The development of a cryogenic accelerometer for KAGRA

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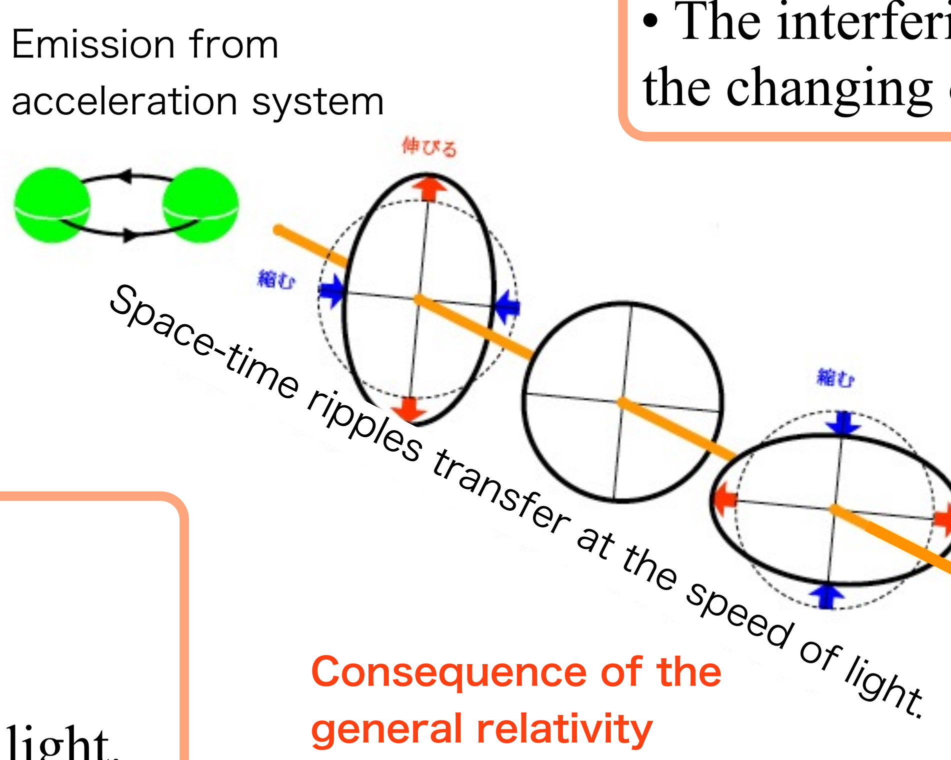
1.Abstract

The Large-scale Cryogenic Gravitational Wave Telescope named KAGRA is under construction in the Kamioka mine. In the final stage some mirrors of the interferometer will be cooled down to 20K in order to decrease the thermal noise which limits the detector sensitivity around 100Hz. Each of these mirrors is surrounded with a radiation shield which interferes with income of 300K radiation and connected with this shield to be cooled. The mirror motion caused by this radiation shield can be large noise for gravitational wave detection. To investigate this effect we will measure the vibration of the radiation shield during its cooling test. The cryogenic accelerometer which we are developing is based on a Michelson interferometer. The measured results of grand motion with this accelerometer are consistent with that of a commercial accelerometer (RION). The cooling test of the accelerometer is now in progress.

