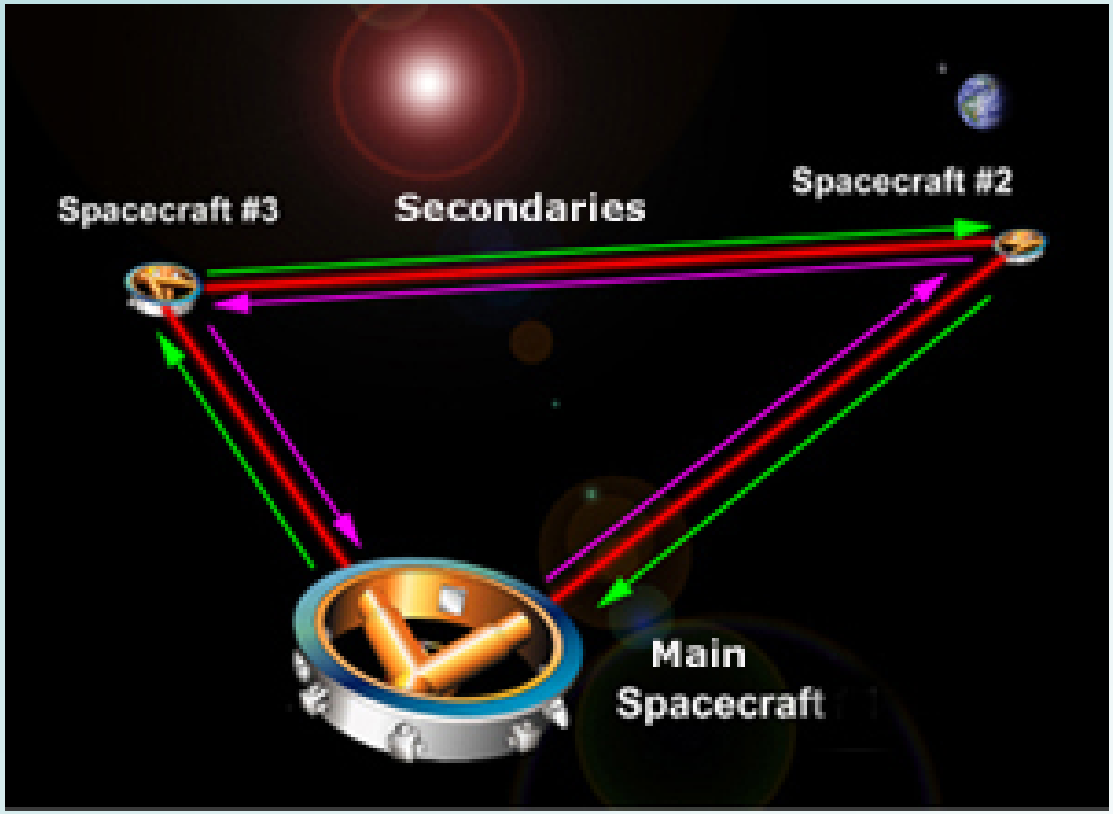


Image source: http://lisa.nasa.gov/TECHNOLOGY/LISA_interfer2.html

- Each spacecraft is the light source of another.
- Using the three interferometers simultaneously will allow gravitational waves polarization to be determined.
- Rather than reflecting light back, the secondary spacecraft transmit another laser beam in phase with the incoming light

