

Report on the scientific activities

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Activities

Five secondments in **Japan** and one in **Germany**:

1. 27/06/2018 - 14/07/2018: ICRR (*The University of Tokyo*)
2. 15/09/2018 - 30/09/2018: ICRR (*The University of Tokyo*)
3. 01/12/2018 - 15/12/2018: ICRR (*The University of Tokyo*)
4. 14/04/2019 - 22/04/2019: ICRR (*The University of Tokyo*)
5. 24/06/2019 - 30/06/2019: Impex Hightech Gmbh (*Münster, Germany*)
6. 17/07/2019 - 28/07/2019 ICRR (*The University of Tokyo*)

Collaboration

- **ICRR**: located in the Kashiwa-noha Campus (*The Tokyo University*), ICRR is one of the funding institutions of the KAGRA observatory. The group is mainly involved in the development and characterization of the KAGRA payload at cryogenic temperature.
- **IMPEX HIGHTECH GmbH**: the company head office is located in Munster (*Germany*) but the operative core is in Armenia. The company has developed and produced the main parts for the silica monolithic suspension of Virgo experiment and the sapphire parts for Kagra monolithic suspensions.

Secondment topic

(ICRR 27/06/2018 – 14/07/2018)

4th Kagra International Workshop, Seoul
(Chorea) – 27-30 June 2018

Poster on the development of a cryogenic
accelerometer based on a new paradigm

ICRR, The Tokyo University, 1-14 July 2018

Assembling of the first prototype of a silicon
cryogenic suspension for the 3rd generation of
GW detectors.

Low temperature performances of UNISA monolithic folded pendulums for the next generations of interferometric detectors of gravitational waves

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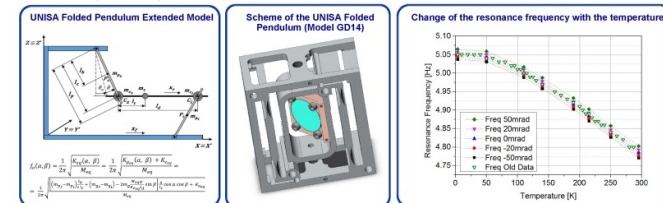


GOAL: First evaluation of the performances of the UNISA Folded Pendulum class of sensors at cryogenic conditions, for understanding advantages and limitations as sensors for measurement, control and alignment of interferometric detectors of gravitational waves of the third generation.

SENSOR: For the tests a standard UNISA Folded Pendulum – Model GD14 (size: 8 cm x 8 cm x 4 cm, weight: 200 g, material: Al 6062-T6 - Anticorodal), developed for seismic measurements and equipped with a standard one-inch mirror (to improve an optical level acquired by a shadow-sensor), has been positioned within a suitably modified cryostat of the INFN Perugia, adapted to avoid unwanted recoil losses.

TECHNIQUE: The cryostat temperature was reduced in steps, allowing the sensor stabilization in temperature. At each step the pitch angle was changed and the frequency and the loss angle (and, consequently, the quality factor, Q) were measured.

PERFORMANCES: The tests show the relevant decrease of the loss angle ($\Phi \approx 1.4 \times 10^{-5}$) of the oscillator at low temperatures (4K), corresponding to a quality factor, Q \approx 70000 at the folded pendulum resonance frequency (5 Hz). This result opens a yet unexplored application field for applications to the third generation of gravitational waves interferometric detectors.



CONCLUSIONS

- Cryogenics is not a limit for the sensor indeed its performances improve at very low temperatures: a loss angle $\Phi \approx 1.4 \times 10^{-5}$ has been measured at a temperature ($T = 4K$) for a resonance frequency $f_0 = 5$ Hz. This measurement corresponds to a quality factor $Q \approx 70000$.
- The material is the main limit of sensor performances: new material with lower losses (e.g. Al5056) maybe only for the joints (stress totally confined in the elastic joints).
- The sensor is easily scalable/flexible that means that it is possible to optimize its main parameters (mass, resonance frequency, dimensions) taking into account its use, environment and position.