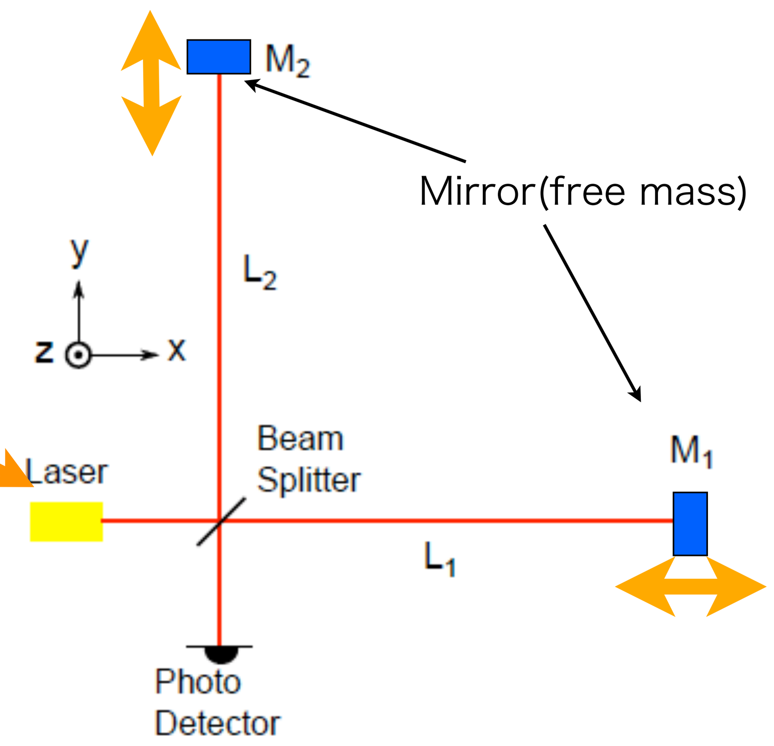
2.Gravitational wave and detector

Sources of gravitational wave:
- Nutron star merger
- Supernova
- The early universe
- Etc

Gravitational wave:
- Propagation of space-time ripples
- Directly detection is not yet
- The transmittance is higher than that of light.



Gravitational wave detector:
- Laser interferometer is the main detector type in the current world.
- The interfering light changes during the gravitational wave passing because of the changing of the length of light path.



Detector noise:
- Seismic noise
- Quantum noise
- Thermal noise
- Etc

KAGRA

The Large-scale Cryogenic Gravitational Wave Telescope

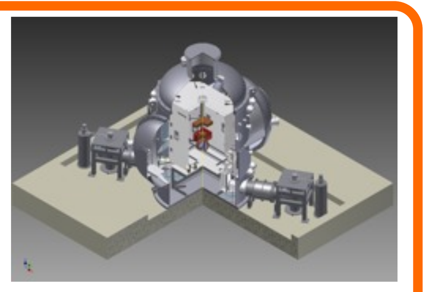
3.KAGRA

The Large-scale Cryogenic Gravitational Wave Telescope: LCGT

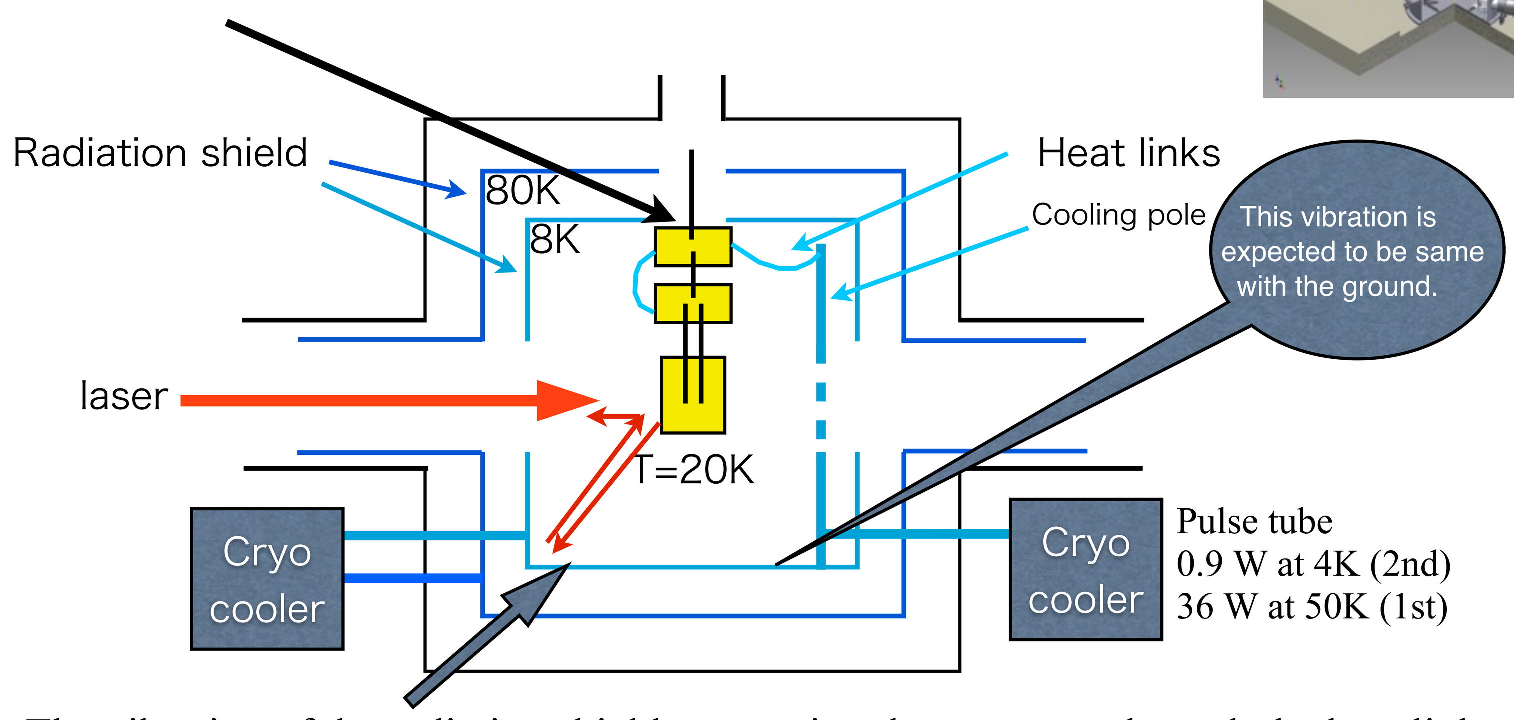
Purpose:
Detection of gravitational waves and construction of the gravitational wave astronomy

