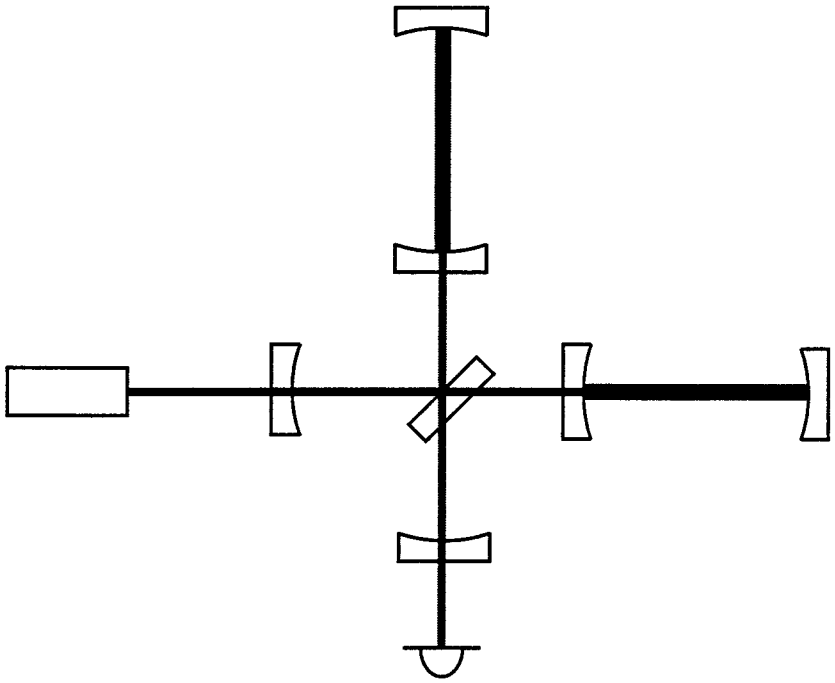
Signal Recycling and Resonant Sideband Extraction

Science Integration Meeting

Dec. 12, 96



Seiji Kawamura

James Mason

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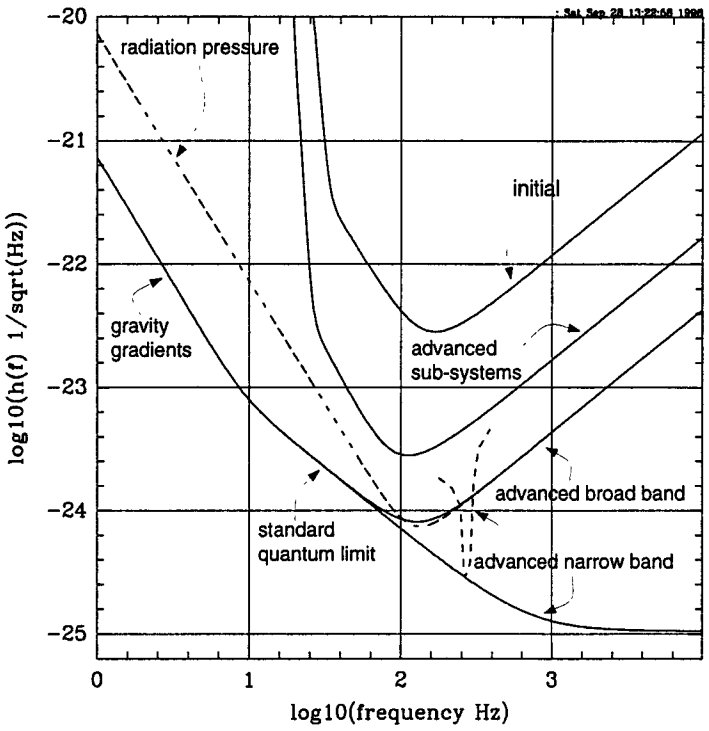
What's good with SR and RSE?

- Narrow band operation is possible.



