Experimental Demonstration of Resonant Sideband Extraction in a Sagnac Interferometer

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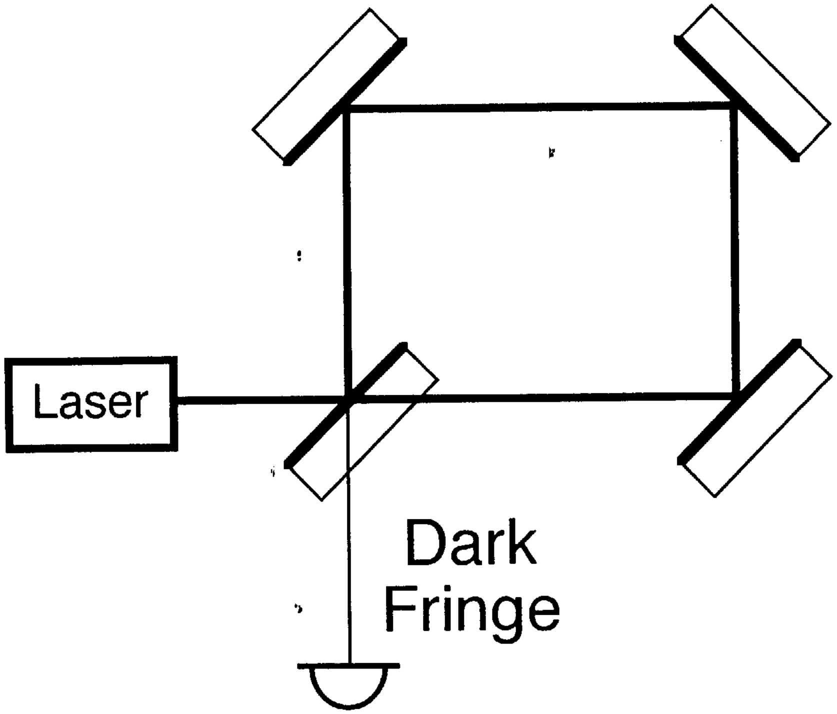
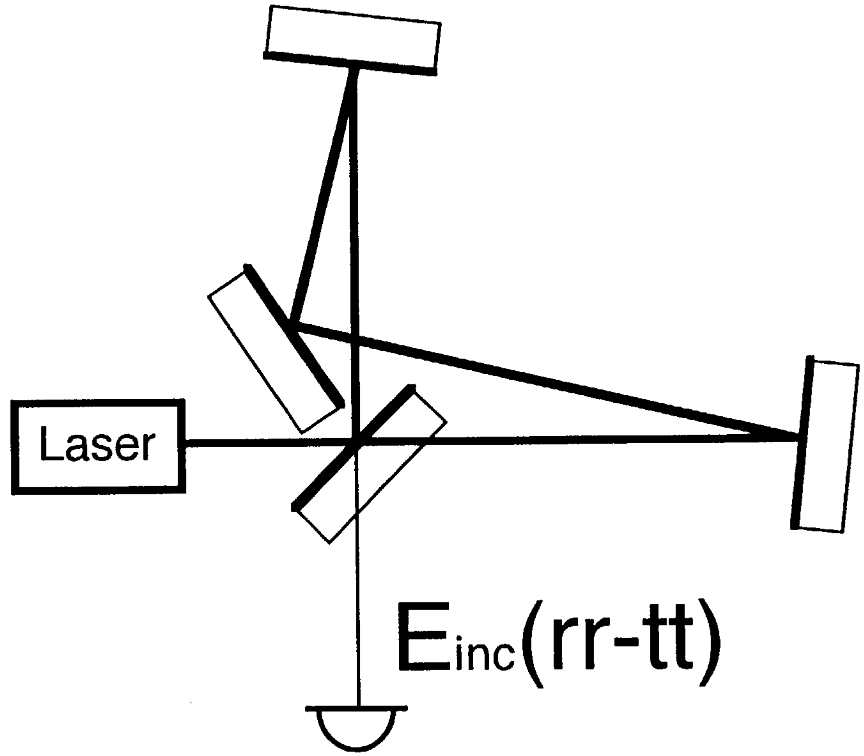


Conventional Sagnac



GW detector Sagnac

Sagnac Characteristics

- ◊ Responds to antisymmetric signals (including gravity waves).
- ◊ Ring interferometer ➔ Counterpropagating beams experience same paths, losses.
- ◊ No response at zero frequency insensitive to drift, always on a dark fringe.
- ◊ Sensitive to beamsplitter ratio.