Predominant feature:
- Large-scale interferometer (3km)
- Very low seismic vibration (100 times better than Tokyo)
- Seismic Attenuation System
- Cryogenic payload
- Etc

4.Cryogenic payload



Cryogenic payload: cooled suspension system and mirror



The vibration of the radiation shield may swing the test mass through the heat links.
The scattering laser may be reflected by the shield and recombine into main laser.

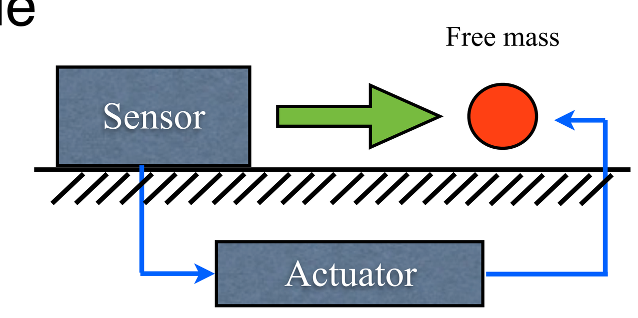
➡ We are developing an accelerometer which work at cryogenic temperature.

5.Cryogenic accelerometer

Purpose:
Measuring the vibration of the radiation shield of KAGRA during cooling test

Requirement for the cryogenic accelerometer:
- Noise level ~ 10^{-9}m/rtHz@10Hz
- Work at low temperature (~10K)
- Work at Ultra High Vacuum (~10^{-7}Pa)

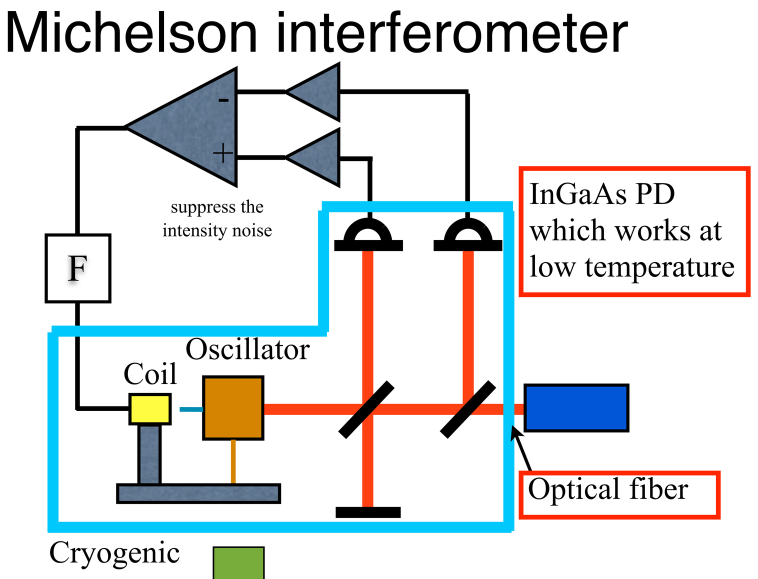
Principle

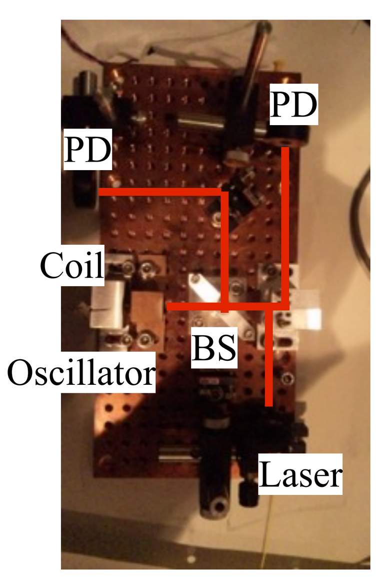


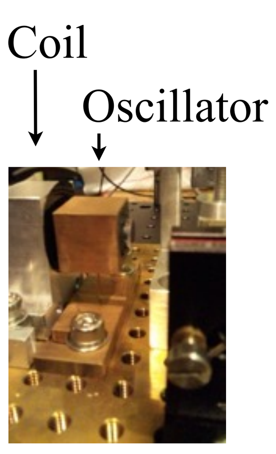
This force is the same as the inertial force.

