Asymmetry Scheme

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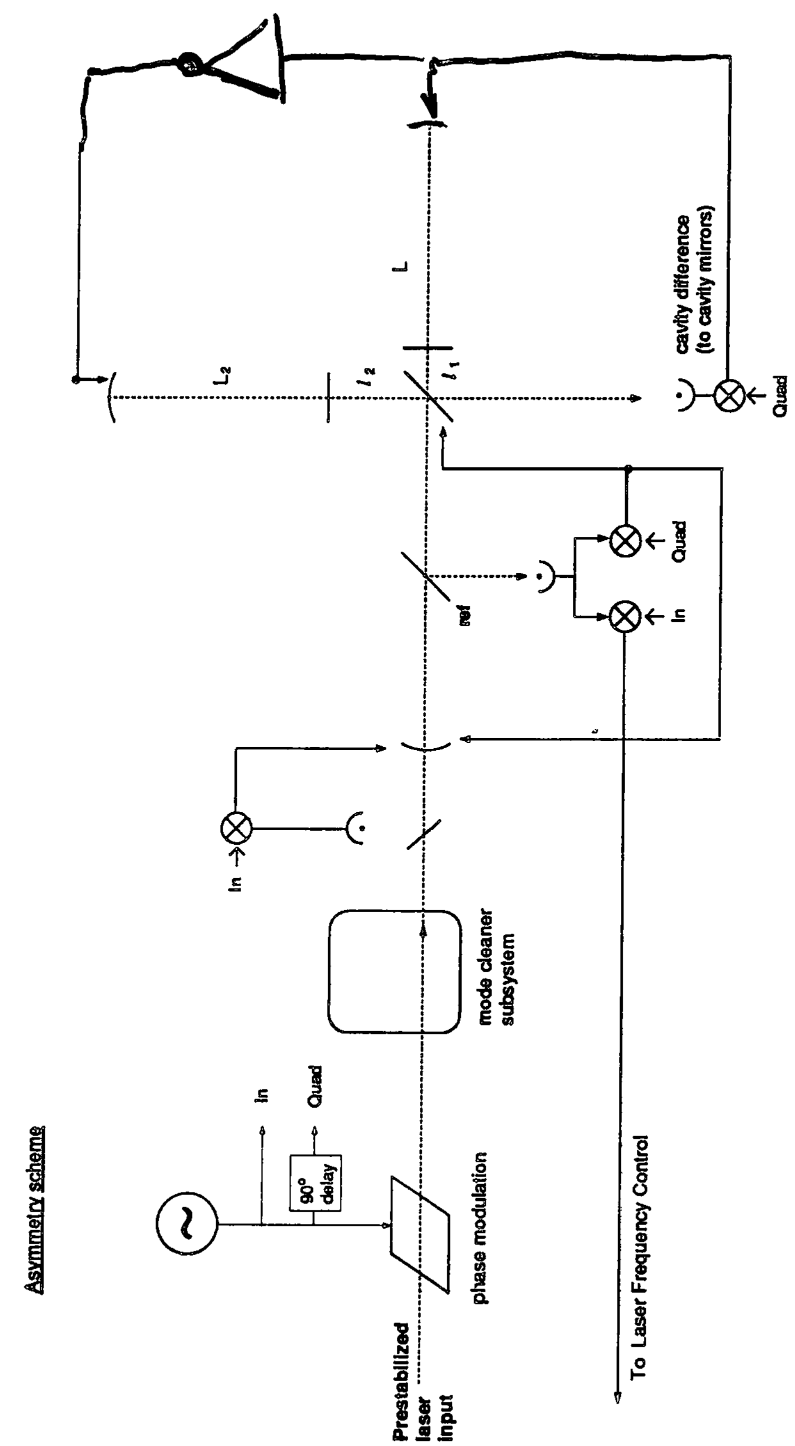
LIGO G930063-00-R

