2009-08-13

SPI 特別作業部会

SPI 関連の問題点の整理

問題の根源	設定値	関連事項
* weak test mass actuator	3 nm /f^2 /V	driver noise of 1 nV/sqrt(Hz)
* high finesse cavity	1250 (1550)	laser power through ITM is limited by cooling capability
* Insufficient SAS performance	1.0-1.3 um RMS in displacement 0.13-0.34 um/s RMS in velocity	30 nm of actuator range impulse limit 32 nm/s ringing velocity 53 nm/s
* No damping in heat links	??? um RMS in displacement ??? um/s RMS in velocity	

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Test mass actuator の設計変更

* weak test mass actuator	3 nm /f^2 /V	driver noise of 1 nV/sqrt(Hz)

Such a naive actuator is out-of-date.

For lock acquisition
75 nm /f^2 /V

switching →

For steady operation
75 nm /f^2 /V + (pole 1Hz, zero 5Hz)^2
Above the 5Hz region, driver noise contribution can keep same level.

* Insufficient SAS performance	1.0-1.3 um RMS in displacement	750 nm of actuator range
	0.13-0.34 um/s RMS in velocity	impulse limit 160 nm/s
		ringing velocity 53 nm/s

--> improve, but not enough.

Can Alternative Lock Techniques solve the problem?

* Insufficient SAS performance	1.0-1.3 um RMS in displacement	750 nm of actuator range
	0.13-0.34 um/s RMS in velocity	impulse limit 160 nm/s
		ringing velocity 53 nm/s

* Green Lock (low finesse 100)		
	not enough	750 nm of actuator range
	will solve (*)	impulse limit 400 nm/s
	can solve	ringing velocity 4175 nm/s
* Guide Lock		
	not enough	750 nm of actuator range
	may solve (**)	extrapolation limit 7500 nm/s
	may solve	ringing velocity 53 nm/s

* In reality, about a half of impulse limit is a critical velocity to success the lock acquisition.
Therefore, it is no margin or is hard to lock when large micro-seismic motion is occurred.

** To success the guide lock, it is suitable that the mirror motion is dominated by pendulum resonance. In this situation, it is easy and is proper to extrapolate the mirror motion with uniform velocity assumption. If not, it is hard to assure of its performance.

--> Cannot solve!

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Test Mass Displacement への要求値

Test Mass Displacement への要求値
*** 75 nm RMS** <-- feedback signal is set to be 1 volt RMS

SAS の性能が良くない？
--> 少なくとも他の自由度や、制御設計なども含めた議論が必要。
CLIO-TAMA 3ヶ月 study でもレポートしたように防振系の設計の遅れは深刻。
一連の特別作業部会が終了したら、防振作業班は特別部会に昇格させて半年くらいの集中検討が必要。

integral interval	[0.01-4 Hz]	[0.1-4 Hz]	
RMS in displacement	1.0-1.3 um	0.023 - 0.27	um
RMS in velocity	0.13-0.34 um/s	0.030 - 0.30	um/s

good (0.023 / 0.030)
when micro seismic is large not enough (0.27 / 0.30)

SPI で解決可能？

SPI でなければならないか？

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The necessity of heat link damping

*** No damping in heat links**	**??? um RMS in displacement** **??? um/s RMS in velocity**

Eddy current damping (passive damping)
低温部は、冷却により数 mm 単位で縮むので eddy current damping のような gap を mm 単位で維持しないといけないという要求は厳しい。また永久磁石の磁力が温度で変化することも分かっているので室温での干渉計調整から冷却への移行を考慮すると実用的な問題が多い。

Active damping (1) : by displacement sensing with reference to the inner shield (cryostat) or something inside the cryostat.

Active damping (2) : by inertial sensor

Active damping (3) : local SPI / with reference to something outside the cryostat.

いずれにせよ、もっと具体的な低温部の構造（メインの防振系＋ヒートリンク系）が決まらないと定量的な議論にならない。

--> 剛体モデル以前の問題である。

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The necessity of Green Lock

*** SPI があれば、Green Lock は不要か？**

Deterministic lock を実現するには不可欠。

この問題の結論を SPI 特別作業部会レポートに盛り込むか否か。

盛り込むなら

Feasibility:
- Cavity design
- Coating design
- Fiber induced phase noise cancellation
- Total system design

Cost estimation: