Conversion of the Glasgow 10m Prototype for Detuned Operation

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LSC - AIC
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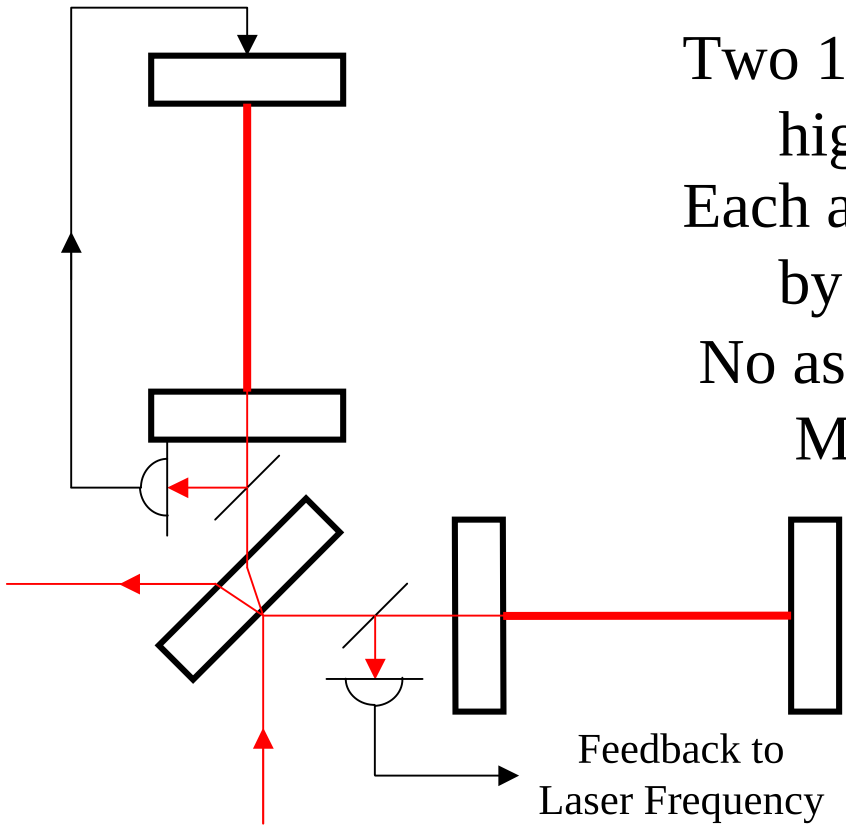
Schedule

1. Design control scheme (Jun 2000)
    - Use proposed mirror properties and physical layout to model IFO response
2. Mechanical Alterations (Oct 2000)
    - Addition of SR tank to existing configuration
    - Changes to suspension assemblies
3. Optical Alterations (Mar 2001)
    - Addition of new mirrors & modulators
    - Re-modematching arm cavities.

Schedule - Continued

4. Design and Build Electronics (Jun 2001)
   - Photodiodes and demodulation scheme
   - Force feedback actuators
5. Locking and Control (Sept 2001)
   - Design of feedback electronics
   - Formulation of a viable method to control all degrees of freedom
   - Expected completion early 2002

Before…



Basic Fabry Perot Michelson set-up:

- Two 10m arm cavities composed of highly reflective mirrors
- Each arm cavity locked separately by RF reflection locking
- No asymmetric length at the inner Michelson

Unaltered Details

Arm Cavity Properties:

Inner Mirrors: R = 0.9996, T = 0.0003, Plane

Outer Mirrors: R = 0.9999, T = 1e-6, 15m Curved

Length: 10m

50-50 Beam-splitter

From previously measured data the finesse of each Arm Cavity is around 10,000

Fundamental Physical Changes

A 0.13m asymmetry in the inner Michelson to allow for Schnupp modulation locking scheme

Addition of a Signal Recycling mirror with 90% reflectivity

Initial modelling of the proposed system indicated 90% would give almost a factor of 10 increase in bandwidth at our proposed 80 degree detuned operating point

SR cavity length is 1.35m – this is an approximate value

New Features

We will now have two modulation frequencies at 12MHz and approx. 100MHz with modulation depth 0.2, each being applied using a Pockels cell

The second modulation frequency is dictated by the length of the signal recycling cavity

The modulation scheme calls for demodulation at both modulation frequencies and the beat between them

We also need photodiodes and phase-shifters which can operate at these higher frequencies. But where to put the photodiodes…

Degrees of Freedom

First, we have 4 lengths (or Degrees Of Freedom) to control:

- L+ : Common arm length
- L- : Differential arm length
- l- : Differential inner Michelson length
- ls : Signal recycling cavity length

Logically, we need to find 4 detection points from which to derive our error signals

Locking Points

Modelling shows that by using 2 modulation frequencies control of the DOF’s can be given by:

CP1: Dark port, demod at upper mod frequency

CP2: Dark port, demod at beat between mods

CP3: Light port, demod at beat between mods

CP4: Light port, demod at lower mod frequency

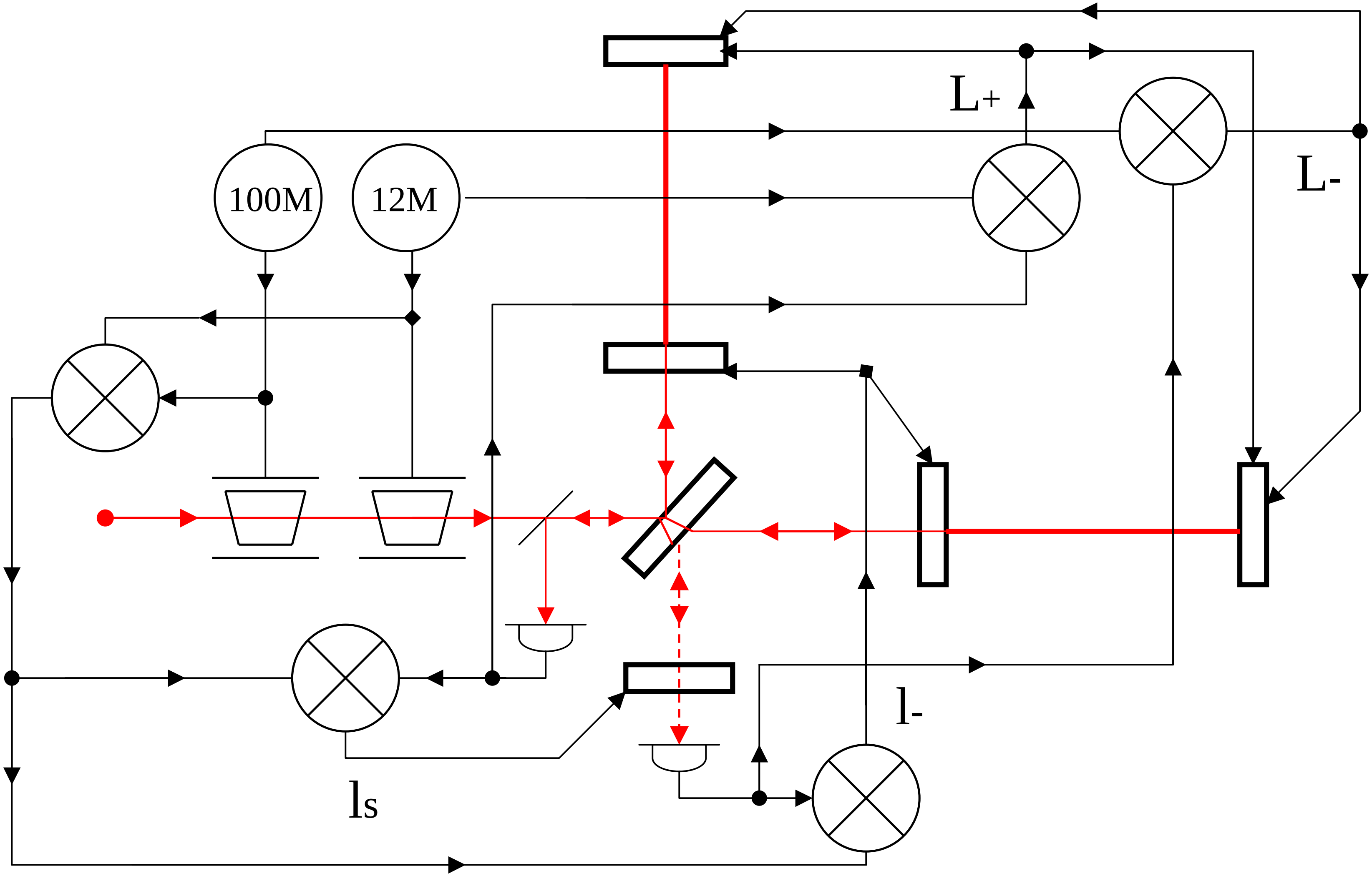
These locking points when examined with the DOF’s for an 80 degree detuned SR mirror gives…

Modelled Control Matrix

	L-	l-	ls	L+
CP1	-2.14	-8.9e-5	4.3e-8	-8.1e-5
CP2	1.4e-8	6.7e-5	3.4e-5	2.9e-9
CP3	8.0e-9	2.2e-5	2.9e-3	2.6e-7
CP4	-0.68	-1.6e-4	5.9e-6	-32.1

These values indicate the optical gains for the interferometer control signals while locked.