Resonant Sideband Extraction Motivation

- ◊ Dominant noise source within the signal bandwidth expected to be Shot Noise.

PHOTON NUMBER = N
SIGNAL α N, Noise α $\sqrt{N}$
S/N α $\sqrt{N}$

To get better sensitivity must increase the power stored inside the instrument.

- ◊ Increase laser power
- ◊ Use power recycling
- ◊ Use Fabry-Perot cavities in the interferometer arms

Thermal distortions

◊ With power recycling large optical powers are transmitted through the beamsplitter (and possibly other substrates).

◊ Thermal distortions destroy the interference and may severely limit the sensitivity of an instrument.

Frequency Response

◊ Optimum sensitivity obtained when,

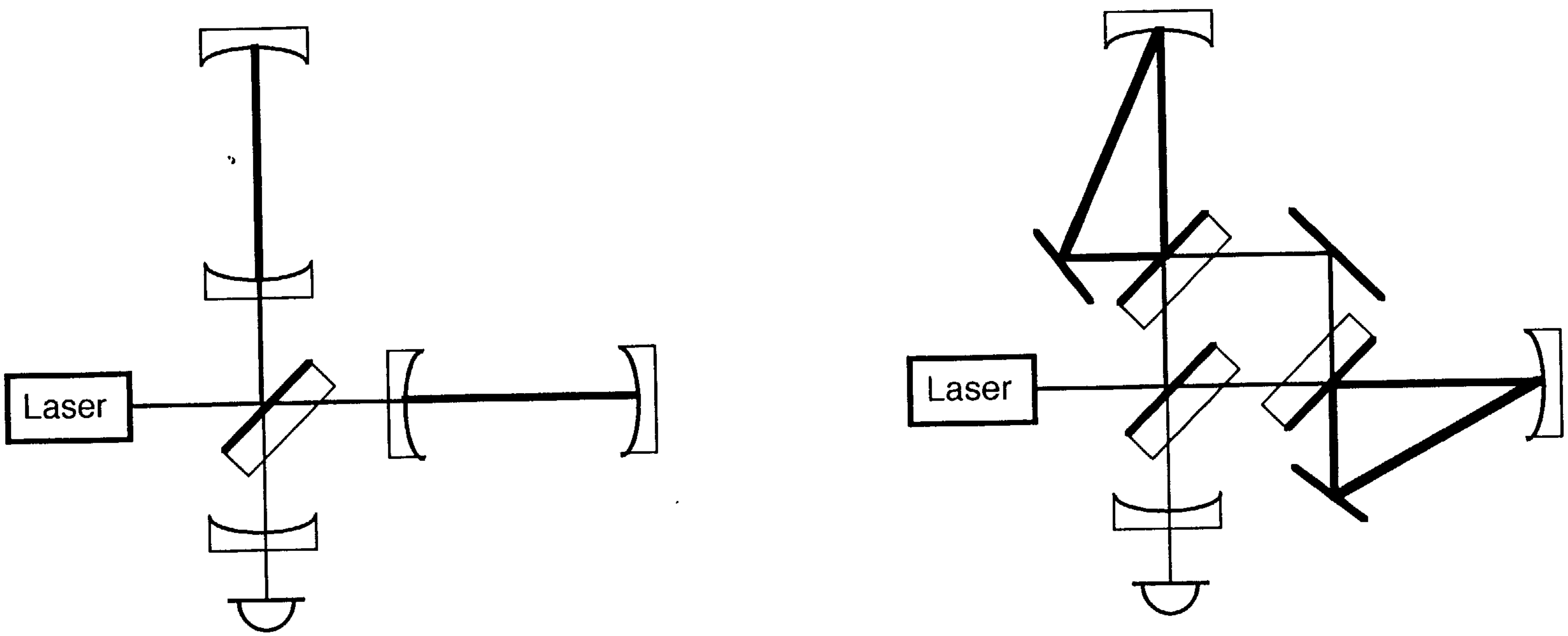
$$\tau_{storage} = \frac{1}{2}\tau_{gw}$$

