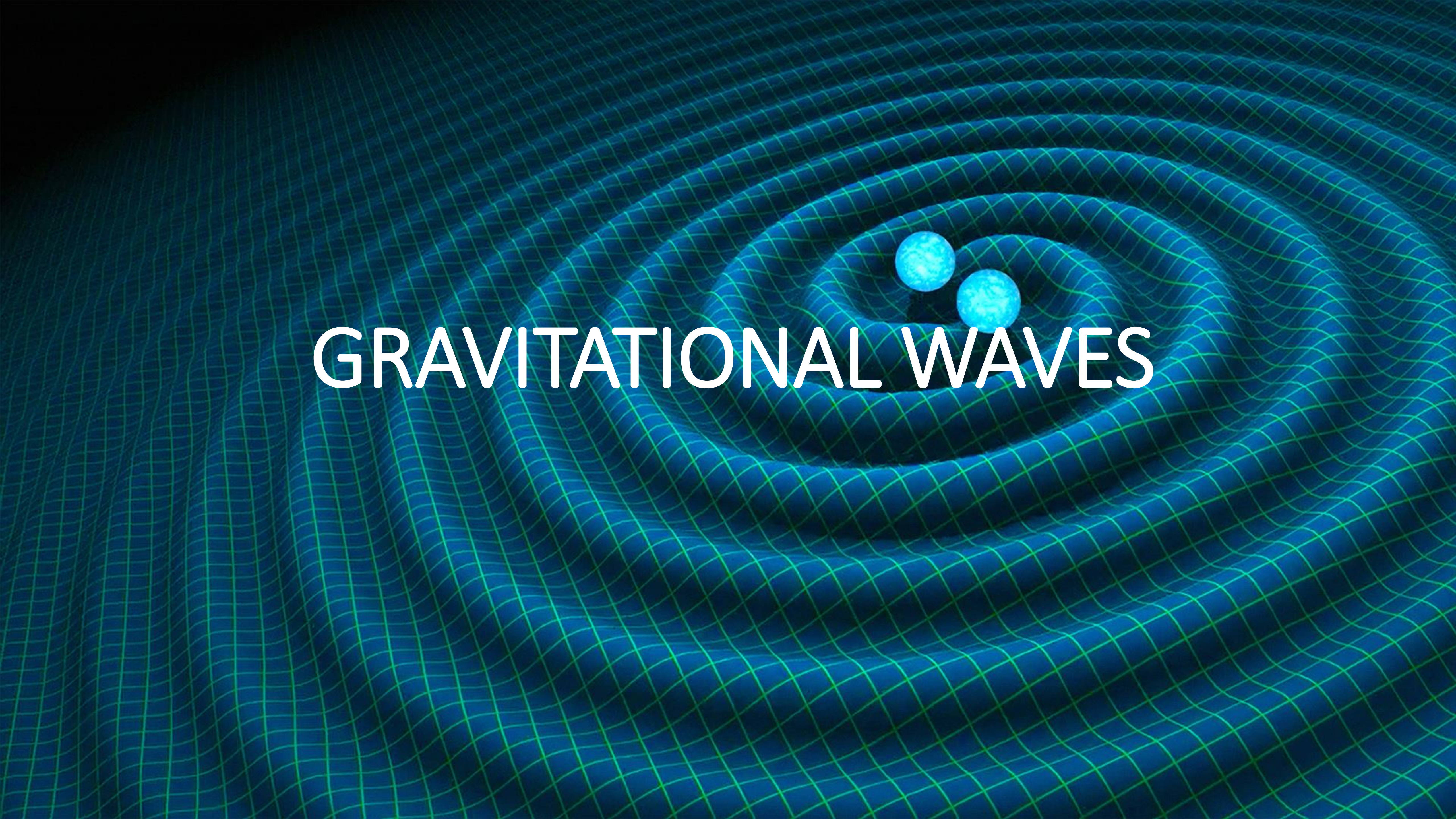
GRAVITATIONAL WAVES



What is a gravitational wave

- **One way to describe gravitational waves is as "ripples in space-time." They were predicted a century ago by Einstein's Theory of General Relativity.**
- **His theory describes how space-time is affected by mass. We can think of space-time as a fabric that bends or curves when we place an object on it. (Of course, space is actually 3-dimensional, plus the added dimension of time.)**

Where do Gravitational Waves come from?