- High power operation is possible. (RSE)
  - ››Less power at a beamsplitter

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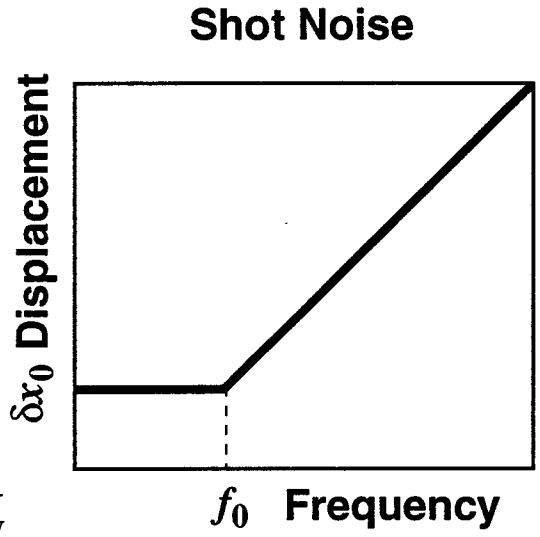
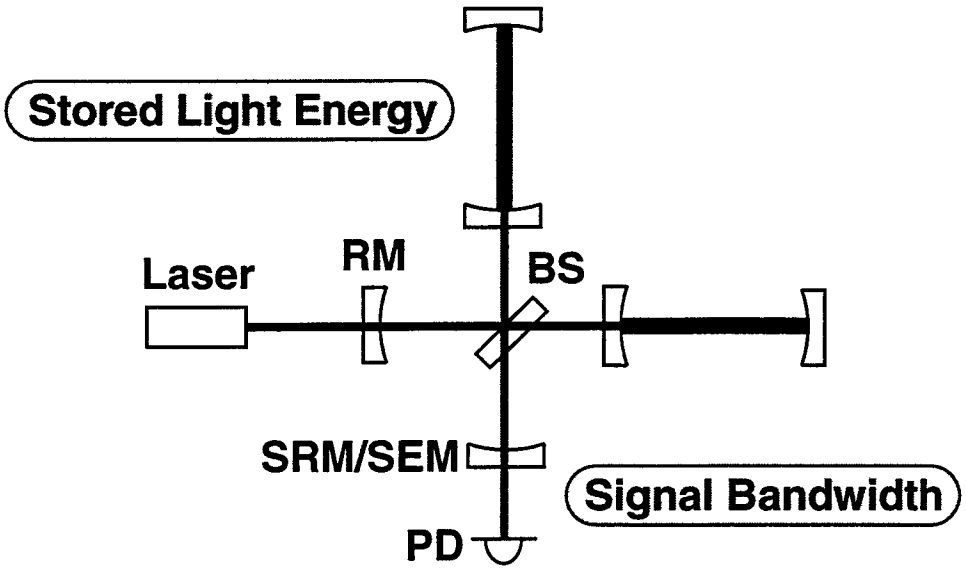
Sensitivity Theorem (Mizuno)



$$\delta x_0 \geq l \cdot \sqrt{\frac{2\bar{h}\lambda}{\pi c}} \cdot \sqrt{\frac{\Delta f_{\mathrm{BW}}}{E}}$$

