Characterization of Cryogenic Suspension in KAGRA

Masahide Tamaki [A,B,*], Takafumi Ushiba [B], Koseki Miyo [B], Takayuki Tomaru [C], Ryutaro Takahashi [C], Shinji Miyoki [B]

*Phys. S. U. T [A], ICRR [B], NAOJ [C] * tamaki83@icrr.u-tokyo.ac.jp*

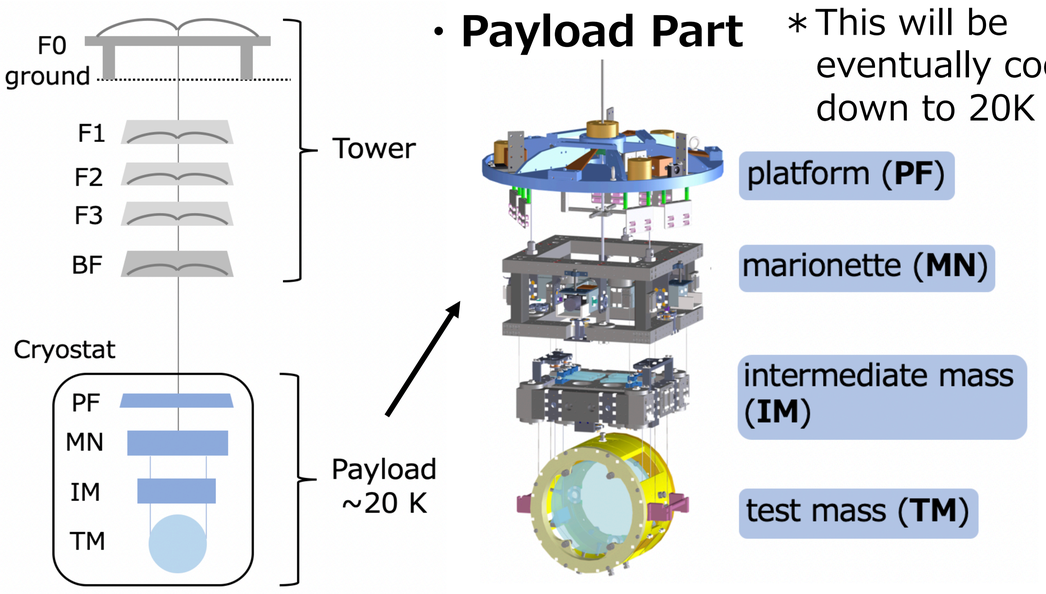
Abstract

Cooling of cryogenic suspension (Type-A Payload), is in progress and the current temperature of ETMX (the coolest suspension now) is roughly 80 K. Then we compared how the transfer function Q-value and photosensor counts changed compared to their values at room temperature (for MN and IM). In this poster, the results of the comparisons and the discussion on them are reported.

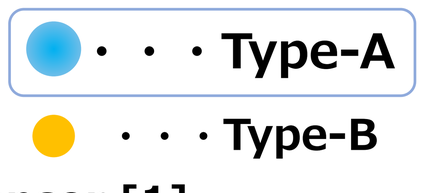
Overview of Cryogenic Suspension

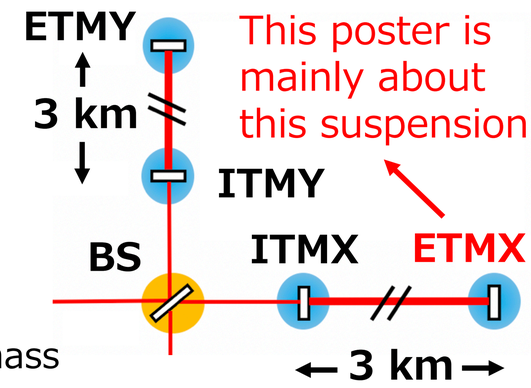
・**Type-A Suspensions**・・・for sapphire mirrors