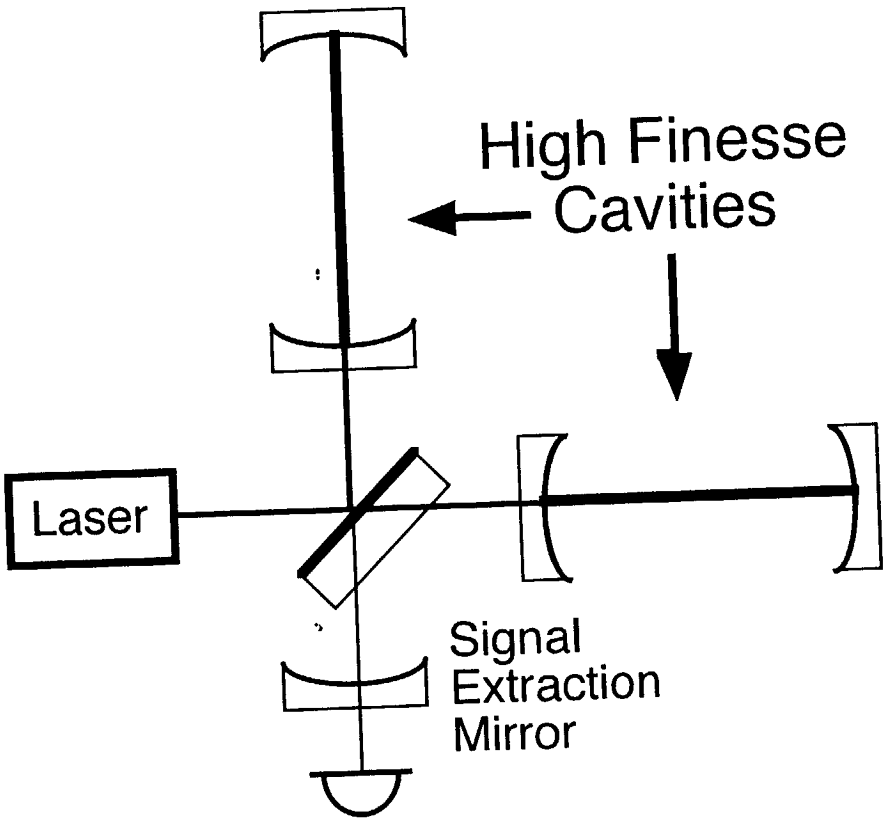
$\tau_{gw} \sim 0.1s - 1ms$

⇒ Increasing storage time limits the bandwidth of the instrument

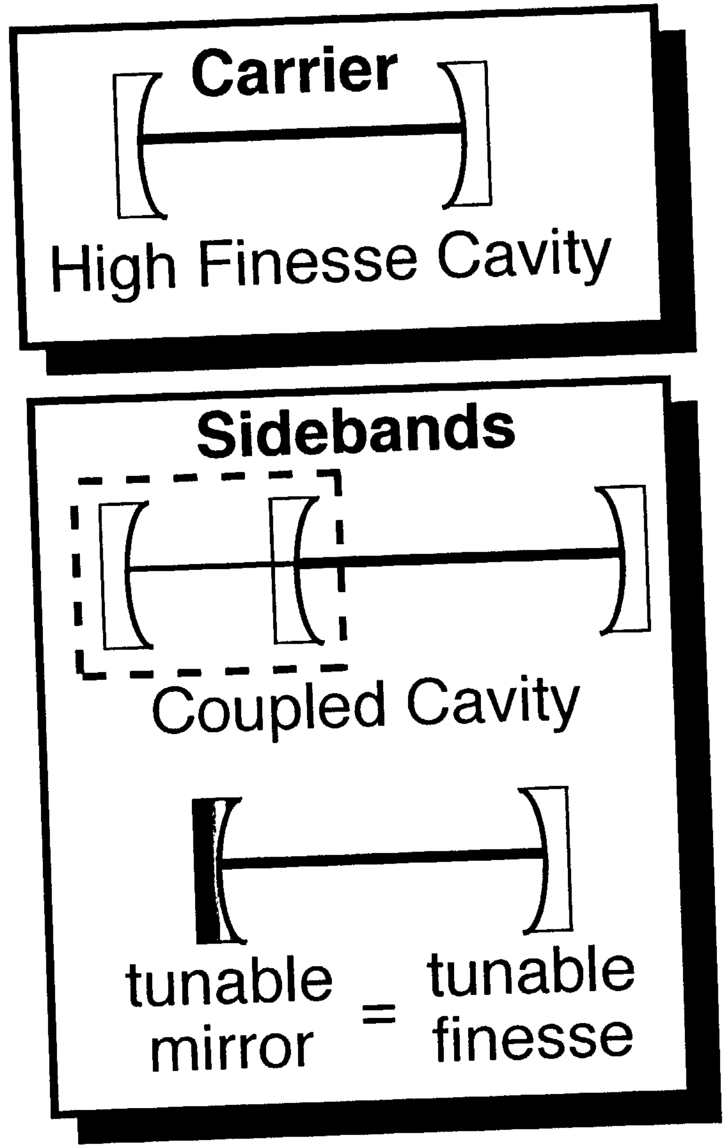
Resonant Sideband Extraction allows us to…

- ◊ Maximise the stored power without thermally loading the beamsplitter.
- ◊ Alter the storage time of the signal sidebands in the arm cavities ➔ adjust the bandwidth of the instrument