- Gravitational waves are produced by masses moving through space-time in a special way. The simplest system that produces gravitational waves is two masses orbiting their common center of mass.

- One of the most common such system is a binary star system(two stars orbiting each other's common center of mass).

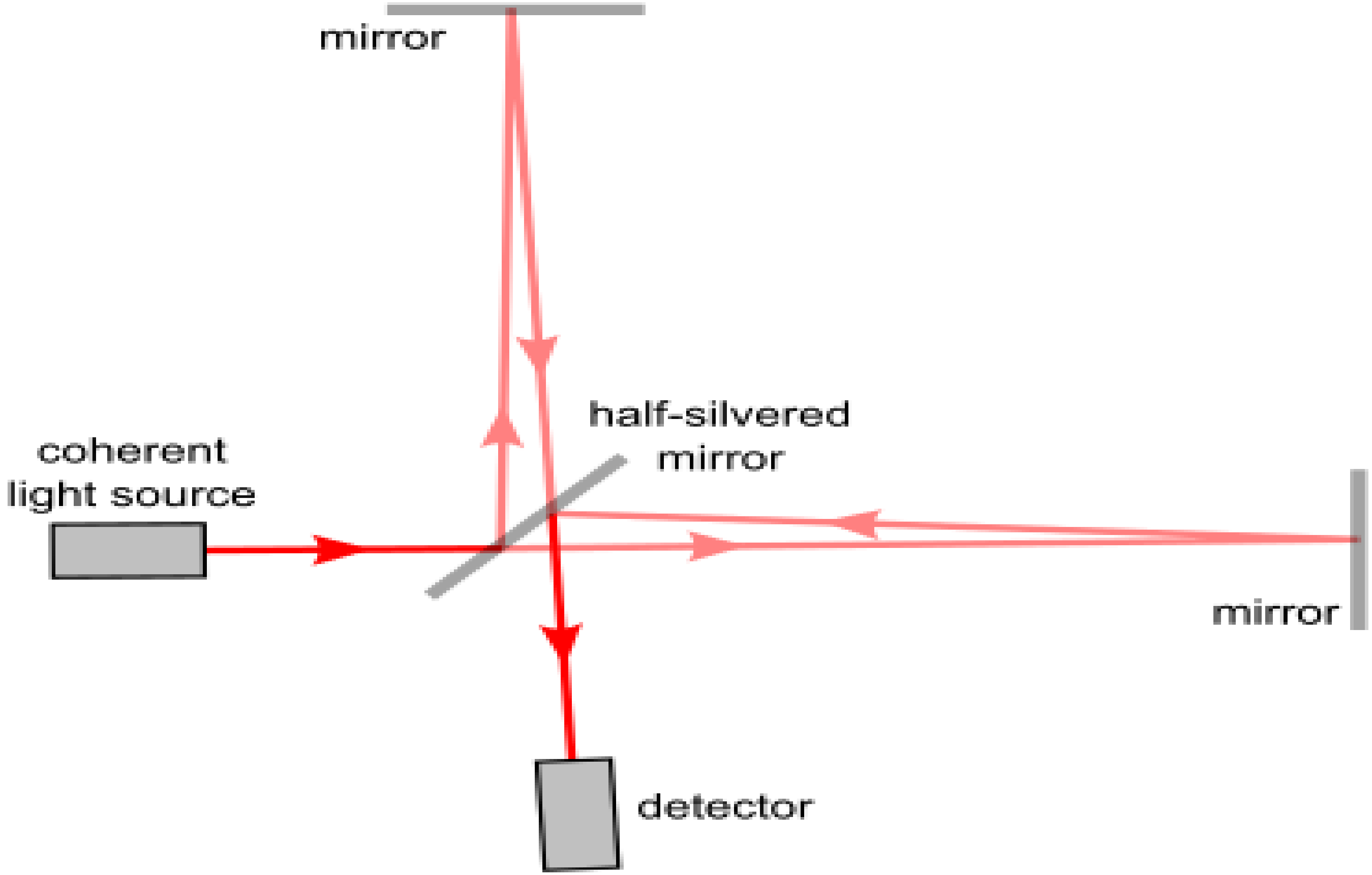
- Another place you might find large masses orbiting each other is the center of a galaxy - if two galaxies merged, their central supermassive black holes would orbit for a long time before they also merged.

