Definitions for the DRMI commissioning

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Yutaro Enomoto, Yuta Michimura and Kiwamu Izumi

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1 Purposes of the commissioning test

The Dual-Recycled Michelson Interferometer (DRMI) is one of the critical building blocks for running the full KAGRA interferometer. The main purposes of the DRMI commissioning are (1) to demonstrate that a resonance of the DRMI can be robustly acquired by using the digital feedback control system, and also (2) to demonstrate that we can reproduce almost the same interferometer alignment condition which is sufficient to proceed with the subsequent full lock sequence.

Additionally, the definition of the DRMI configuration in this document is written in section 4 in order to avoid confusions.

2 Goals of the commissioning test

The below shows a list of goals that we are aiming to achieve during the DRMI commissioning period. They are listed in the order of the importance – the very top item has the highest priority.

The derivations and reasoning for the quantities are described in section 5 in great detail.

1. Keeping all three length degrees of freedom in the DRMI locked **for a duration longer than 30 minutes continuously** using the standard Pound-Drever-Hall and Schnupp readout schemes

2. The same as above but with the use of **the third harmonic demodulation** signals.

3. Development and implementation of an initial alignment process. After

this process, the interferometer alignment must be good enough so that **the DRMI acquires lock within a waiting time of 10 minutes**. This must be experimentally evaluated several times.

4. Holding the locked DRMI with a global alignment control system engaged using the wavefront sensors **for a duration of longer than 2 hours continuously**. The length control can be done either by using the standard 1f or 3f signals. **We do not make specific requirement values for the residual angular fluctuations**.

5. Full automation of the acquisition and initial alignment processes.

6. Production of the calibrated- and unsuppressed- displacement monitor channels for all three length degrees of freedom in the digital system.

7. (OPTIONAL) Control of the Michelson degree of freedom in the carrier-resonant power recycled Michelson interferometer confuguration.

3 Parameters to be measured

We will measure several key parameters. The parameters are divided into two different categories; the primary and optional parameters. The primary ones are those we must measure while the optional are those we may measure depending on the progress in the commissioning activities.

3.1 Primary parameters

- Power recycling gains for the f1 and f2 sidebands with and without the signal recycling cavity.
- Sensing matrix for the length signals including the standard demodulation and the third harmonic demodulation signals.
- The power recycling gain for the carrier field.
- The macroscopic length of the power recycling cavity[2].
- Sensing matrix for the angular sensing.

3.2 Optional parameters

- The size of the Schnupp asymmetry.
- The cavity round trip Gouy phase of the power recycling cavity.
- The cavity round trip Gouy phase of the signal recycling cavity.
- The macroscopic length of the signal-recycling cavity.
- The signal recycling gain.

4 Some definitions and conventions

4.1 Focus on broadband RSE

Even though KAGRA is capable of detuning the signal recycling cavity length [3], it is highly likely that the interferometer will be locked on the broadband RSE (called BRSE or simply RSE in this document) condition during LIGO-VIRGO's third observing run or O3. So for this reason, the commissioning experiments for testing the DRMI focuses on the RSE configuration only. Therefore all the parameters and statements we refer in this document are those with the signal recycling cavity locked on a resonance for the carrier field.

4.2 Interferometer configurations

4.2.1 DRMI

Ignoring the ETMs and their effects, we define the locked DRMI as the configuration which satisfies the following interference conditions.

- The power recycling cavity is resonant for the sidebands (i.e. the carrier is anti-resonant).
- The Michelson interferometer locked on a dark fringe for the carrier field.
- The signal recycling cavity is resonant for the carrier field.

4.2.2 PRMI

We foresee the use of two different PRMI configurations; (A) the carrier-resonant PRMI and (B) the sideband-resonant PRMI. In either case, the Michelson must be locked on a dark fringe for the carrier field.

5 Some derivations

5.1 Requirements on Length Fluctuations

TBW.

5.2 Requirements on macroscopic lengths

PRC, SRC and Schnupp — TBW.

5.3 Requirements on angular fluctuations

TBW

References

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[2] A. Effler, Section 4.4 in "Performance Characterization of the Dual-Recycled Michelson Subsystem in Advanced LIGO," Ph. D. thesis, Luisiana State University (2014) https://digitalcommons.lsu.edu/gradschool_dissertations/2888/

[3] Y. Aso *et al.*, "Interferometer design of the KAGRA gravitational wave detector," Phys. Rev. D 88, 043007 (2013)