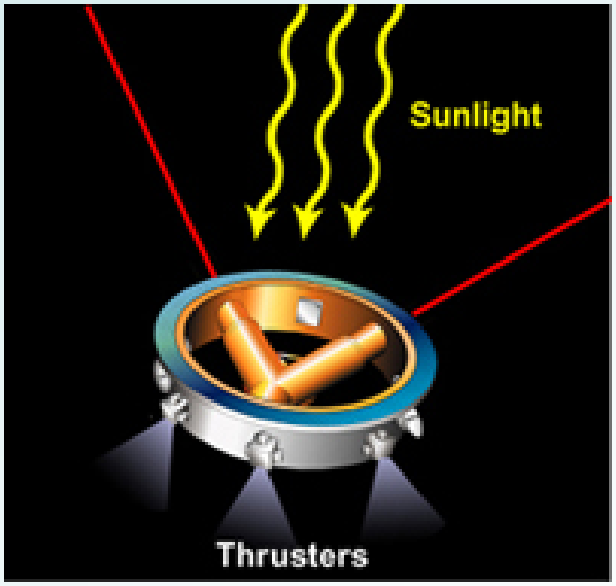
Technological challenges of LISA

- The LISA mission depends on three central technologies:
  - gravitational reference sensors
  - micronewton thrusters
  - laser interferometry

  The spacecraft is controlled to follow the test masses with an accuracy of 10 nanometers (1/100th the wavelength of light) to counteract disturbances which include:
  - solar wind buffeting
  - spacecraft drift
  - test mass charging
  - interference from the interplanetary magnetic fields

My project:
try to control charge using UV light

- LISA proof masses will be charged by solar rays
- LISA design includes UV light to knock charge off or on the test masses