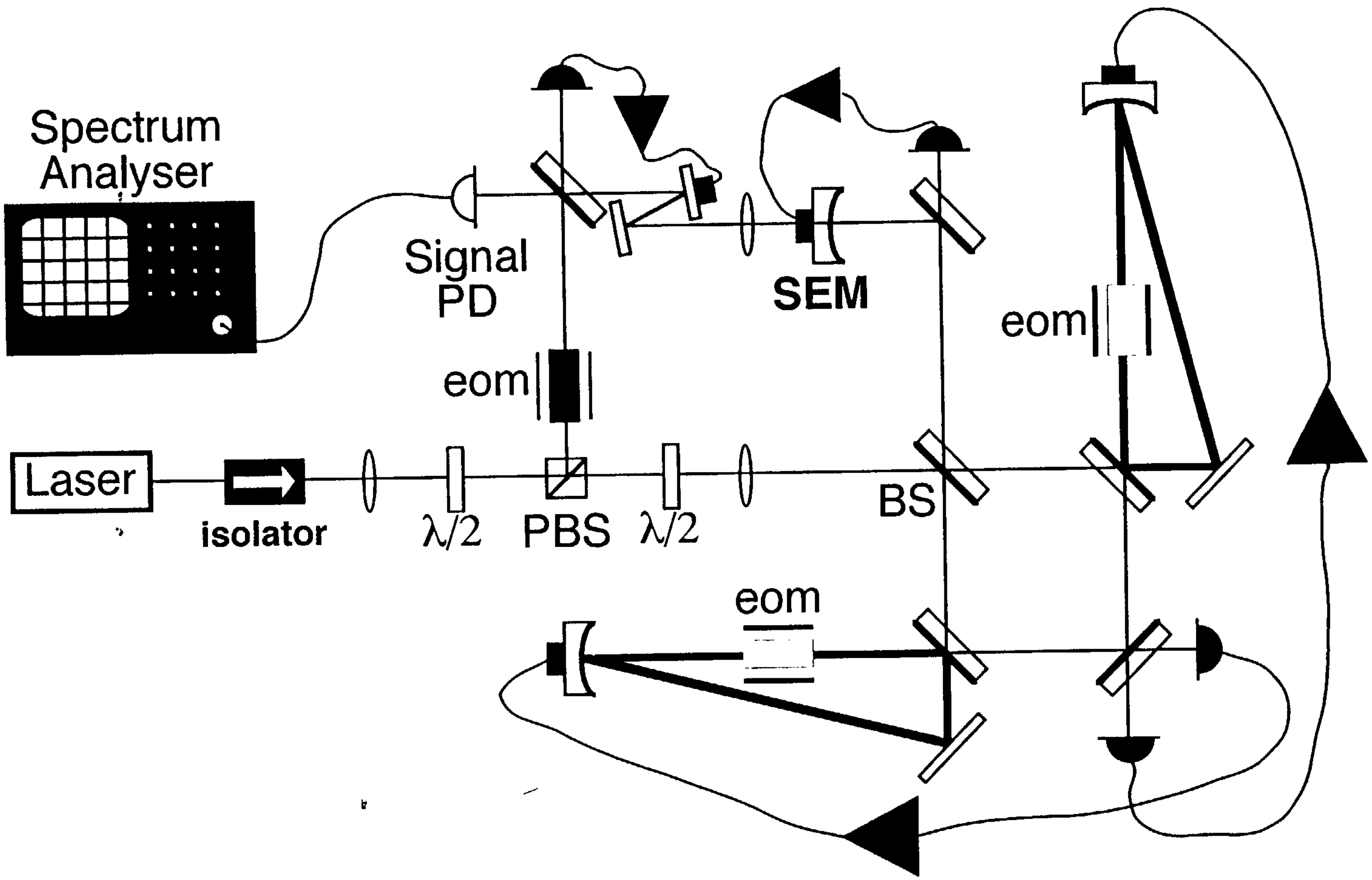




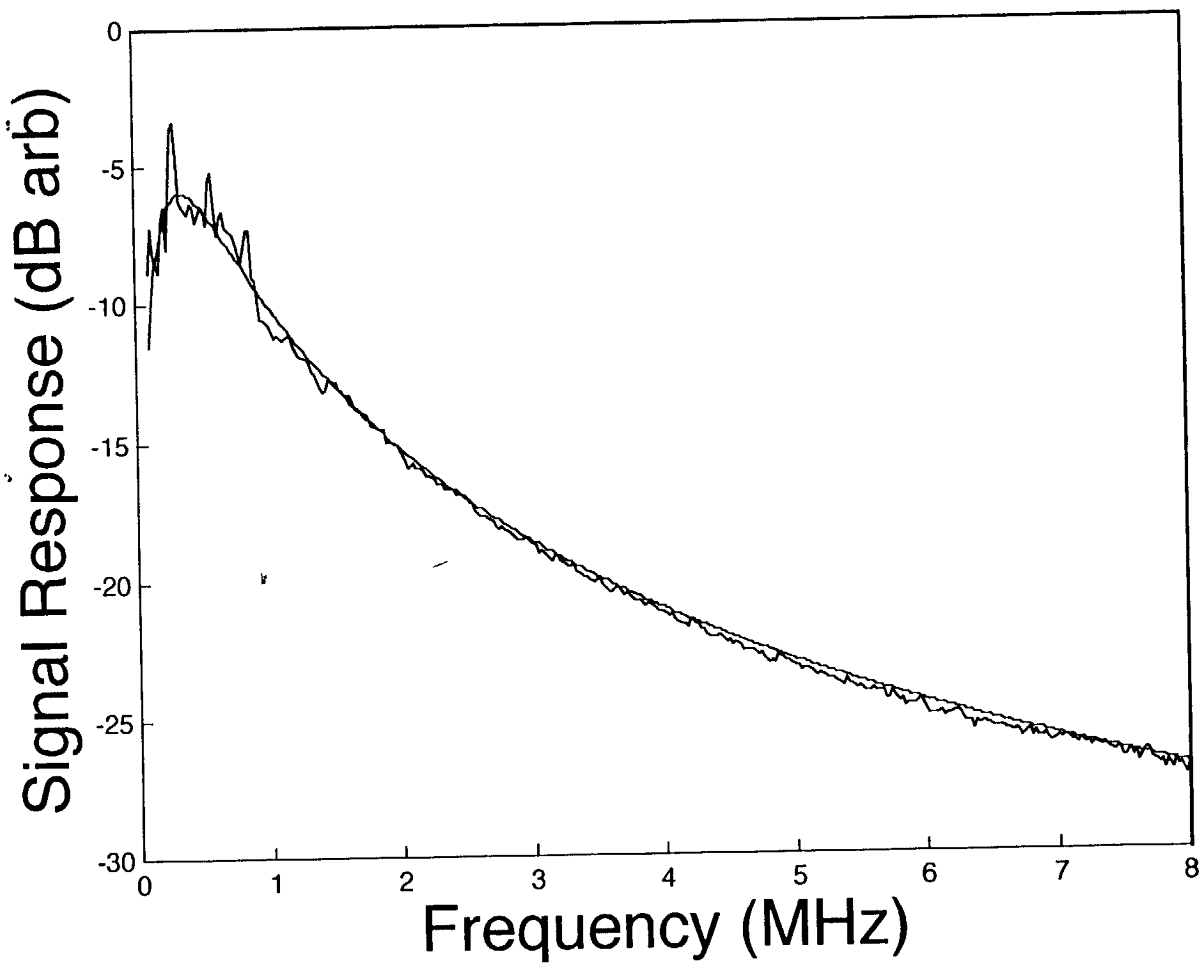
Resonant Sideband Extraction
in a Michelson



