Control Noise Reduction for Cryogenic Suspension in KAGRA KAGRA

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Solution

Result



KAGRA : Gravitational Wave detector with Laser Interferometer Unique Feature : Cryogenic Suspension for high sensitivity

Pendulum-type Suspension system For high vibration isolation ratio, but vibration is amplified at resonant frequency

2. About Cryogenic Suspension

Cryogenic Payload : 4-stage pendulum [1]

- Cool the mirror down to 20 K for thermal noise reduction
- High vibration isolation at high frequency to reduce



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Problem

the effect of ground vibration (5 more pendulum stage in upper section)

• Equipped with sensor & actuator for control



KAGRA Sensitivity in O3GK [2]



Mass

Filter

Low noise control

filter for observation

We designed low noise control

4. Noise Reduction



Switching control based on interferometer phase

* Several steps must be taken before the interferometer can be moved to the observation phase

Control

Observation-Ready Phase

Control focused on suppression of disturbance

- Control the position and posture of the mirror to make it observable asap
- The last observation was conducted with this control

5. Results

Observation Phase





e.g.) ITMX MN Pitch Open Loop TF

Frequency [Hz]



6. Outlook for Less Control Noise



Result Control noise was reduced by 2~3 order of magnitde • We could reduce the

control noise below the target sensitivity in O4 with OBS filter Improvements are needed to reach the final target sensitivity

New Control Scheme

Develop optimal control based on numerical simulation

• For example...

Decompose the pendulum vibration into modes and perform the control according to the shape of the modes \rightarrow suitable for multi-stage pendulum

7. Reference

[1] T. Ushiba *et al.*, Class. Quantum Grav. **38** 085013, (2021) [2] H. Abe *et al.*, PTEP, (2022)

New Cryogenic Sensor

Local Control update

We need cryogenic sensor with higher performance

• High sensor performance is essential for low-noise control

 Also critical for next generation GW detector \rightarrow cryogenic operation like KAGRA