NEXT STEPS

- to characterize the same sensor with a lower resonance frequency (~ 0.1 Hz) (resonance frequency)
- to characterize the smallest sensor (mass, dimensions, resonance frequency)
- to produce and characterize prototypes with new materials (Q)

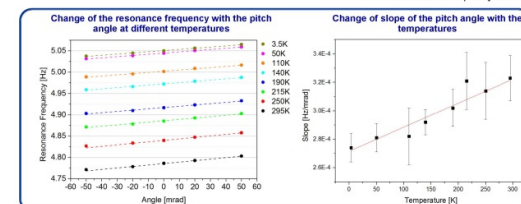
ALTERNATIVE RESULT

A positive counterpart of this analysis is that the sensor proved to be an excellent system for the study of materials. Due to its peculiarities, with measurements of frequency and loss angle, it is possible to extrapolate:

- Young's modulus (Freq vs Temp)
- Thermal conductivity (Freq vs Time to thermalize)
- Pre-stress effects (Angle at rest, oscillating mass)
- Internal losses (Phi vs Temp)

ACKNOWLEDGMENTS

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Secondment topic

(ICRR 15/09/2018 – 30/09/2018)

Payload

Suspension of a silicon substrate through a Cu-Be wire (*cradle configuration*) in a cryostat for its characterisation

Read-out system

Installation of a Michelson interferometer for the mechanical quality factors measurements at cryogenic temperature



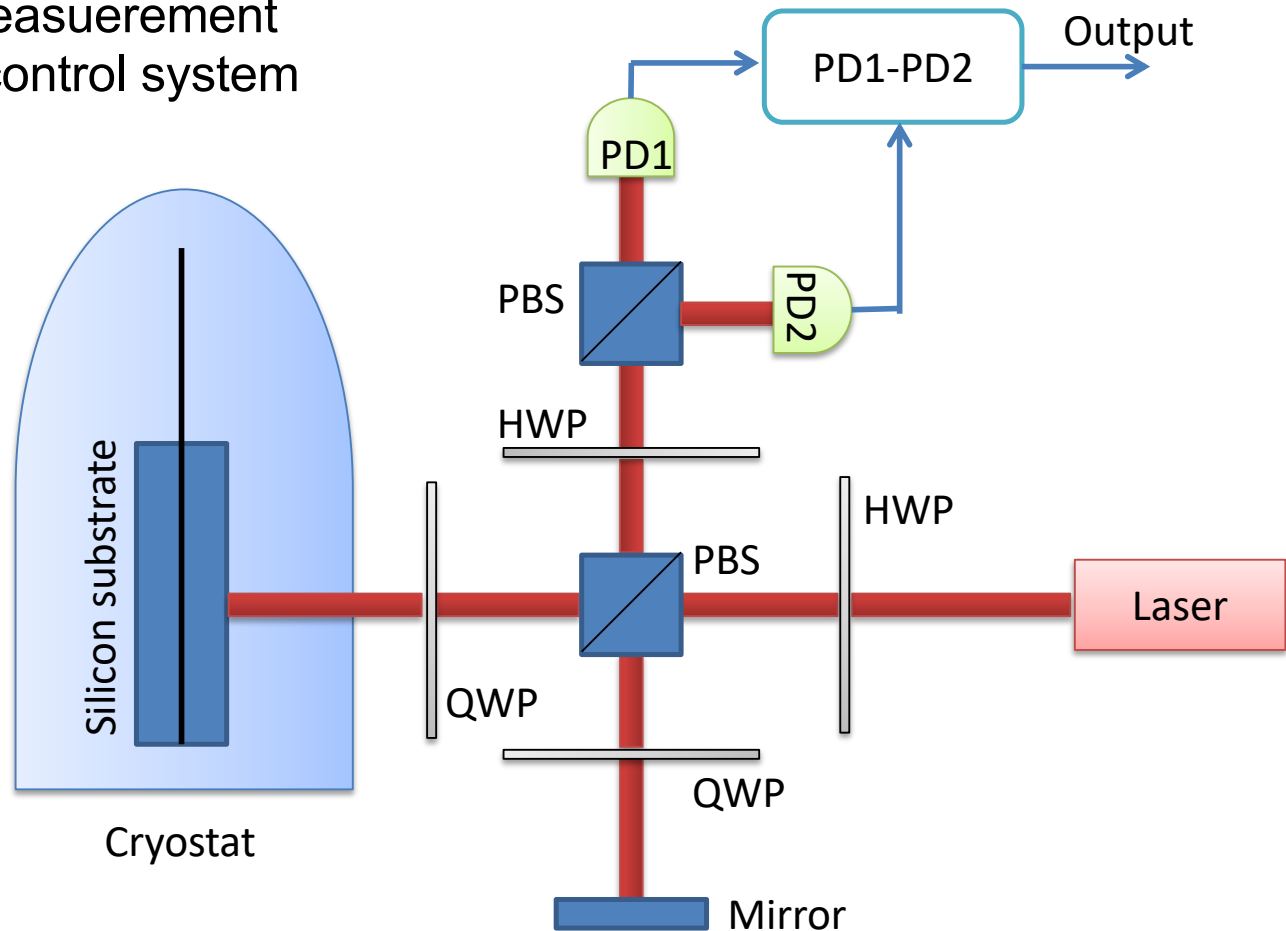
Secondment topic

(ICRR 1/12/2018 – 15/012/2018)

