UNIVERSITY OF BIRMINGHAM

Comparing Finesse and Optickle simulations of the Advanced LIGO Dual-Recycled Michelson

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LIGO DCC: T1400270-v1

Issue: 1
Date: 29/08/2013

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1 Introduction

Summary of simulations carried out for the Advanced LIGO dual-recycled Michelson interferometer (no arm cavities), using FINESSE . The purpose is to compare the performance of our FINESSE model with the results produced using Optickle (`https://alog.ligo-la.caltech.edu/aLOG/index.php?callRep=8102`), in preparation for commissioning. All the plots match between FINESSE and Optickle agree.

2 Power recycled Michelson

We begin by looking at a power recycled Michelson (no signal recycling).

2.1 PRC and MICH operating points

An offset of 0 should correspond to the two sidebands resonant in the power recycling cavity (PRC) and the Michelson tuned to be on the dark fringe. The first step is to check we are tuned to right operating points. Figure 1 (left) shows that at 0 the resonance condition of the power recycling cavity is satisfied and figure 1 (right) shows that we are on the dark fringe.

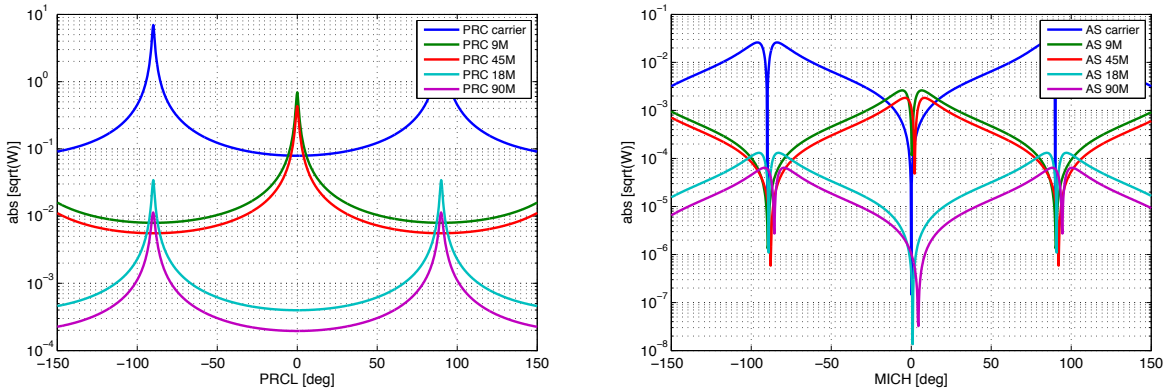

Figure 1: Plots showing the amplitude of the carrier frequency, two sideband frequencies (9 MHz and 45 MHz) and double demodulation frequencies (18 MHz and 90 MHz) in the power recycling cavity (PRC) and at the AS port in the PRMI.

2.2 $2f$ signals

We look at the power build up of the $2f$ signals (double the demodulation frequencies) in the different cavities. The demodulation phases (for comparison with the Optickle results) are those which maximise the signal in DRMI.

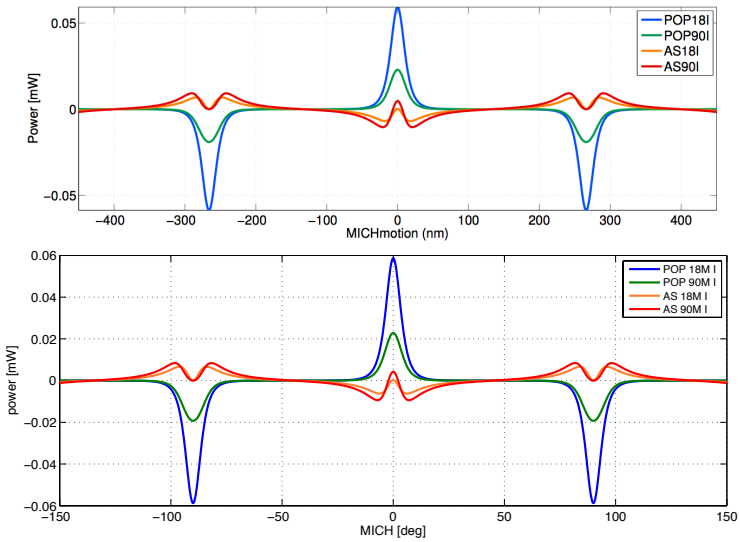

Figure 2: The $2f$ signals at the anti-symmetric (AS) and power recycling pick-off (POP) ports of the PRMI as MICH is tuned. The Optickle results are shown for comparison.