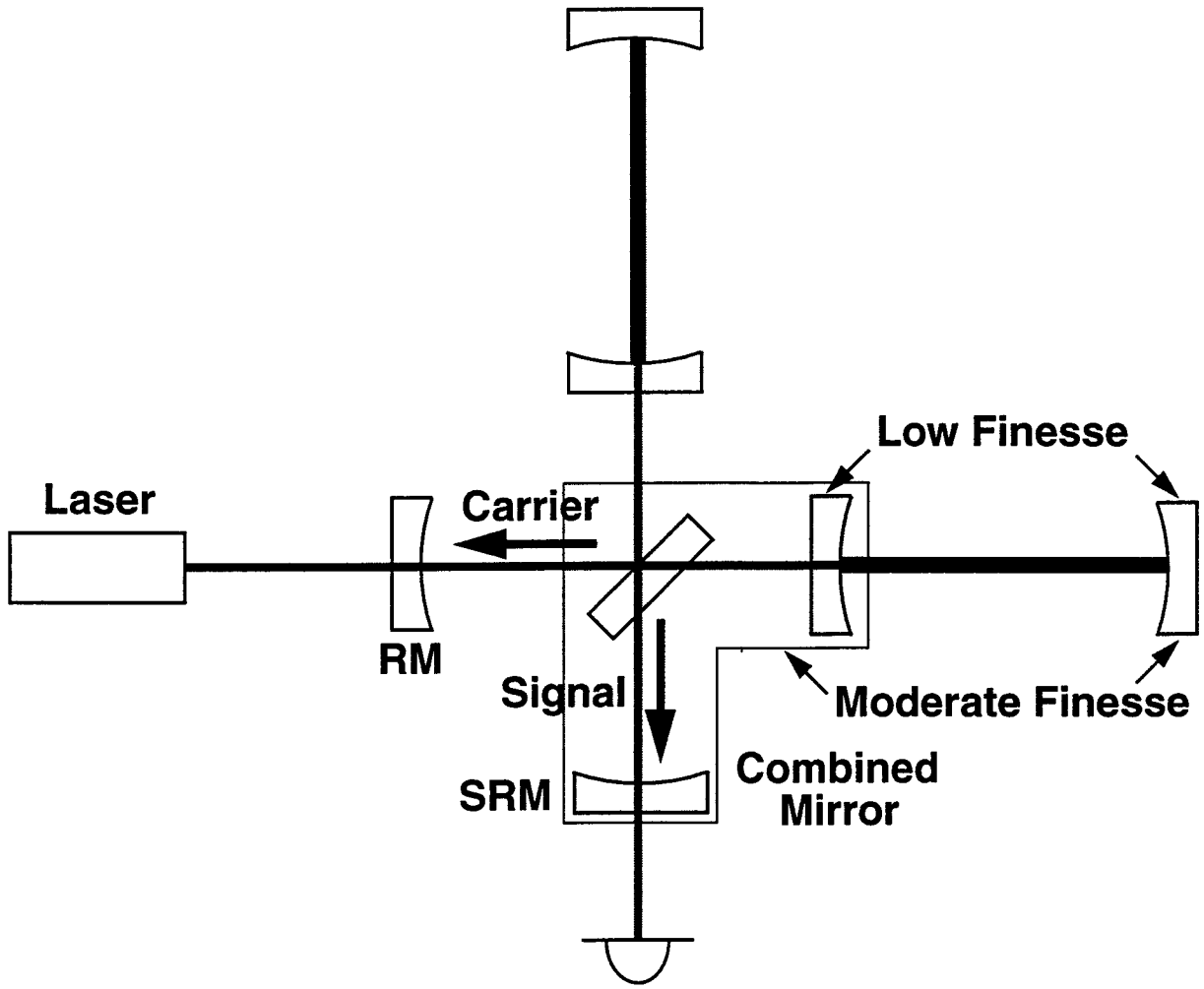


Principle of Signal Recycling (Meers)