How Can We Detect Gravitational Waves?

The detection of gravitational waves requires measurements that detect changes in distance less than the size of an atomic nucleus. To do this, scientists use interferometry.

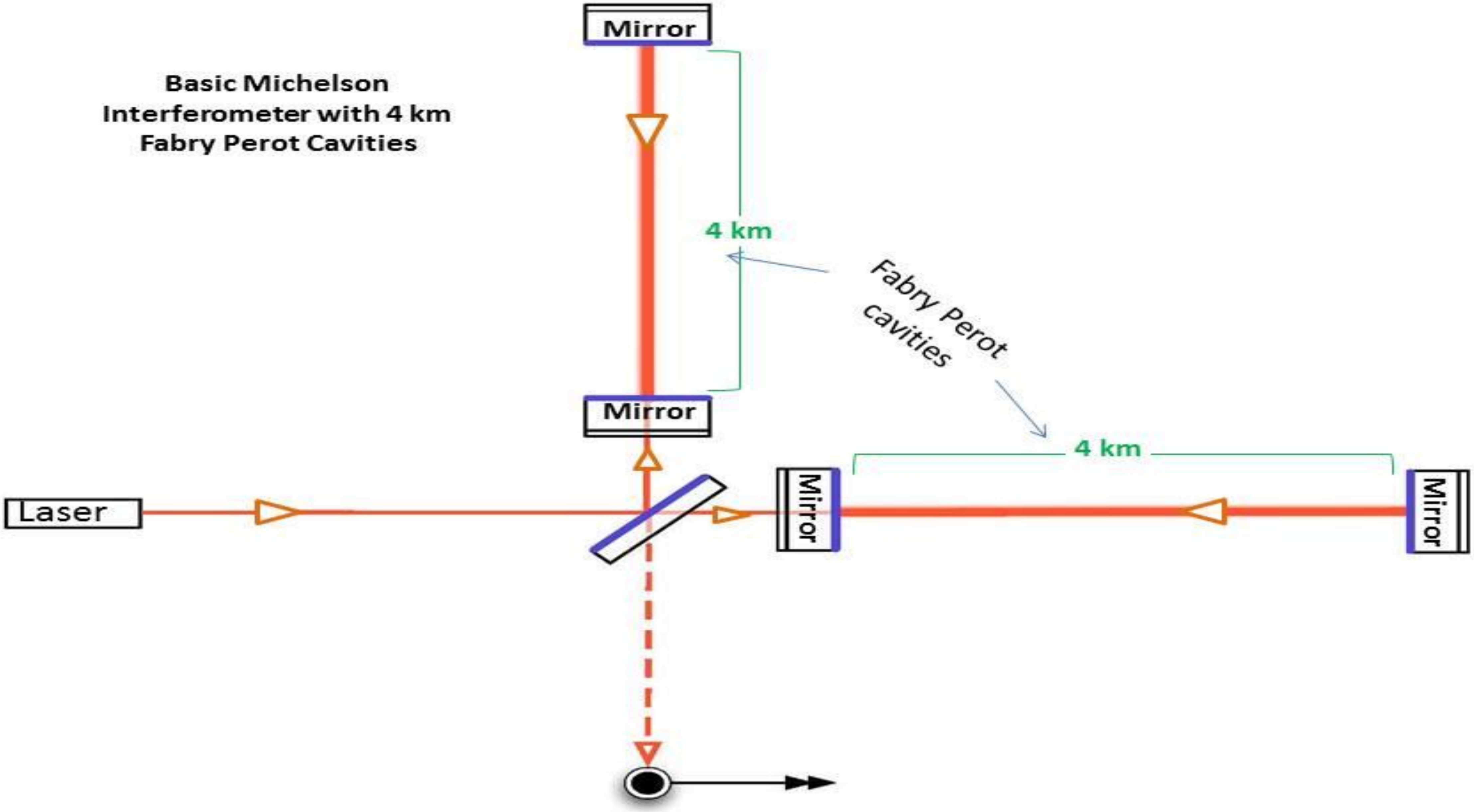
Interferometry

- **Interferometry is a family of techniques in which waves, usually electromagnetic waves, are superimposed, causing the phenomenon of interference, which is used to extract information.**
- **Interferometers are widely used in science and industry for the measurement of small displacements.**