・**Payload Part**　＊This will be eventually cooled down to 20K

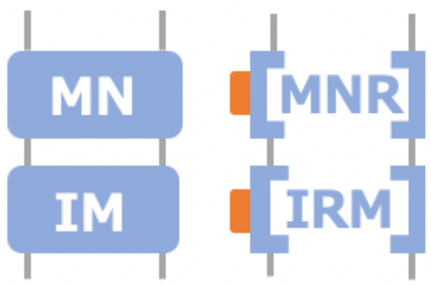


・**Type-B Suspensions**・・・for silica mirrors

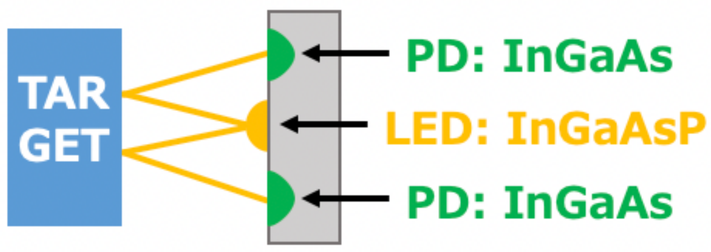




・**Reflective Photosensor [1]**



Attached to MN Recoil mass and IM Recoil mass.
6 sensors are mounted on each stage (corresponding to the rigid body 6 DOFs).

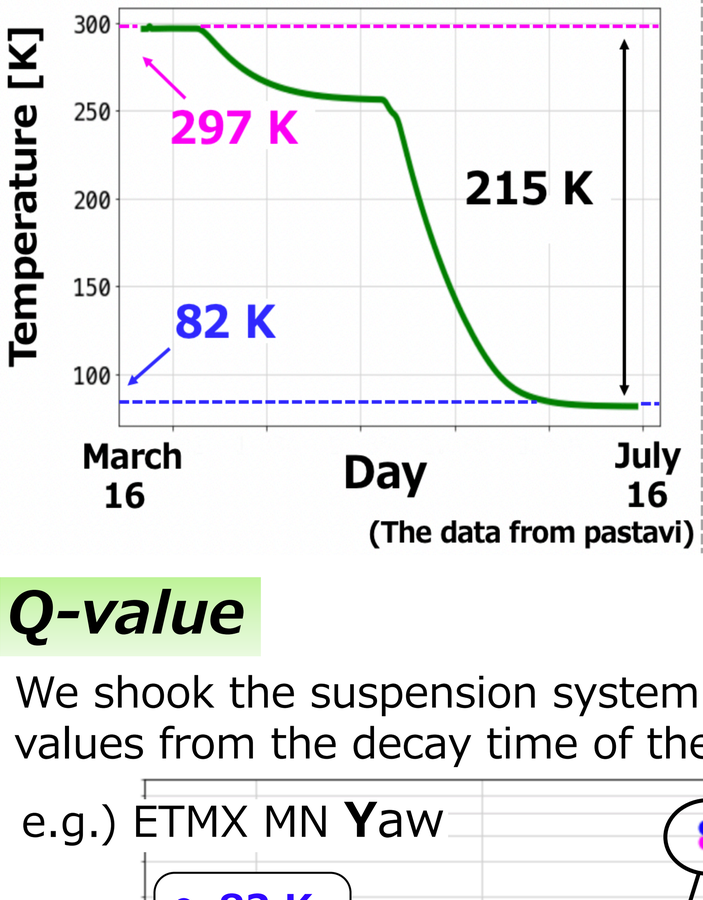


← How the sensor works

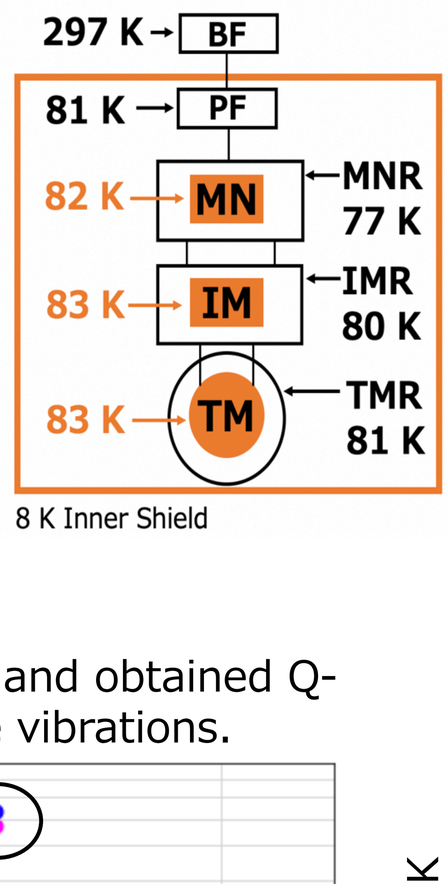
Relative displacements of MN, IM and their facing recoil masses are read

