Current status of KAGRA
Cryogenic

K. Yamamoto and KAGRA collaboration

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0. Abstract

KAGRA: First km-scale cryogenic interferometer

It is being constructed now!

Progress for cryogenic system of KAGRA in the last one year
Contents
1. Introduction
2. Cryostat
3. Cryocooler unit
4. Cryogenic payload
5. ELiTES
6. Future Plan
7. Summary
1. Introduction

KAGRA (previously known as: LCGT)

2nd generation interferometer in Japan

Key feature of KAGRA project

Cryogenic system: Reduction of thermal noise

I will explain the progress for cryogenic system in the last one year.

Now, the first km-scale cryogenic interferometer is being constructed!
1. Introduction

Outline of cryostat and cryocoolers
Four mirrors of arm cavity will be cooled.

Vibration isolation system, Cryostat, Cryocooler, Cryogenic payload
1. Introduction

Outline of cryostat and cryocoolers

Cryostat

Vibration Isolation (Type-A)

Cryogenic payload

Mirror

14m in height

Cryostat

PTC units

S.Koike
2. Cryostat

1. Outline

Cryostat
Stainless steel t20mm
Diameter 2.6m
Height ~3.6m
M ~ 10 ton

Cryo-coolers
Pulse tube, 60Hz
0.9 W at 4K (2nd)
36 W at 50K (1st)

4 Low vibration cryocooler unit

Remote valve unit

Main LASER beam

View ports

Mirror

Cryogenic payload
2. Cryostat

2. Photos (Main body)

Main body (Φ2.4m, H3.8m) at Toshiba Keihin Factory
Cryostat Bottom plate SUS 304 t70

Daiwa Shearing Kasuga Factory

Toshiba Keihin Factory
Cryostat Service port flange, side cap and tube

Shimoda Flange Aioi Factory

Flange \( \phi 2200 \)

Side cap \( \phi 1970 \)

Toshiba Keihin Factory

Tube \( \phi 1970 \)
Cryostat components

Ribs inside cryostat

Welding on the connection port

Pipes

Connection port to cryocooler unit

Toshiba Keihin Factory
3. Cryocooler unit

1. Outline

Class. Quantum Grav. 21 (2004) S1005–S1008

Pulse tube cryocooler (Sumitomo Heavy Industries)

Vibration reduction system

Figure 3. Vibration-reduction system we have been developing for the PT cryocooler.
3. Cryocooler unit

2. Photos at Jecc Torisha Kawagoe factory

Work progress in clean room with JIS class 7 (US class 10000)
3. Cryocooler unit

3. Photos

Assembling in Jecc Torisha Kawagoe factory

- 80K thermal conductor
- 8K thermal conductor
- Vespel support rod
3. Cryocooler unit

4. Cooling test: Cryocooler works well.
3. Cryocooler unit

5. Vibration test
3. Cryocooler unit

5. Vibration test

Displacement sensor
3. Cryocooler unit

5. Vibration test

Results is comparable with CLIO. But, improvement is necessary…
3. Cryocooler unit

5. Vibration test

Rigidity of stage will be enhanced.

Parts to fix radiation shields will be installed.
4. Cryogenic payload

1. Outline

- Sapphire fiber
- Sapphire mirror (About 20K)
- Shield (8K)
4. Cryogenic payload

2. How to develop

(1) Experiment of 1/4 cryostat
   in ICRR to check (prototype) payload
   1/4 means number of cryocooler, not size.
   (a) How to assemble and install
   (b) Cooling test
   (c) Control and damping

(2) Other R&D
   Sapphire fibers to suspend mirror,
   External vibration via heat links
   (details are in T. Sukiguchi talk in Tuesday
   and K. Yamamoto talk on Thursday)

and so on...
4. Cryogenic payload

3. 1/4 cryostat
Cryocooler has already arrived at ICRR!
4. Cryogenic payload

3. 1/4 cryostat
Design of 1/4 cryostat is in progress.

Preliminary.
5. ELiTES

ELiTES: ET-LCGT interferometric Telescope Exchange of Scientists
Grant for collaboration about cryogenic between KAGRA and ET

European people can visit Japan for KAGRA.
5. ELiTES

ELiTES consists of four Working Packages.

WP1: Cryogenic payload (E. Majorana)

WP2: Cryogenic mirror (R. Nawrodt)

WP3: Cooling system (K. Somiya)

WP4: Organization
5. ELiTES

Kick off meetings of WP1 and 2 have already been held (WP3 meeting coming soon).

Teleconference every month

General meetings in Japan and Europe

First visitor from Europe : This autumn

Informal meetings are during this GWADW !
6. Future plan

Mar. 2013: All cryostats and all cryostats units are assembled.
1/4 cryostat arrives.

Apr. 2013 - Sep. 2014: Experiment of 1/4 prototype

Jul. 2015 - Dec. 2016: Installation and test of cryogenic payload in Kamioka mine


Apr. 2018 - : Tuning and observation
7. Summary

Cryostats and cryocooler units are assembled and tested now (until Mar. 2013).

Development of cryogenic payload is in progress.

1/4 cryostat: Prototype test
Payload should be prepared by Mar. 2015.


We proceed with construction of first km-scale cryogenic interferometer vividly.
Thank you for your attention!
2. Cryostat

2. Drawing by Toshiba
Toshiba starts to make our cryostat.

Cryostat (cryochamber)
2. Cryostat

2. Drawing by Toshiba

Cryostat (radiation shields)
2. Cryostat

3. Photos

Ribs inside cryostat

Welding on the connection port

Pipes

Connection port to cryo-cooler unit

Main body (Φ2.4m, H3.8m)

Photos by T.Suzuki

at Toshiba Keihin Factory
4. Cryogenic duct

1. Outline

**Cryogenic ducts** are along optical axis and next to cryostat.

17 m in length, 0.9 m in diameter, **Baffles** to prevent propagation of 300 K radiation
4. Cryogenic duct

2. Design: in progress

Details: K. Yamamoto talk tomorrow afternoon
4. Cryogenic payload

4. Other R&D items
   (a) How to suspend mirrors using sapphire fibers
   (b) Vertical spring in cryostat
   (c) Development and test of sensors, actuators, motors in cryostat
   (d) Thermal noise (Q measurement of wires and coating and so on)
   (e) Seismic noise, external vibration noise (vibration of shield, transfer function of heat link)
   (f) Baffles for scattered light
3. Cryocooler

5. Vibration test