Conceptual Layout of Squeezing-Enhanced Gravitational-Wave Interferometry Test at Caltech 40m Interferometer

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I. TWO TEST SCHEMES AND PURPOSES

Currently, we have two experimental plans for the squeezing-enhanced gravitational-wave interferometry test at Caltech 40m: (1) MHz squeezing test in the semi-Advanced LIGO configuration, meaning a detuned RSE with the power recycling (PRM), but without the output mode cleaner (OMC), and (2) low-frequency squeezing test in the Fabry-Perot Michelson (FPMI) configuration. The experiment in each configuration has a different purpose. In Scheme (1), the effect of squeezing on the Advanced LIGO type interferometry will be tested. However, since the 40m interferometer has not yet reached and will not reach shot noise in the GW band in the next few years, squeezing will be tested at a few MHz at which the interferometer is shot noise limited. This test has the disadvantage that RF photodetectors and electronics need to be prepared due to the 40m's digital sampling rate (16kHz). In Scheme (2), the effect of squeezing on the suspended interferometer in the LIGO band will be tested. Although the interferometer configuration is different from RSE, this will be the very first test of squeezing in a suspended interferometer in the GW band.

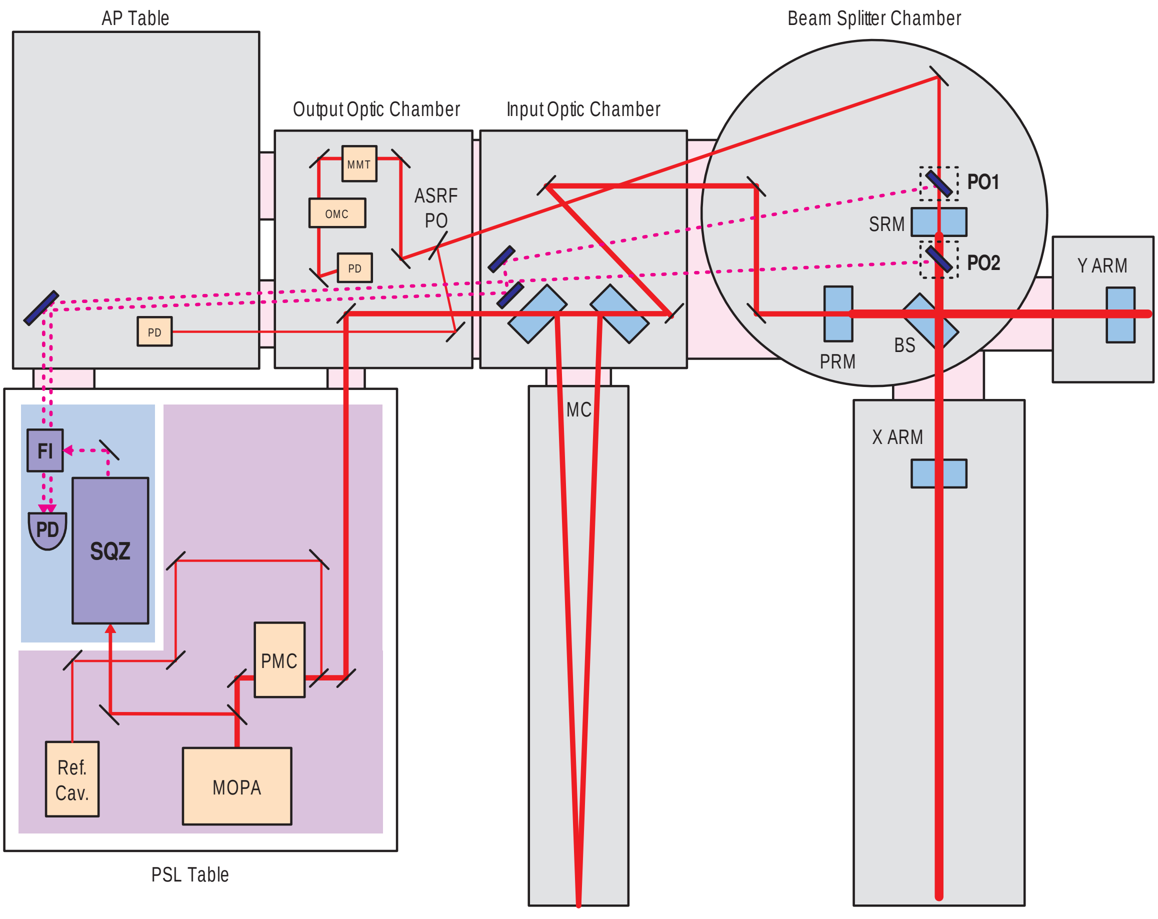

FIG. 1: Conceptual layout (not to scale). SQZ: squeezed vacuum generator, FI: Faraday isolator, PD: high quantum efficiency InGaAs photodetector, PO1, PO2: pickoff mirrors, ASRF PO: antisymmetric port pickoff. The new parts appear in blue or bluish colors. PO1 and PO2 are on picomotors such that they can be inserted or removed by external control.

II. CONCEPTUAL LAYOUT

Fig. 1 shows the conceptual layout of the squeezing-enhanced gravitational-wave interferometry test at Caltech 40m. The new experimental parts appear in blue or bluish colors. The squeezed vacuum and interferometer output beams appear in magneta. For the two different schemes, two pickoff mirrors (PO1 and PO2) will be used for Schemes (1) and (2) respectively. They are on picomotors so that they can be inserted or removed by external control. They are mounted on simple mirror mounts without angular control knobs.

It is desirable to put PO1 at the location for a few reasons. First, the beamsplitter chamber (BSC) has the largest available space of all the chambers. There is some space available between the SRM and the first mirror. Although there are many optics and mounts in the way of the beam path from PO1 to the AP table, a beam path higher than the others can be used to avoid the issue. Likewise, a similar technique can be used for the beam path from PO2 to the AP table. Second, it cannot be placed after the ASRF pickoff beamsplitter with ratio 70/30 because it leads to a 30 % loss of squeezing. The location of PO2 is pretty much fixed because it needs to be placed between the BS and SRM. Since the beam spot size at the SRM is about 1 cm, a telescope may be used in between the pickoff mirror and the AP table or on the AP table.

The squeezed vacuum generator (squeezer) will be installed on the PSL table and occupy its upper left corner (about 36"×48"). About 2 W of light will be picked off at the output of the new MOPA laser before the phase-correcting EOM for the PMC such that it is free of sidebands. The light is injected into the squeezer and most of the power is used to pump the second-harmonic generator (SHG). The optical parametric oscillator (OPO) generates squeezed vacuum and then it is injected via the Faraday isolator into the interferometer. The signal light from the intereferomter is guided by either PO1 or PO2 back to the same Faraday isolator, but goes straight through it and is detected by the photodetector.