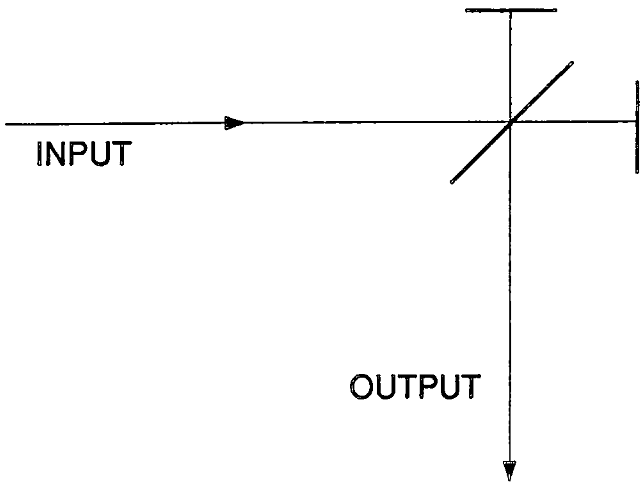
Asymmetry Scheme



Gravitational Wave Sensing

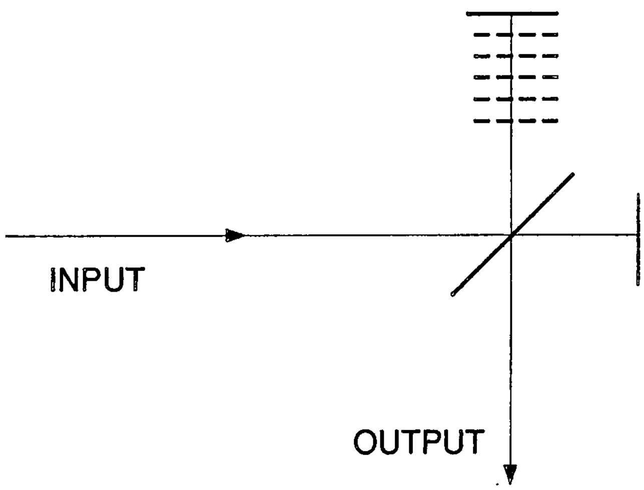
(Schnupp, '86 or '87)

Symmetric Michelson Interferometer:



•Output dark for all wavelengths if dark for any.

Introduce asymmetry by shifting one mirror away from beamsplitter by a (large) integral number of half-wavelengths of green light:



Now output is still dark for carrier, but not for RF sidebands.

•Gravitational wave distorts interferometer, causing carrier to appear also at output: AM produced by beating together of carrier and sidebands.

Asymmetry Scheme

Note: In the language used to describe modulation above, the AM produced is due to the fact that the RF sidebands at the output are shifted in phse by +/- 90° respectively. Carrier is also shifted in phase, by +90°or - 90°, depending on direction of gravitational deformation of interferometer.

Auxiliary Sensing

Need also to detect $L_1 + L_2$ (Average arm cavity length), $l_1 + l_2$('Average recycling cavity length') and $l_1 - l_2$ ('Michelson near mirror difference').

Average Arm Cavity Length

•Carrier phase (but not sideband phase) changes when arm cavity length changes, producing amplitude modulation in recycling cavity