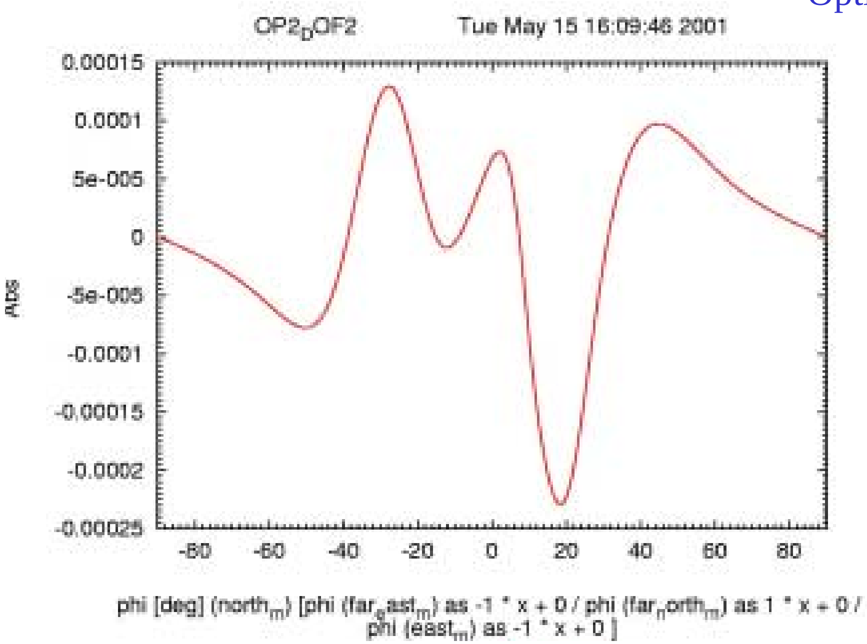
…After

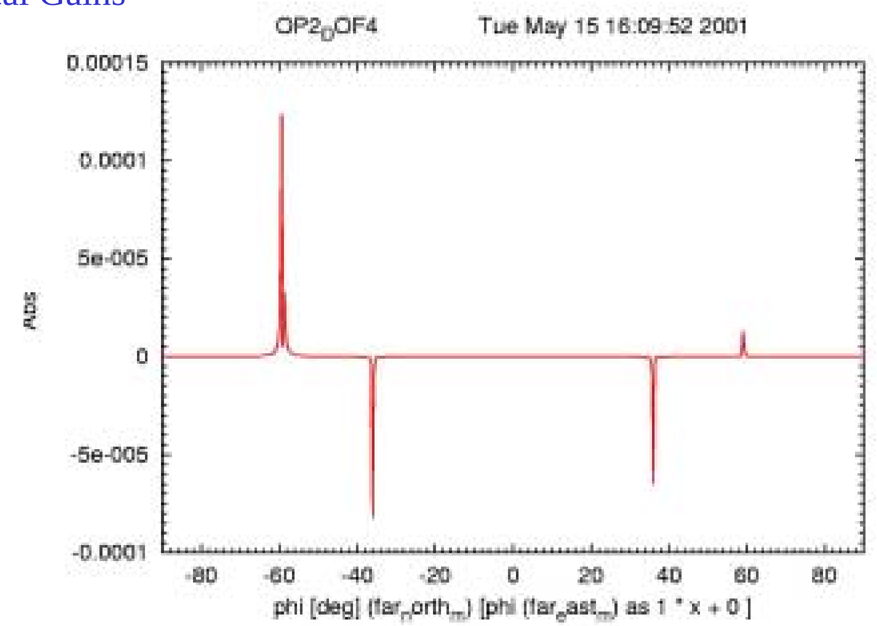


Thoughts on Locking

So we have our detection scheme, but each of the elements of the control matrix depend on the fact that all the other degrees of freedom are already controlled. In other words how will we acquire lock?

Optical Gains





Thoughts on Locking cont'd

From the previous example it is obvious that the signals from the arm cavities will dominate. Thus we have two options:

1. Lock the arm cavities first – this option will require a way to insure the arms stay locked if the Michelson drifts through a null signal position.
2. Lock only the beamsplitter and signal recycling cavity – requires a way to buffer the lock from the arm signals.

Currently, preference is for the first alternative. The problem now lies in locking the arms…

Possible Arm Locking Methods

The key point to make here is: the initial lock of the arms need not be high performance. We want only to bring both arms close to resonance at the same time – not a common occurrence without intervention.

One possibility is to slowly drive the arms (we now have actuators on both ITMs and ETMs) until they both resonate – easily seen on the error signal.

Another thought is to attempt a transmission locking scheme. Performance would not be high but should be good enough for our purposes.

What Lies Ahead?

First of all we need more concrete decisions regarding the best way to achieve lock. Once we have this we can build a feedback system around the basic framework.

Secondly, a reliable way to stay locked is required. From the model we believe the system will be stable in its locked state.

Thus we will have a fully suspended signal recycled IFO operating at a detuning of 80 degrees. We even expect that by careful iterative alteration of the modulation frequency changing the set-up to a 60 degree detuning may be possible.

Acknowledgements

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