Arm Cavity: low finesse

RM: to increase stored light energy

SRM: to narrow signal bandwidth



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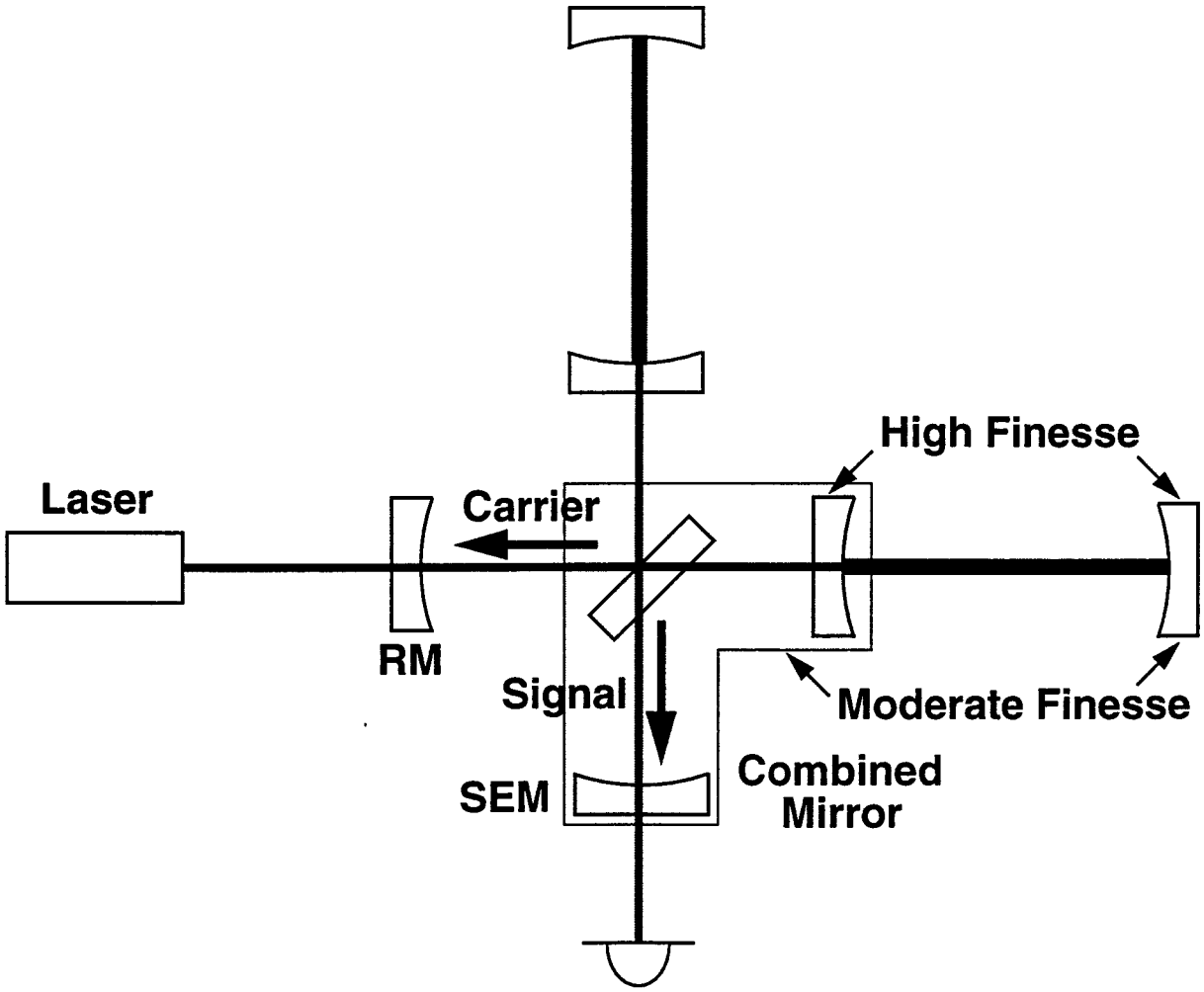
Principle of Resonant Sideband Extraction (Mizuno)

Arm Cavity: high finesse
RM: to increase stored light energy
SEM: to broaden signal bandwidth



