New Folder Name Pockels Cell Noise tests

LIGO-T900041-00-R

Further Notes on Pockels Cell Noise, and Some Other Possible Noise Sources Arising in the Region between the Mode Cleaner and the Input Cavity Mirrors of the 40 m Interferometer.

(September 26,1990; R.Drever.)

A. Pockels Cell Noise tests.

In a previous "Notes on Pockels Cell Noise" (Sept.17,1990) it was concluded that it would be desirable to remove the phase correcting cells between the mode cleaner and the beamsplitter. This test was effectively simulated on September 22nd by first considerably reducing, and then completely removing, the drive to the low frequency phase correcting Pockels cell: significant reductions in interferometer noise resulted.

Separate polarization observations of noise in demodulated light from the Pockels cells suggest that the azimuthal misalignment of the Pockels cell optic axes was an important factor. The use of separate circulators to obtain the output signals from each arm, possibly with their optic axes not identically aligned, can make the present interferometer configuration more sensitive to this noise coupling mechanism than a recombined interferometer would be. However a recombined system would still be vulnerable to the amplitude noise produced, and also to possible coupling mechanisms involving generation of beam wiggle by the Pockels cells.

B. Some Other Possible Noise Sources between the Mode Cleaner and the Input Cavity Mirrors. (See Fig. 1.)

(1) Coupling of Fluctuating Magnetic Fields to the Faraday Rotator.

Varying ambient magnetic fields can cause small fluctuations in the rotation of the plane of polarization produced by the Faraday glass in the optical isolator. This could lead to interferometer noise by two different mechanisms:-

(a) Fluctuations in isolation efficiency of the isolator.

This will alter the amplitude of spurious "Michelson fringes" produced by reflection of light between the input mirrors of the cavities and the output mirror of the mode cleaner. As the Michelson fringe phase is a function of the precise position of each mirror there may not be significant cancellation of the effect between the two arms.

(b) Conversion of polarization azimuth fluctuation to phase fluctuation.

This can take place if the light passes through a birefringent material which has its optic axes inclined relative to the predominant plane of polarization. Some stress-induced birefringence has been noticed in Faraday glass itself when its mounting has caused stress. A uniform fluctuation in phase over the wavefront of the light will be equivalent to some additional frequency noise, and may be reduced in magnitude by the loop gain of the primary arm stabilizing system. A non-uniform birefringence, which is likely if caused by stress, can be more serious since it can couple differentially into the two arms if they are not identical in alignment or mirror figure, and the resultant interferometer noise will then not be reduced by the loop gain factor.

Both of these possible noise sources are completely eliminated if use of Faraday isolators is avoided in this part of the interferometer, and this can be achieved by use of a 3-mirror (ring-cavity) mode cleaner instead of a 2-mirror one. I propose use of this technique in the 40-m rebuild (LIGO Monthly Review, 8/30/90), and it may be worth considering use of it before that stage.

2. Transverse Relative Motions of Mirrors and Other Components.

Reduction of transverse motions of test masses and other components has long been recognised as desirable. One coupling mechanism can be through scattering by imperfections in the optical surfeaces, coupled with fine structure in the optical wavefront produced by scattering at other components. This coupling mechanism would lead to effects of the same order of magnitude for all components between the mode cleaner and the input cavity mirrors, so damping of all of them is desirable. This is another reason for minimizing the number of components in this sensitive region, and encourages use of a 3-mirror mode cleaner rather than a 2-mirror one.

An experimental test of effects of transverse motion has recently become more practicable through the possibility of artificially enhancing the transverse horizontal motion of the beamsplitter or of one of the circulators by driving an appropriate horizontal OSEM head. Interpretation may not be simple, as the effects are likely to be be highly nonlinear and amplitude-dependant. However an experiment of this type could give some indication of the magnitudes of the effects to be expected, at least for the present level of sensitivity.

3. Beam Wiggle Effects, generated by -

(a) the Piezo-driven mirrors on the mode cleaner, or

(b) wiggle induced by nonuniform fields or other imperfections in the Pockels cells.

The magnitude of (a) has been estimated assuming a simple coupling of the wiggle to the cavities, by Alex. He finds the effect small for this coupling mechanism. However coupling via the modulation Pockels cell may be a significantly larger effect.

