AIC – summary & recommendations

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Length Sensing

- We looked for baseline LIGO II length and alignment sensing
- Focused on reference design broad-band interferometer
- Base-line sapphire mirrors, fall-back to Suprasil SV if needed
- Chose relatively high finesse arms to reduce substrate heating
  - very important in sapphire due to high absorption
  - not very harmful in silica (check implications for alignment)

Sensing schemes

- It was helpful to split problem into 3 smaller problems
  - GW readout
  - Auxiliary length sensing (recycling, signal recycling, Michelson, common arm mode)
  - Alignment sensing

GW Readout

- We rely on having an efficient output mode-cleaner to reduce the 'junk' light at the asymmetric output where the GW signal is measured
- DC readout signal sidebands are mixed with TEM_{00} carrier at the output
  - Carrier is generated by a combination of differential loss in arms and deliberate offset of the differential arm cavity lengths
  - Choice of offset (several pm) determines homodyne measurement phase (useful in SR system)
- RF readout, there are several options. Consider the 'simplest'
  - Increase strength of PM or SSB needed for auxiliary sensing

Motivation for and problems with RF sensing

- New QM results predict improvements in sensitivity over some frequency ranges (mid-band) and loss of sensitivity over other ranges
- Frequency dependent mixing of two quadrature detection of beat between single RF SB and signal could improve the overall sensitivity
- Problem of thermally induced instability of sideband field in recycling cavity as in LIGO I.
- Possible solution is to resonate an (additional) SSB in an arm to help stabilise the field

Auxiliary sensing scheme

- Uses 2 frontal PM in series (nominal 9 MHz and 180 MHz)
- All length DOF sensed with excellent signal separation
- Sensing at symmetric and asymmetric ports
- Double demodulation at both frequencies used to improve separation of signals
- Scheme relatively stable against parameter variation, can be adapted when reference design is changed

Alignment (wavefront) sensing

- Same 9/180 MHz modulations allow relatively clean extraction of all alignment signals
- Parameter changes may require the addition of additional 'non-resonant' PM side-bands to improve signal separation (ways to do this are identified)
- Modal-model was used to evaluate alignment sensitivity. With output mode-cleaner requirements are similar to those in LIGO I

Requirements

- Requirements for frequency noise at PSL/MC/PR calculated for both GW readout schemes: not especially onerous
- Requirement for power noise determined overwhelmingly by technical radiation pressure noise. Sets a relatively hard goal at low frequency (10 to 50 Hz)
- Other technical requirements relating to photo-detectors, mode-cleaners, etc. have been communicated to Laser and Optics group.

Unresolved issues

- Full consequences of QM noise analysis remain to be understood and assimilated.
- Sensing scheme to be checked in context of narrow-band interferometer