Homodine system

Installation and test of a homodine system for a more sensible Q measurement system and for a future control system

During our stay, we had the chance to participate to the [21st Kagra F2F meeting](#) held in NAOJ from 5th to 6th December 2019)



Secondment topic

(ICRR 14/04/2019 – 22/04/2019)

22nd Kagra F2F meeting

The meeting was held at ICRR from 19 to 21 April 2019 giving us the chance to work on the silicon suspension activities and to talk with other partners of the collaboration about the ongoing experiment

ICRR activities

Before and during the meeting, we discussed the noise induced by the pumping system on the suspended substrate



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noise

Secondment topic

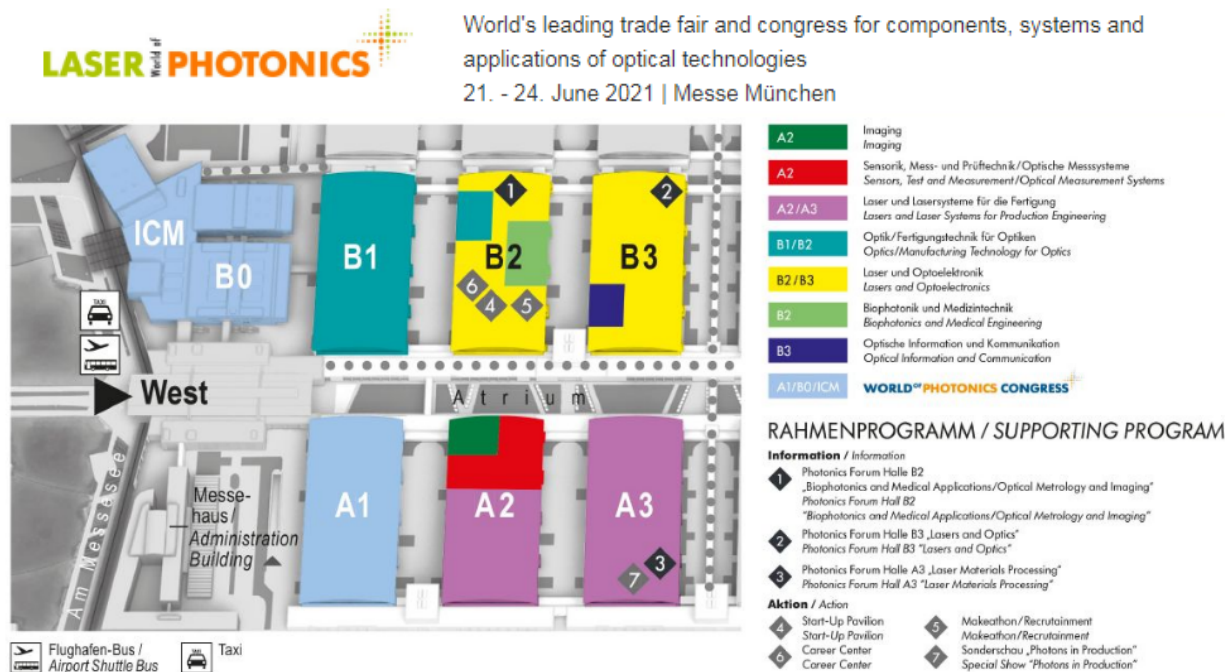
(ICRR 24/06/2019 – 30/06/2019)

Laser World of Photonics Congress

The fair was held in the old city airport: the Impex Hightech GmbH company had a booth where was possible to talk with companion companies as well!