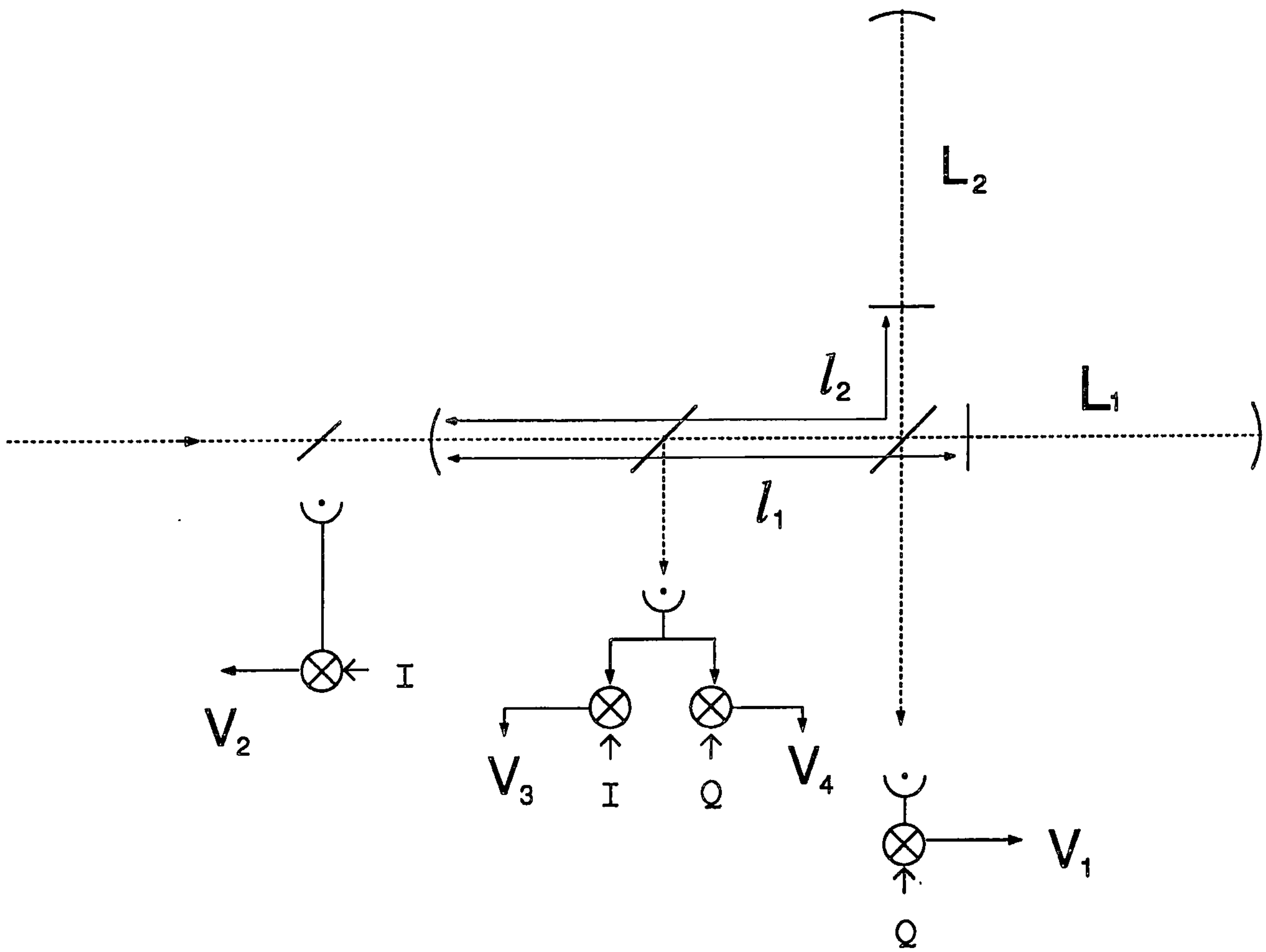
Average Recycling Cavity Length

•Carrier phase changes at a different rate from that for the sidebands when recyling cavity length changes

Michelson Near Mirror Difference

•One RF sideband grows in amplitude, and the other shrinks, when one cavity is moved nearer the beam splitter and the other moved away

Asymmetry Scheme



$$V_2 \propto \delta L_1 + \delta L_2 + \varepsilon_2(\delta l_1 + \delta l_2)$$
$$V_3 \propto \delta L_1 + \delta L_2 + \varepsilon_3(\delta l_1 + \delta l_2)$$
$$V_4 \propto \varepsilon_4(\delta l_1 - \delta l_2)$$

Locking Techniques

• Once gains and phases set correctly, prototype acquires automatically when beam splitter is swept back and forth. Mechanism not understood.

• To set gains and phases initially, adjust them in one loop at a time, in the following order:

- laser servo loop (most important)
- differential arm cavity loop
- recycling mirror loop
- Michelson near mirror difference loop

During the procedure, the power circulating in the recycling cavity is monitored by storage scope to measure (and maximize) the length of locked stretches.