The possible existence of these two wiggle phenomena provides further incentive to avoid use of phase-correcting Pockels cells in this region of the interferometer system, and to use mode cleaners with magnetically-controlled suspended mirrors instead of those with mechanically-linked piezo-driven mirrors.

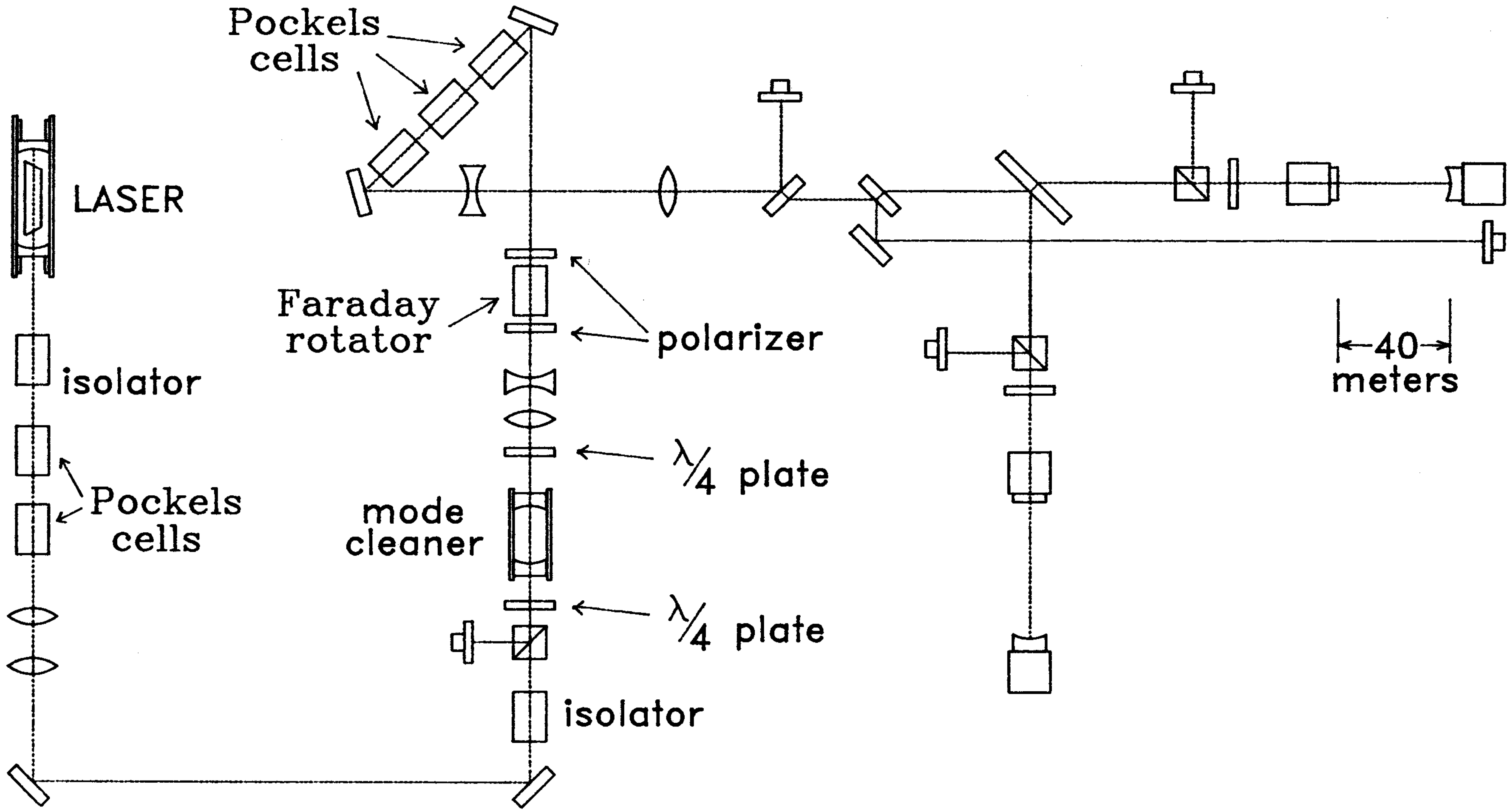

Fig. 1.

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9/26/90