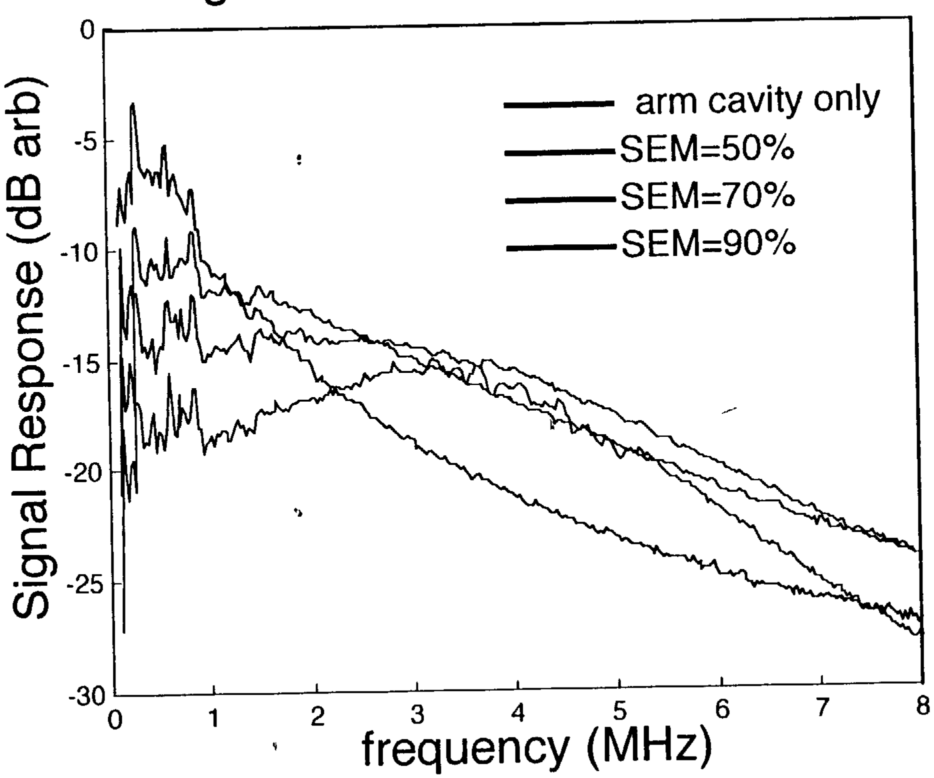
Detailed Experimental Setup



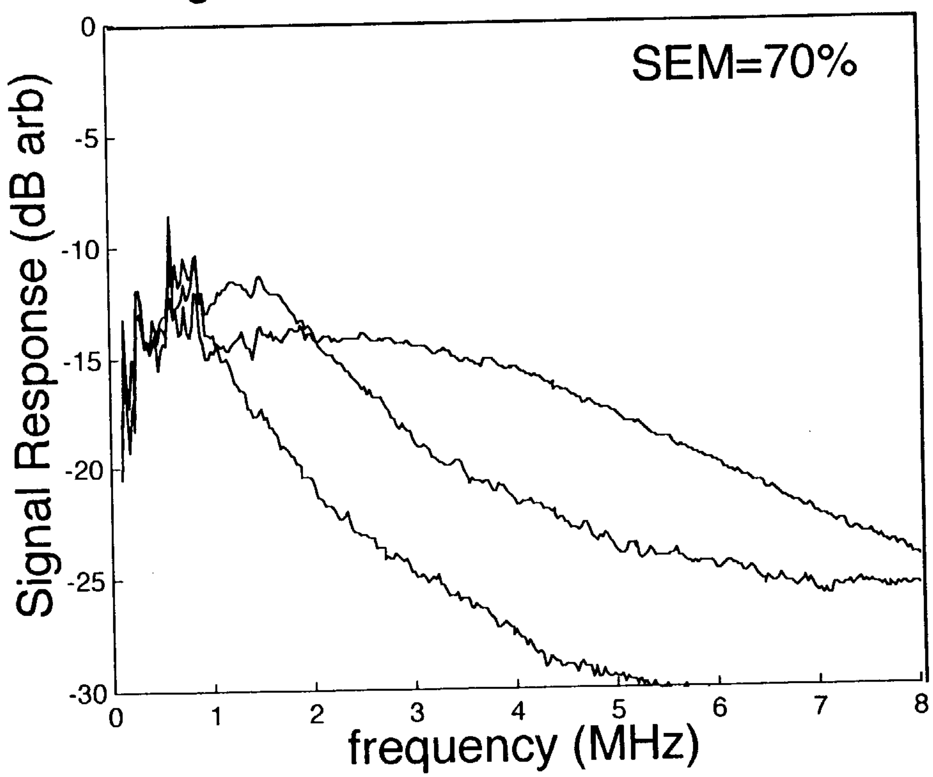
Frequency Response of Sagnac with arm cavities