Impex

After the participation to the fair, it was possible to visit the head office of the company at Munster, talk with the Armenian producer and discuss on the possibilities to machine silicon fibers with two “head”

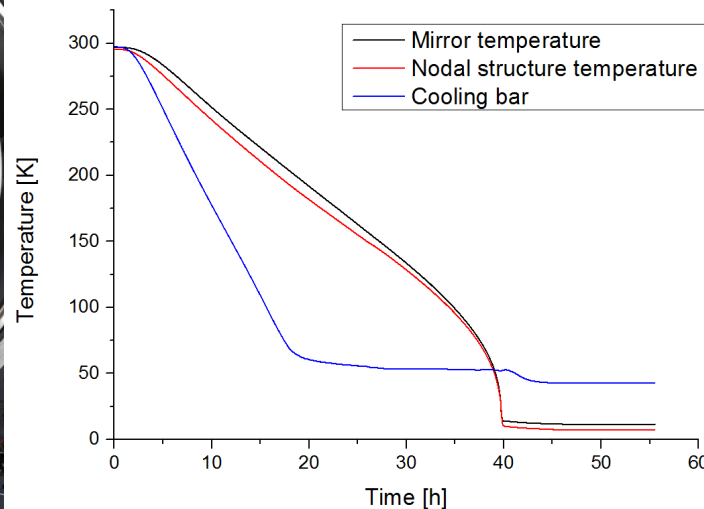
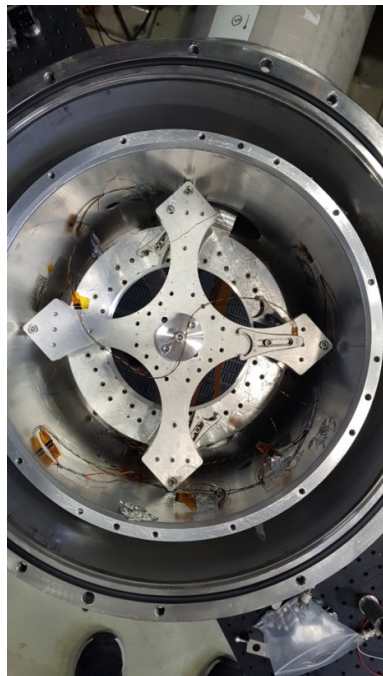
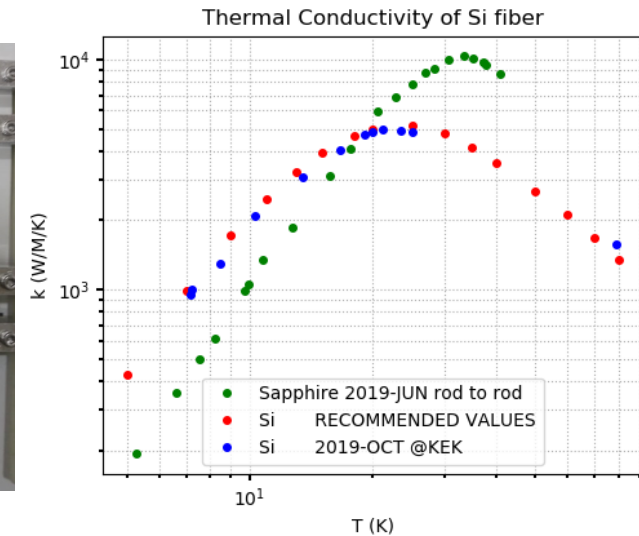
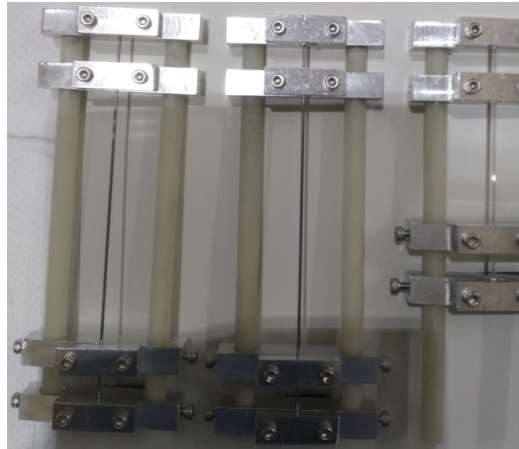


Secondment topic

(ICRR 17/07/2019 – 28/07/2019)

Nodal system for substrates

A nodal system for thick substrate was developed and installed in the cryostat at ICRR: the cooling down efficiency was measured



Fibers Thermal conductivity

Three monocrystalline silicon fiber were installed into a cryostat in KEK to measure silicon thermal properties at cryogenic temperature and to see if there is any relevant difference due to the quality of the surface, the dopant and so on