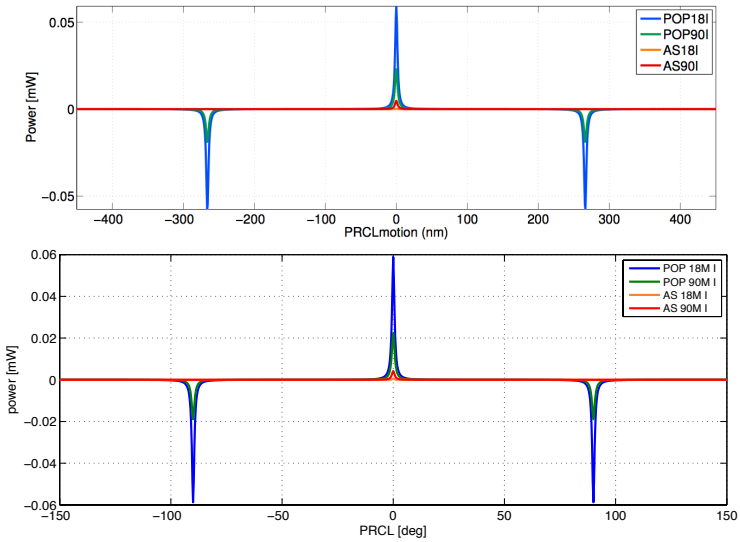

Figure 3: The $2f$ signals at AS and POP as PRCL is tuned in the PRMI. Optickle results shown for comparison.

2.3 Error signals

Error signals (i.e. demodulated at the sideband frequencies) at the reflection port (REFL).

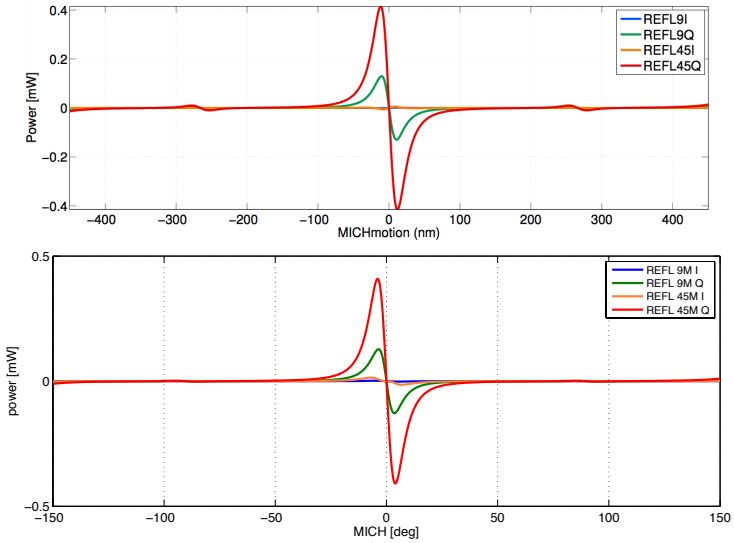

Figure 4: Error signals at the PRC reflection port (REFL) as MICH is tuned in the PRMI.