➡ We can evaluate the seismic vibration.

Accelerometer based on a Michelson interferometer



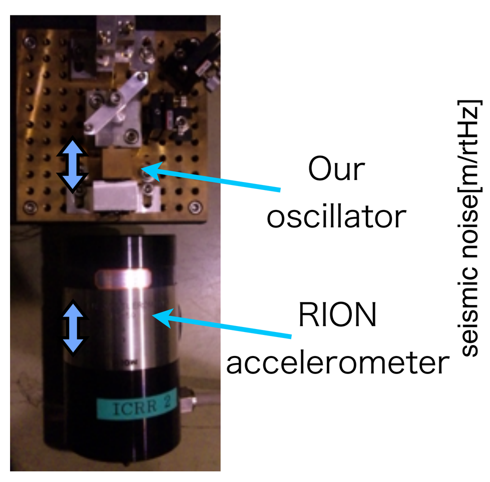


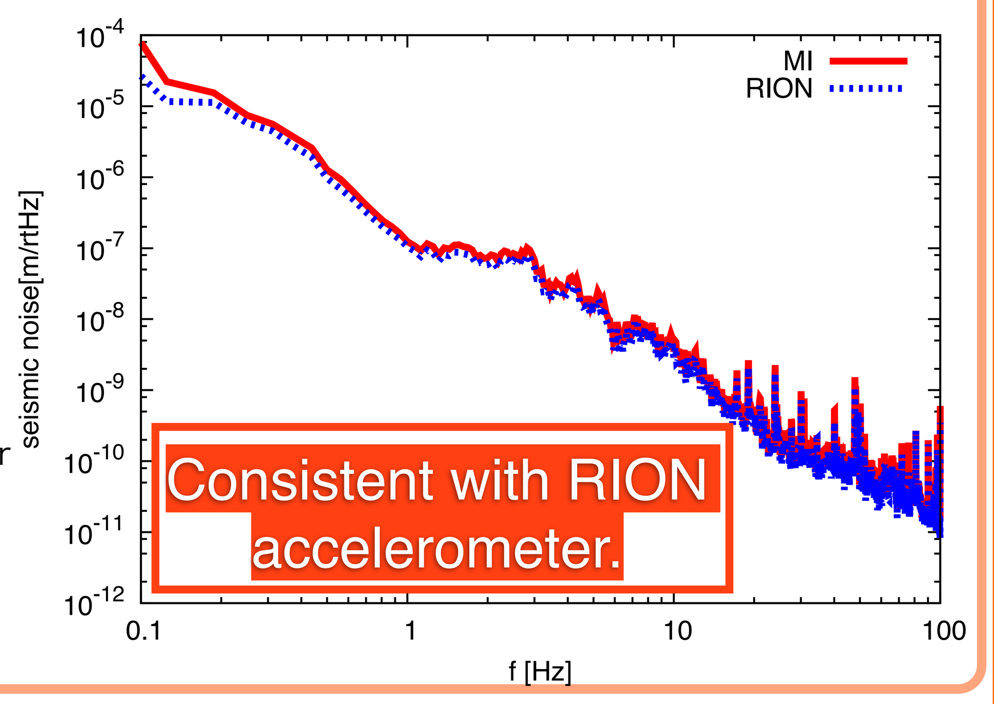


The oscillator is a kind of inverted pendulum.

Measurement test under room temperature

We had a coincidence measurement test with RION accelerometer which is a commercial one.





Cooling test of the accelerometer

The cooling test of the accelerometer is now in progress.

6.Summery and future works

Some of the mirrors of the gravitational wave detector KAGRA is surrounded with radiation shield to be cooled and connected with this shield. Because the vibration of the radiation shield can swing the mirror, we are developing a cryogenic accelerometer to measure the vibration of the radiation shield. We have already tested the accelerometer at room temperature. The measured results of grand motion with this accelerometer are consistent with that of a commercial accelerometer (RION). Before measuring the vibration of the radiation shield, we should have a cooling test of this accelerometer. The cooling test of the accelerometer is now in progress.

22nd Feb. 2013 ICRR student meeting