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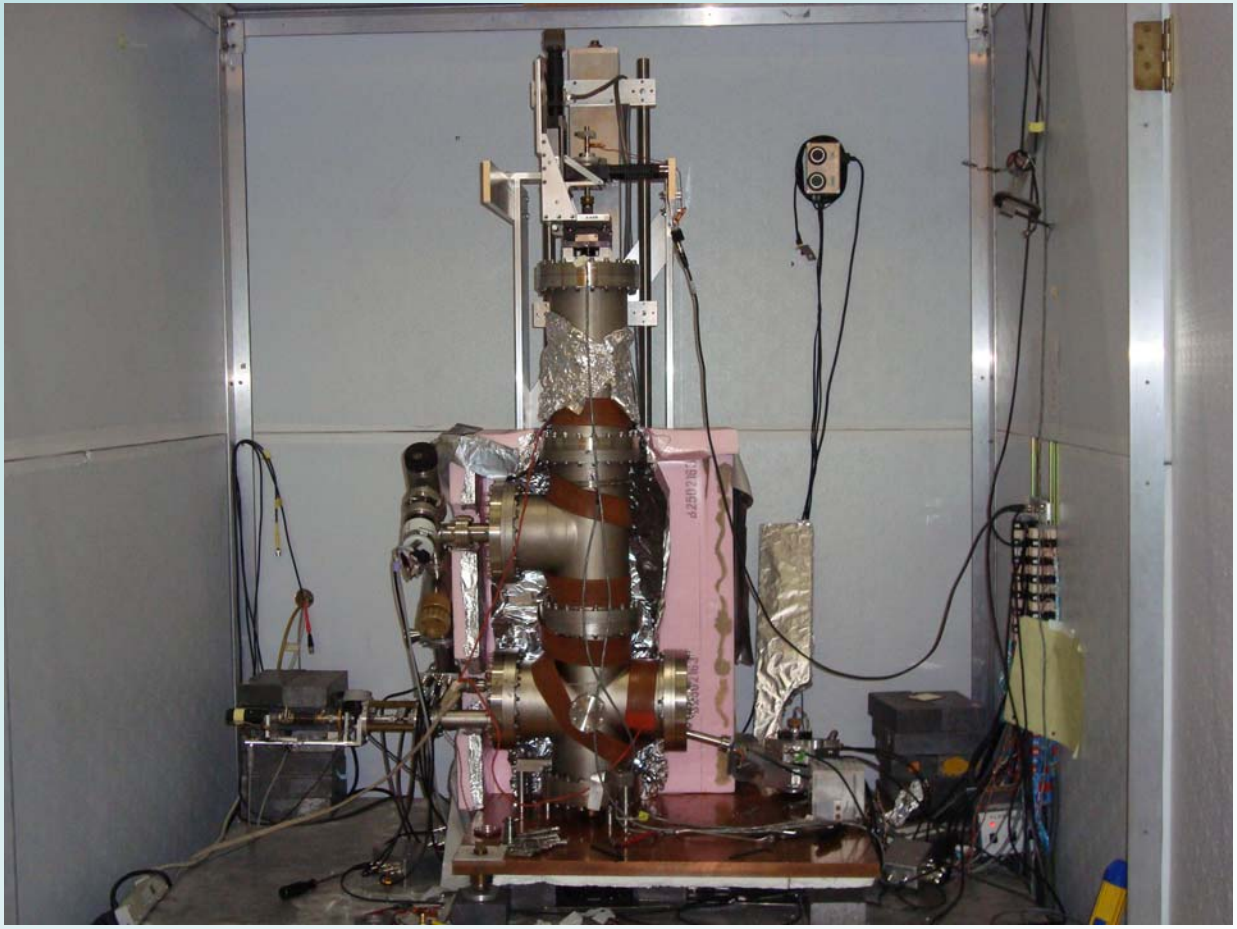
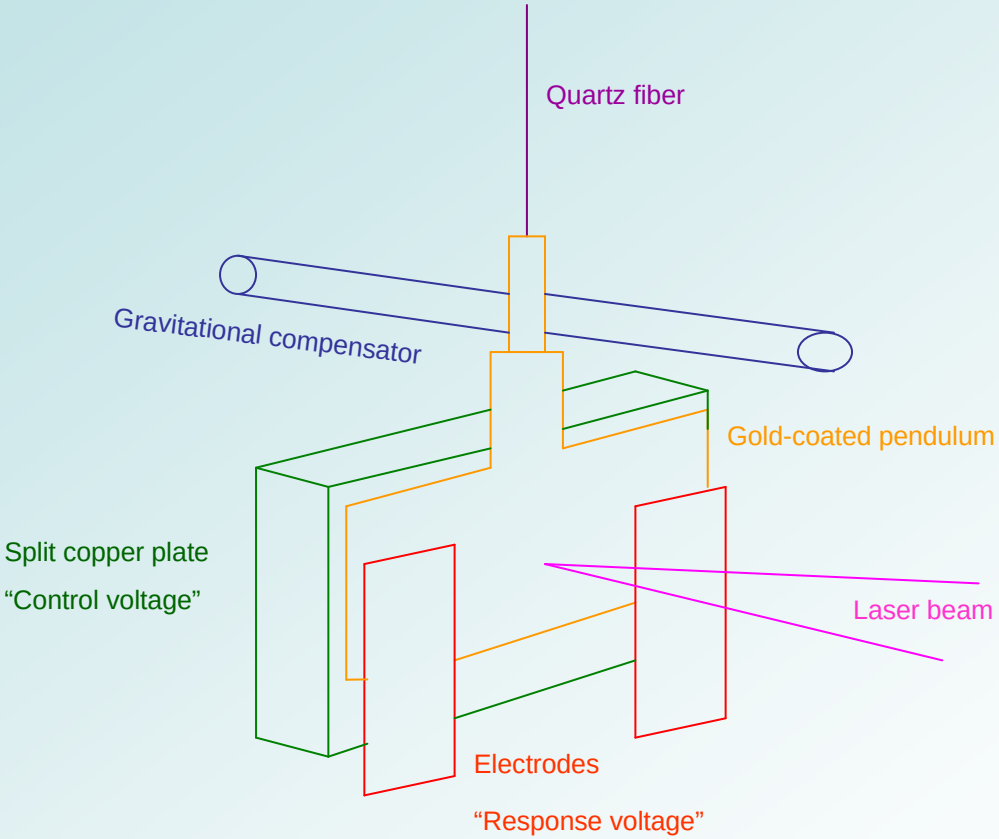
The LISA torsion pendulum



The pendulum simulates the LISA spacecraft in exploring interactions at small distance scales

Torsion Pendulum Set-up



The feedback system