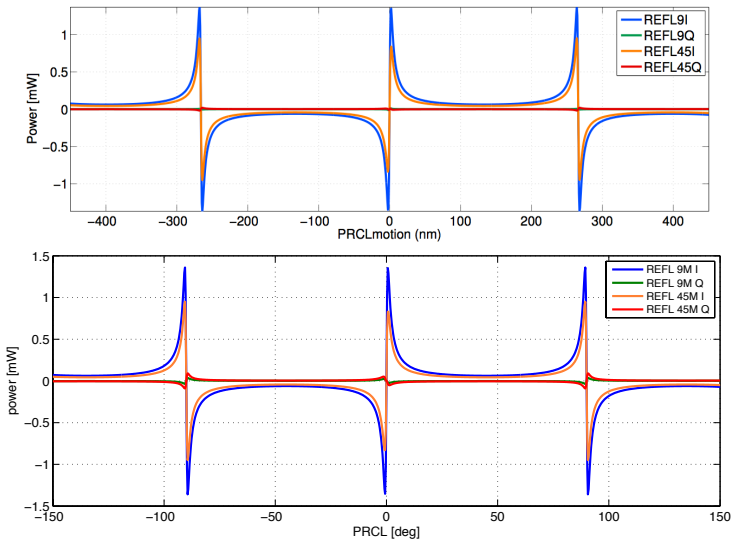

Figure 5: Error signals at REFL as PRCL is tuned in the PRMI.

3 Dual recycled Michelson

We now add signal recycling to the model.

3.1 Operating points

In this case 0 offset refers to the two modulation frequencies resonant in the power recycling cavity, the carrier and f_2 resonant in the signal recycling cavity and on the dark fringe.

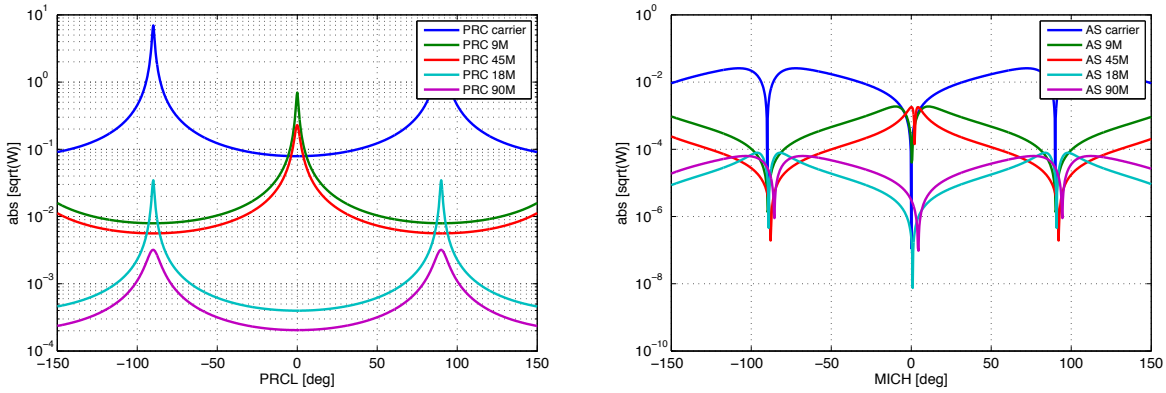

Figure 6: Plots showing the amplitude of the carrier, modulation sidebands and double the sideband frequencies in the power recycling cavity as PRCL is tuned in the DRMI (left) and the power at AS as MICH is tuned.

3.2 $2f$ signals

We look at the power build up of the $2f$ signals (double the demodulation frequencies) in the different cavities.