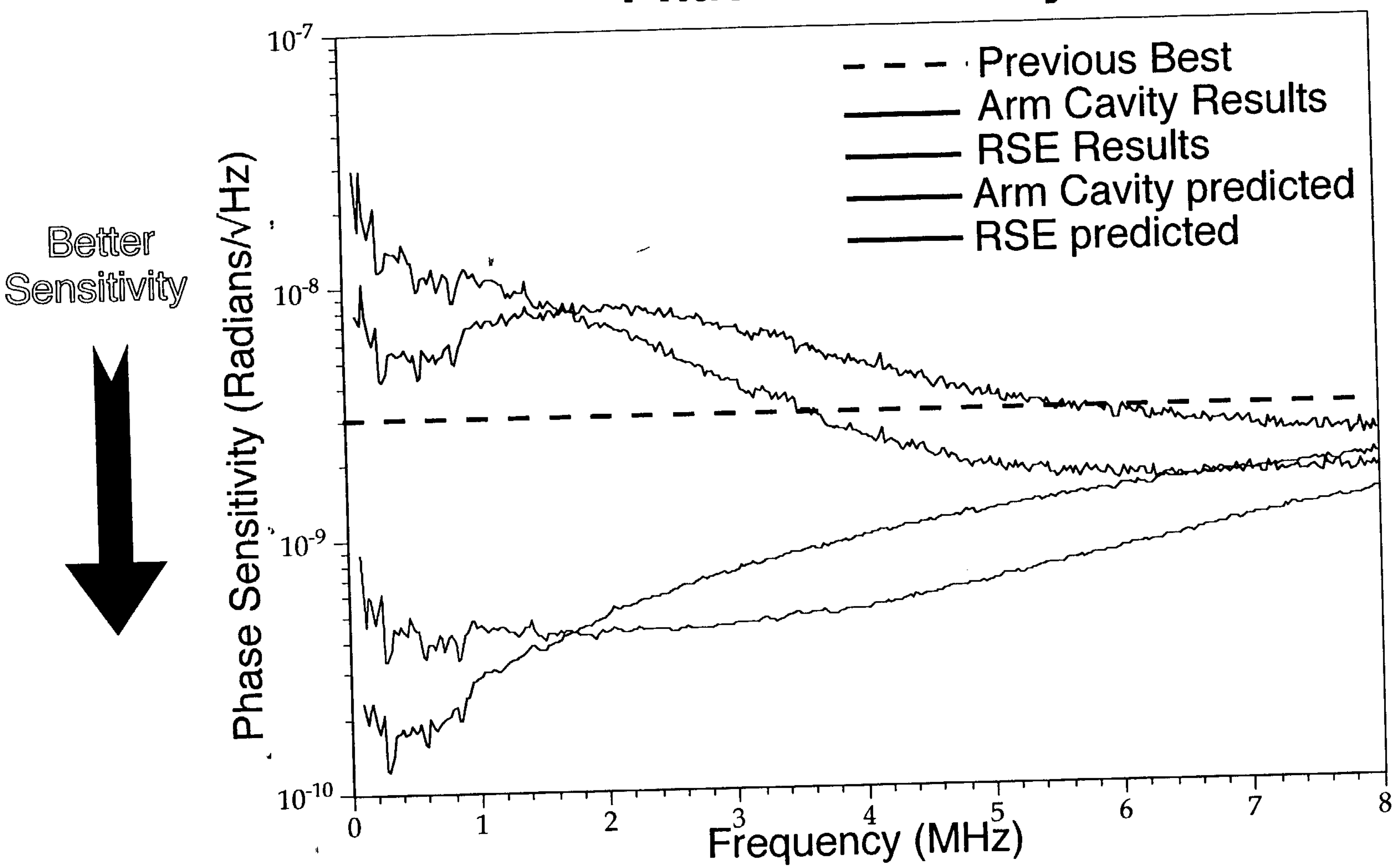
Frequency Response for Different Signal Extraction Mirrors (SEM)



Frequency Response for Different Signal Extraction Cavity Detuning



Phase Sensitivity



Conclusion

- ◊ Demonstrated resonant sideband extraction in a Sagnac interferometer.
- ◊ Increased bandwidth by factor >5
  Incresed sensitivity by 6dB outside the cavity bandwidth.
- ◊ Observed tunable behaviour for high reflectivity signal extraction mirrors.
- ◊ Found resonant sideband extraction system to increase the importance 50:50 beamsplitter.

LIGO Science Collaboration
Configurations Working Group

ACIGA Progress Report

Achievements

- We have built and tested on the bench top
  16 bounce delay line Sagnac;
  an arm ring cavity (Finesse ~ 80) Sagnac interferometer;
  resonant sideband extraction Sagnac interferometer.

- Conclude: we would not use the Sagnac arrangement in a device with arm cavities.

- Numerical simulations of geometric imperfections predict that the Michelson is more tolerant to these types of error than a Sagnac;
- ACIGA(UWA) has implemented power recycling on its 8 m interferometer. Wavefront sensing is required to stabilise the fringe.

Objectives next 6 months (ACIGA)

- design a control system and a signal extraction system suitable for a suspended mass, high finesse dual recycling interferometer

- test the system out on a bench device which will have the same optical parameters as a proposed suspended instrument;

- develop a wavefront sensing system;

- design the optical system for an experiment to measure the frequency distribution of thermal noise.

Note 1, Linda Turner, 04/21/98 09:40:00 AM
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