Temperature Change

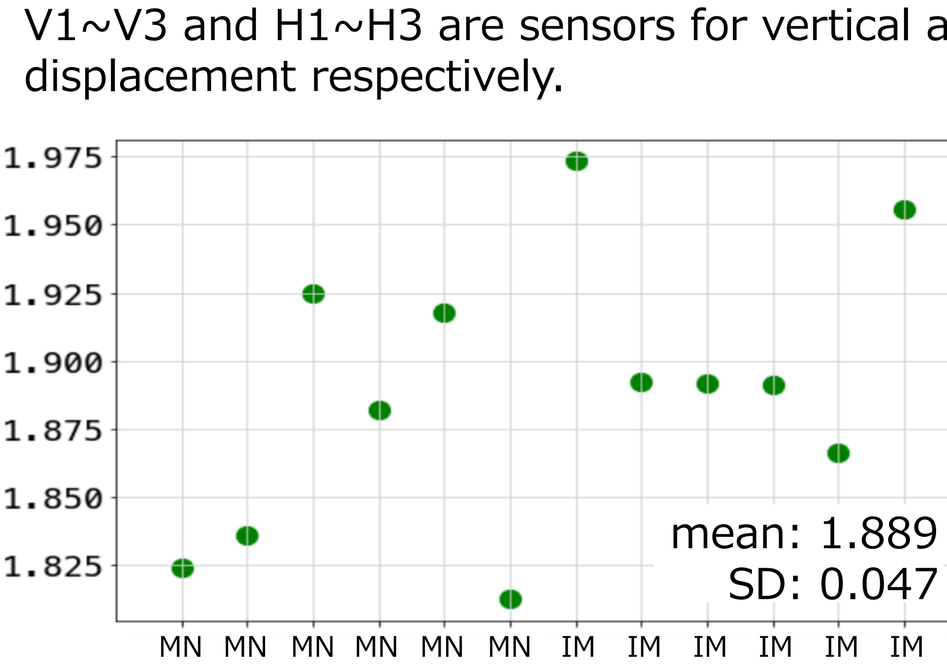
e.g.) ETMX MN



ETMX
(Current Temperature)



Transfer Function (ETMX MN Yaw)



Resonance Modes

Mode 1:
0.297 Hz → 0.305 Hz

Mode 2:
1.665 Hz → 1.669 Hz

Mode 3:
3.125 Hz → 3.135 Hz

Mode 4:
4.083 Hz → 4.152 Hz

Q-value

We shook the suspension system and obtained Q-values from the decay time of the vibrations.

e.g.) ETMX MN **Y**aw

At these modes, sapphire fiber (high Q at low temperature) has a significant effect (Mode2: 2nd TM-chain, Mode3: 2nd RM-chain)

Photosensor's Output

Sensor outputs (OSEMINF_OUT_DQ) at 77 K (MNR) or 80 K (IMR) were compared with the value at 297 K.
V1~V3 and H1~H3 are sensors for vertical and horizontal displacement respectively.

The graph on the left shows how many times the output of the sensor increased at low temperature (MNR: 77 K, IMR: 80 K) compared to room temperature.

Discussion and Future Works

- Resonance friequecies and gain of TF became larger by cooling.
- Higher Q-values were observed as expected at the modes where the sapphire fiber's influence is stronger.
- We don't know why photosensor's count increased at low temperature, so we will consider it.
- We intend to carry out similar characterization on other CRY suspension (EY, IX, IY)systems that are about to start cooling.

References

[1] S. Fukunaga "Development and application of cryogenic displacement sensors towards the damping control of KAGRA cryogenic payloads", Master Thesis, University of Tokyo (2019)