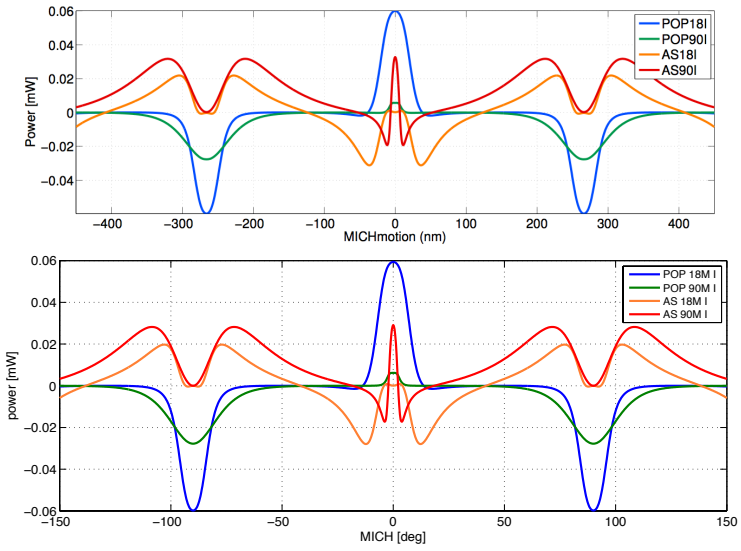

Figure 7: $2f$ signals at AS and POP in the DRMI as MICH is tuned.

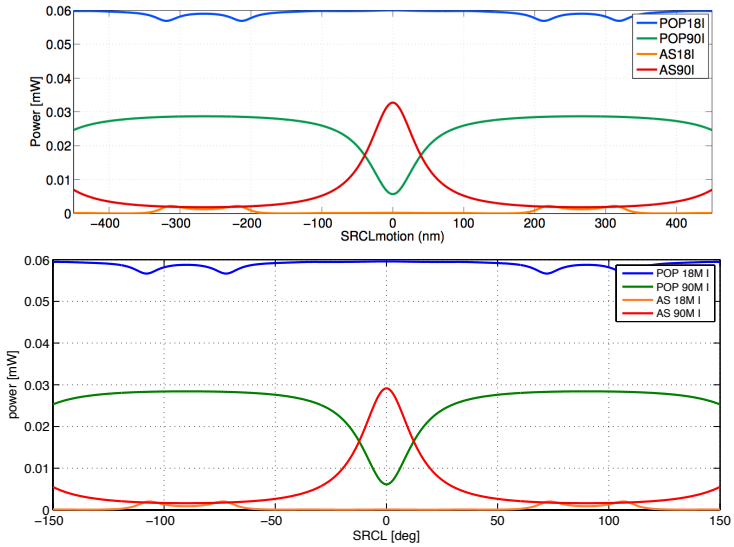

Figure 8: $2f$ signals at AS and POP as SRCL is tuned.

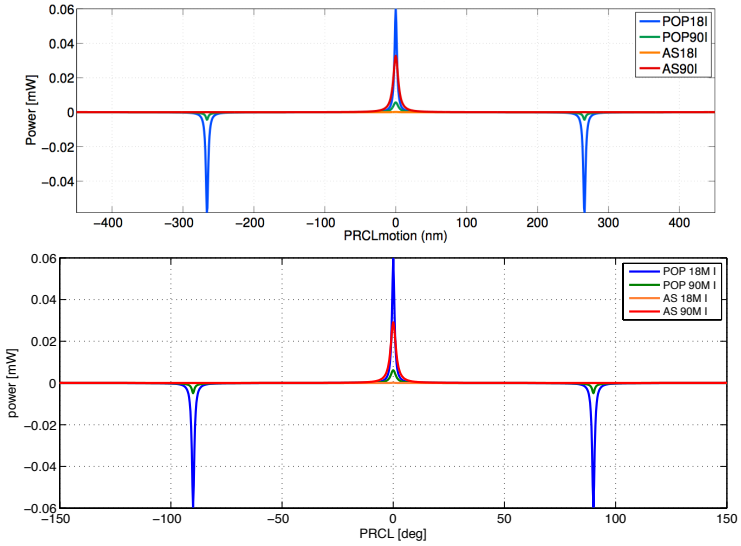

Figure 9: $2f$ signals at AS and POP as PRCL is tuned in the DRMI.

