Advanced Virgo Squeezer Experiment Overview

S. S. Y. Chua as a start

6 October 2014

Chapter 1

Experiment Overview

This chapter outlines the Squeezed Light source and the integration with Advanced Virgo.[**Details, acronyms, numbers are not set, nor correspond to the previous bench diagrams. This is just a quick placeholder on what is needed in this chapter**].

1.1 Squeezed Light Source Bench

Diagrams needed be worked in

The squeezed light source bench will be a $1.3m^2$ table housed in the DET cleanroom. The 1064 nm main driving laser (MAIN) will be phase-locked to the Advanced Virgo (PLL1 - see below) to initially set the squeezing wavelength. Light from the MAIN laser will be split into two paths, with most of the light sent to the Second Harmonic Generator (SHG) for frequency doubling into 532 nm, and the remainder to a diagnostic beam path. Two additional tap-off beams will be taken from the laser, to be interfered with a tap off beam from each of the Auxiliary Lasers (AUX1 and AUX2), thus phase locking each to MAIN with a phase lock loop (PLL 2 and PLL 3).

Light from the SHG will be spatially filtered using a Green Mode Cleaner Cavity (GMC) and power-stabilized using a Mach-Zehnder interferometer (MZ), which is then sent to the Optical Parametric Oscillator (OPO) to drive the nonlinear parametric process for squeezing. Light from AUX1 will be used to lock the OPO cavity length, after being appropriately frequency-detuned and rotated into the orthogonal (p-)polarization, and injected into the OPO HR mirror. Auxiliary Laser 2 will provide the coherent sideband for the Coherent Locking technique, injected also into the OPO HR mirror at the same polarisation as the squeezing (to undergo the required nonlinear process to generate the second coherent sideband). A photodetector (PD_{CL-G}) will readout the coherent beam in the OPO HR mirror reflected port to generate the error signal for the green-to-coherent-beam lock.

The squeezed beam, coherent sideband and leakage OPO locking beam (all spatially overlapped, referenced by the OPO) will pass through the first squeezing Faraday Isolator (SF1), to remove the leakage p-pol locking beam. A flip-in mirror will direct the squeezing/coherent sidebands to the diagnostic Homodyne detector (HD). The Local Oscillator for the diagnostic Homodyne will be the diagnostic beam path from the MAIN laser, after spatial mode cleaning from the IR Mode Cleaner Cavity (IRMC). The Homodyne detector, with its DC and RF readout, will provide both the squeezing measurement and the photodetectors for the LO-to-coherent-beam local bench lock.

1.2 Squeezed Light Source and Interferometer Integration

The squeezed light bench will be located in the DET cleanroom. A tap-off from the Advanced Virgo Pre-Stabilised Laser will be sent via optical fiber to the squeezed light bench. A stabilisation scheme will suppress the fiber-phase noise to ensure good matching of the optical frequency/wavelength of the MAIN laser to the PSL. This is PLL 1 on the squeezing bench, actuating on the MAIN laser's output wavelength.

Returning to the squeezed beam, with the flip mirror out of the squeezing beam path, the diagnostic Homodyne is completely bypassed, and the squeezed/coherent sideband beam begin the injection into the interferometer. The beam will now pass through two more squeezing Faraday Isolators (SF2 and SF3) to minimise backscattered light from the interferometer returning to seed the OPO. In the injection path, there will be two dual-axis PZT mirrors to be used for an auto-alignment system, as well as the mode-matching optics needed to overlap the spatial mode to the interferometer readout carrier beam. The interferometer carrier beam is now the "Local Oscillator" for the squeezing and coherent sidebands.

The squeezed/coherent sideband beam will be injected into the output Faraday isolator (OFI) of the interferometer so that the beams will propagate to the Michelson, and mix with the carrier at the Michelson. The squeezed-carrier and coherent sidebands then propagate to the interferometer readout chain. Light from an existing tap-off in the readout chain [somewhere] (with both squeezed-carrier and coherent sidebands) will be directed onto a PD situated [somewhere], where photodetector ($\mathrm{PD_{CL-C}}$) will provide the error signal for the Carrier-to-coherent-beam control loop. This lock will be fed back to the PLL 1 control loop as an additive offset, so that the phase of the squeezing ellipse will match the readout quadrature via cascade of the squeezing bench control loops (SHG, OPO etc.). Upon reaching the first interferometer Output Mode Cleaner (OMC), the coherent sidebands will be reflected onto the OMC quadrant photodiodes, and a signal from these quadrants will be used for the squeezing auto-alignment scheme, fed back to the dual-axis PZT mirrors.

1.3 Other items to add

- Environment noise controls - Air currents, Dust, Acoustic Noise
- Specifics on electronics - boards
- Remote controls - EPICS, automated paddles for blocking/unblocking beams, readout channels, auto-relockers?
- Provision of space for Filter Cavities?

Bibliography