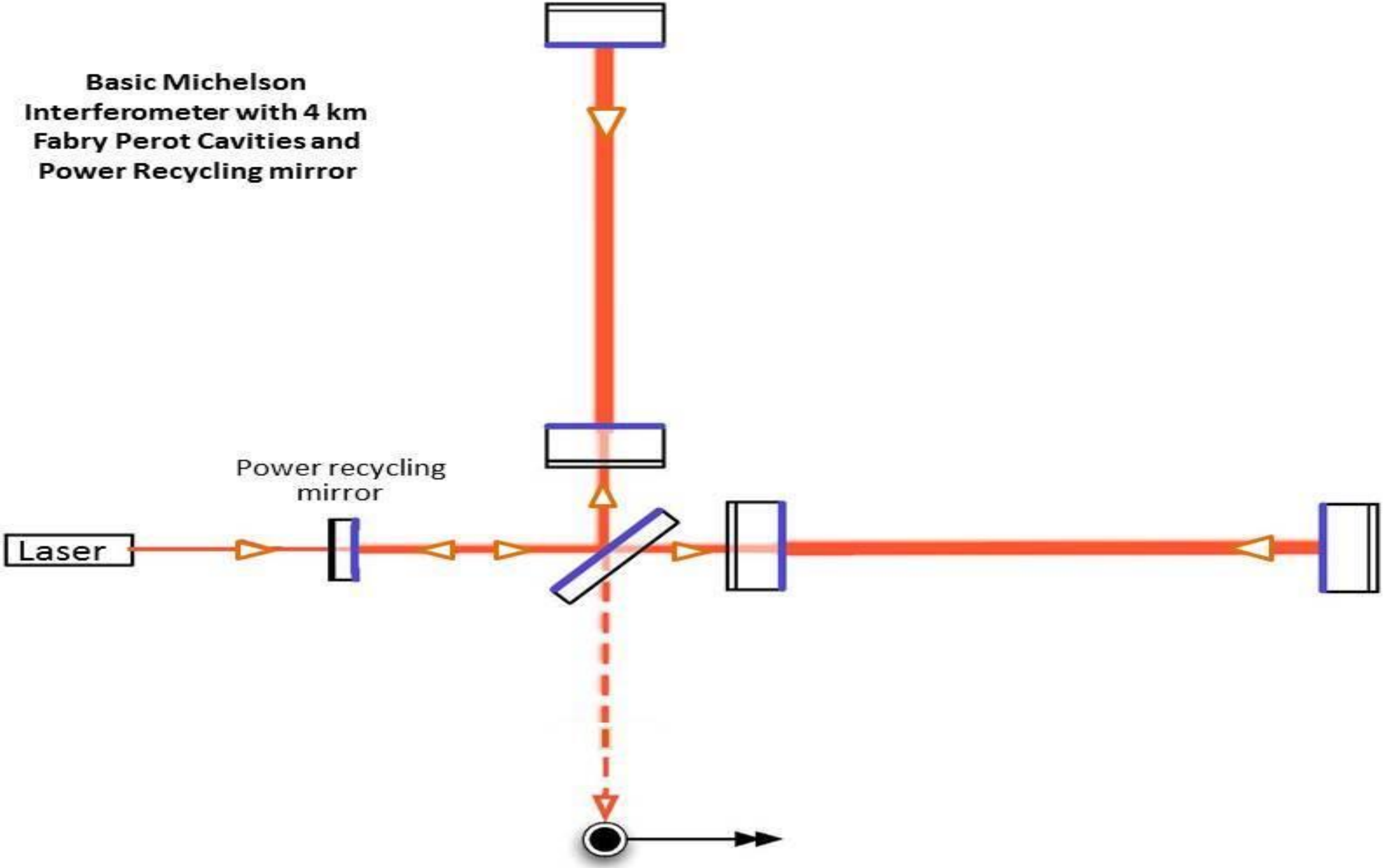

mirror
half-silvered
mirror
coherent
light source
mirror
detector

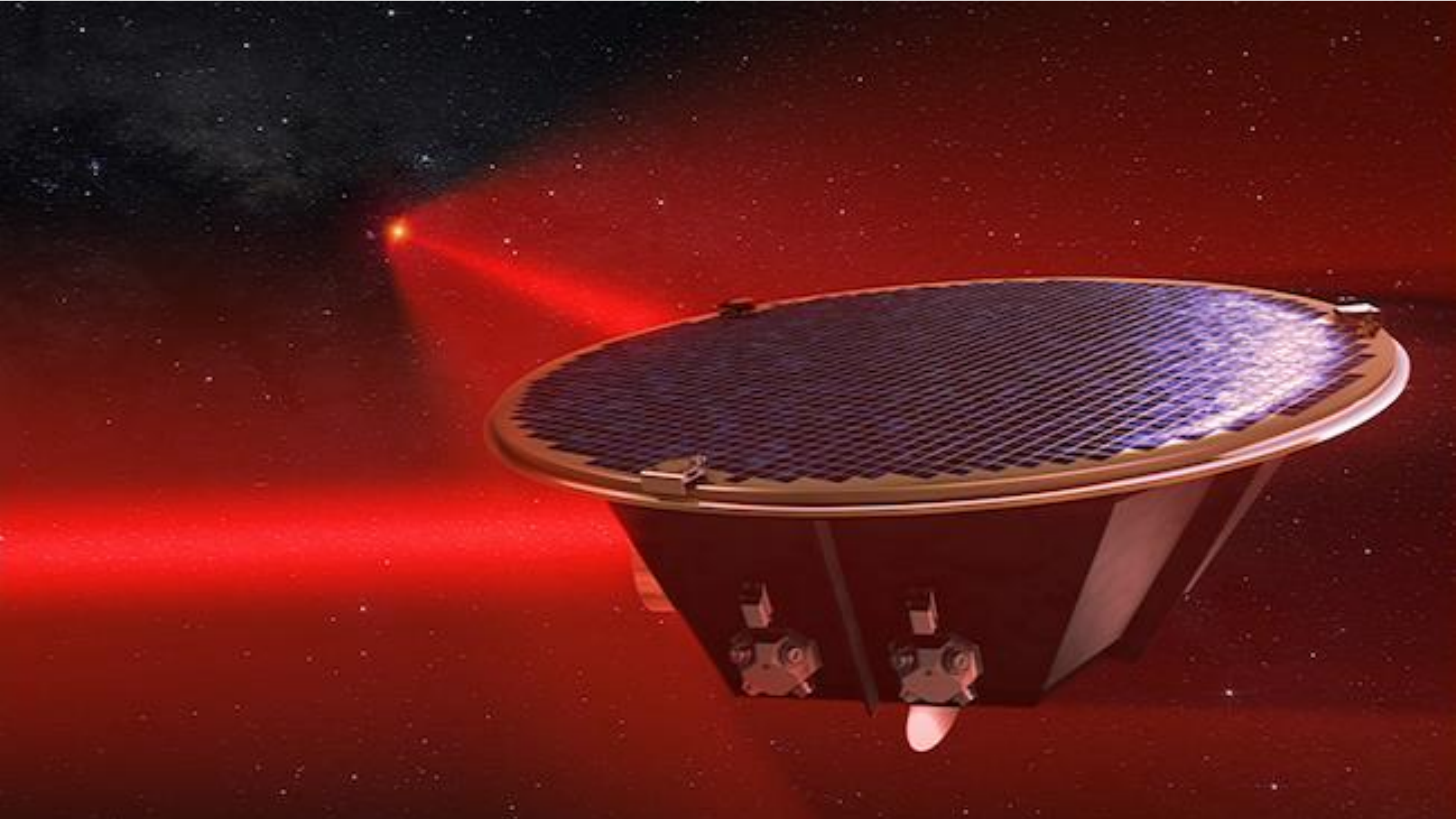
Interferometry in the detection of G waves

- Test masses are set at a large distance from each other, the large distance helps make any change in their distance be large enough to measure. The masses are then shielded from all disturbances except gravity, which we cannot shield against.
- Then lasers make continuous measurements of the distance between each of the test masses. The masses are free to move in response to gravity so that when a gravitational wave passes, space-time stretches and the time it takes light to travel between the masses changes.


Basic Michelson
Interferometer with 4 km
Fabry Perot Cavities
Mirror
4 km
Fabry Perot
cavities
Mirror
4 km
Laser
Mirror
Mirror

Basic Michelson Interferometer with 4 km Fabry Perot Cavities and Power Recycling mirror





What can we learn by understanding the nature of gravitational waves