3.3 Error signals

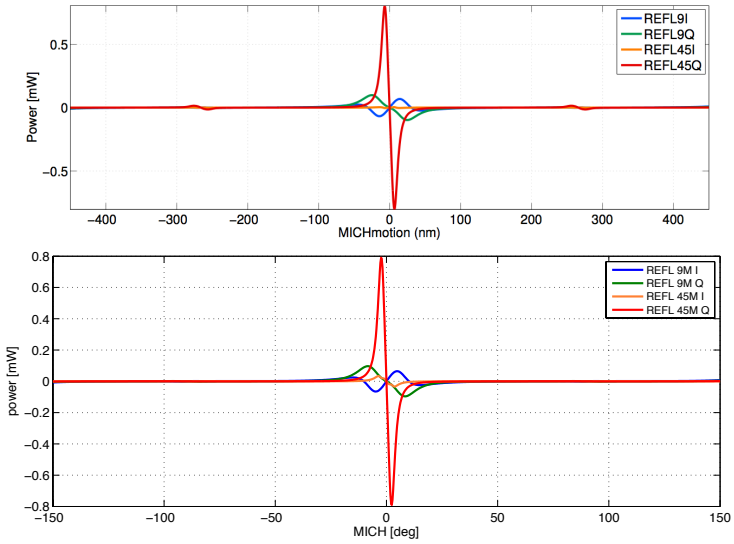

Figure 10: Error signals at REFL as MICH is tuned in the DRMI.

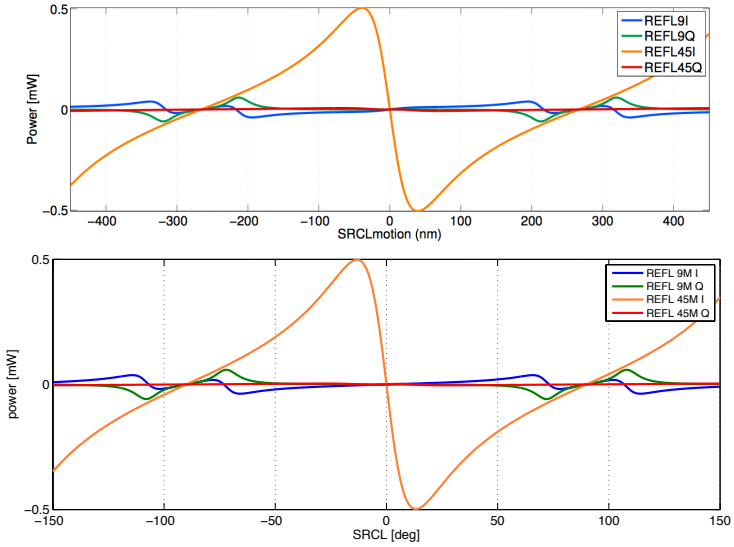

Figure 11: Error signals in DRMI as SRCL is tuned.

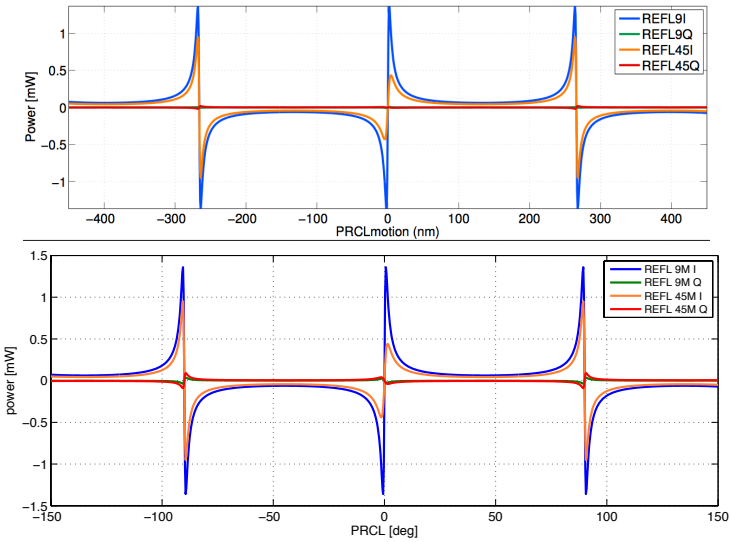

Figure 12: Error signals in DRMI as PRCL is tuned.