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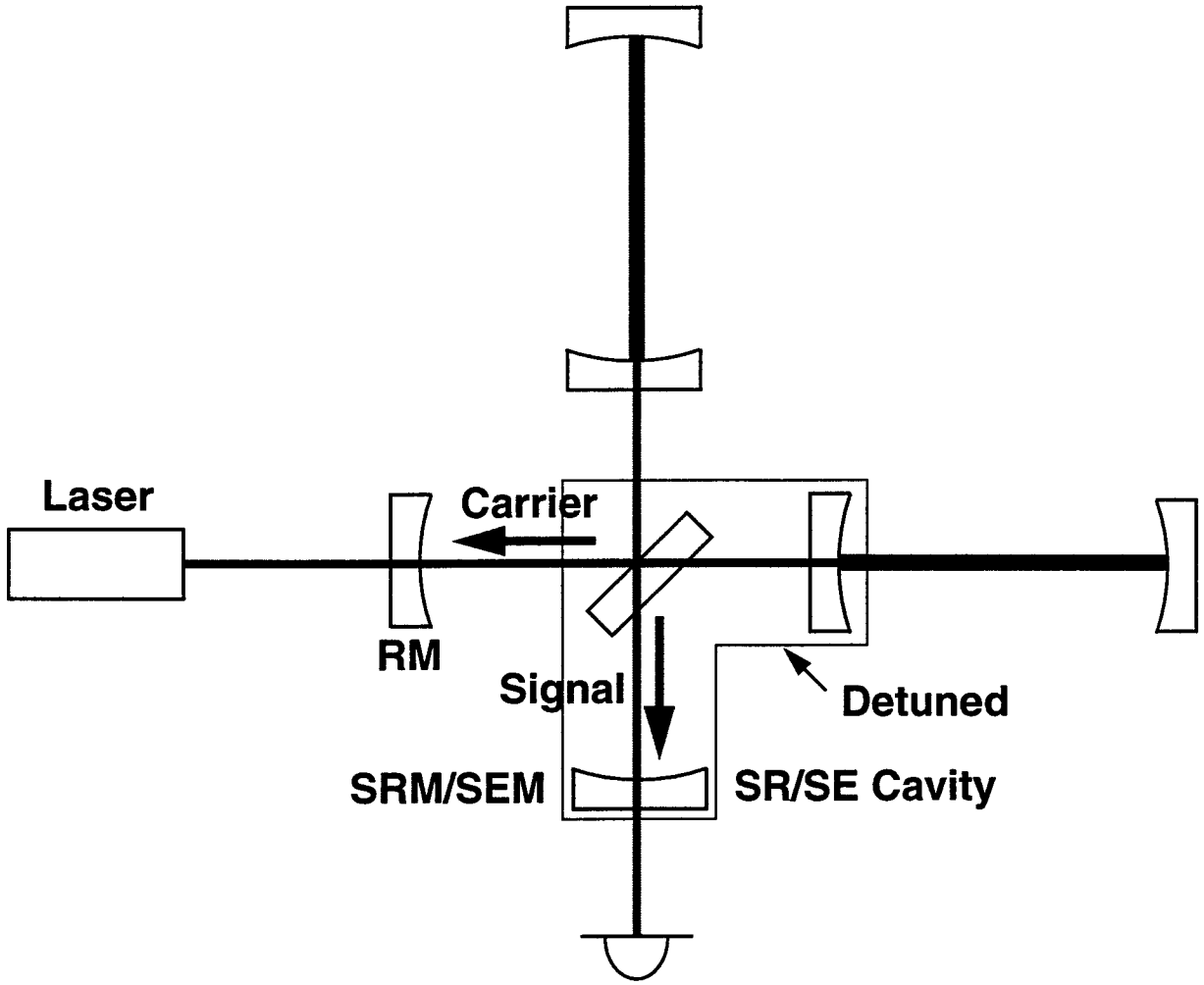
Narrow-band Operation

Arm Cavity: tuned to carrier
SR/SE Cavity: detuned to carrier; tuned to signal



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Experiment of Signal Recycling (Strain)

- Setup
  - ››No arm cavity
  - ››Dual recycling
  - ››External modulation scheme
- Results
  - ››Improved the sensitivity around 250 kHz by a factor of 7 with the DR scheme compared with no-SRM configuration
  - ››Good agreement with the theory

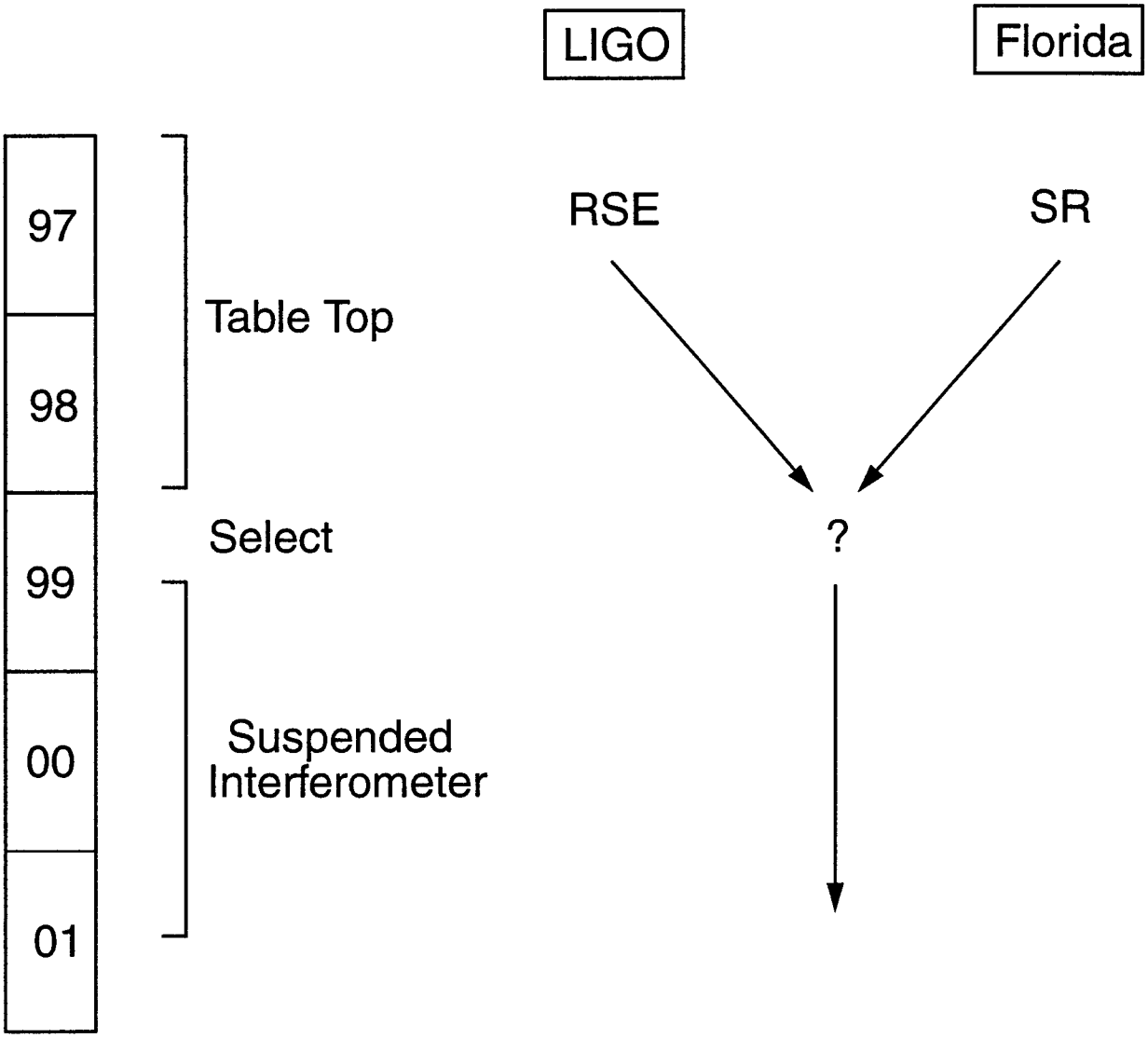
Experiment of Resonant Sideband Extraction (Heinzel)

- Setup
  - ››No power recycling
  - ››External modulation scheme
  - ››Separate locking scheme for arm cavities
  - ››Arm cavity finesse ~3,000
- Results
  - ››Improved the sensitivity around 250 kHz by ~8 dB with the RSE scheme compared with no-SEM configuration
  - ››Good agreement with the theory

Comparison between SR and RSE

Item	SR	RSE
Arm cavity finesse	Low	High
Arm cavity	Not necessary	Necessary
Power at BS	High	Low
BS distortion	Large	Small
Compound cavity	Anti-resonant	Resonant
Tuning of compound cavity	Not severe	Severe
Table top experiment	Easy	Difficult

Research Program



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Significance of Two Table Top Experiments

- First experiment of DR and RSE using the Schnupp modulation
  - ››Sensing and control the length signals
  - ››Switching between broad band mode to narrow band mode
- Comparison
  - ››Practically achievable broad and narrow band sensitivity
  - ››Ease of the band-switching, lock holding, and lock acquisition
  - ››General feasibility and reliability
  - ››Future potentiality
- General experience with each method as a basis for selection for the 40 m interferometer experiment

Significance of the experiment on a suspended interferometer

- To investigate issues associated with scaling to a suspended interferometer
- To learn the way to operate the interferometer (including control issues such as lock acquisition and hold) with the scheme in more realistic condition
- To achieve the shot noise limited sensitivity predicted by the model
- To assess the feasibility of implementing at the level of a full scale enhanced LIGO

Proposal about Resources

- RSE table top experiment
  - ››at Caltech
  - ››S. Kawamura, J. Logan, J. Mason
  - ››Start preparation --- Jan. 97
  - ››Start experiment --- July. 97
  - ››Finish experiment --- Dec. 98
- RSE or SR on a suspended interferometer
  - ››on the 40m at Caltech
  - ››S. Kawamura, J. Logan, Postdocs, Grads.
  - ››99 - 01