Interferometry part 1 : The evolution of the humble Michelson Interferometer

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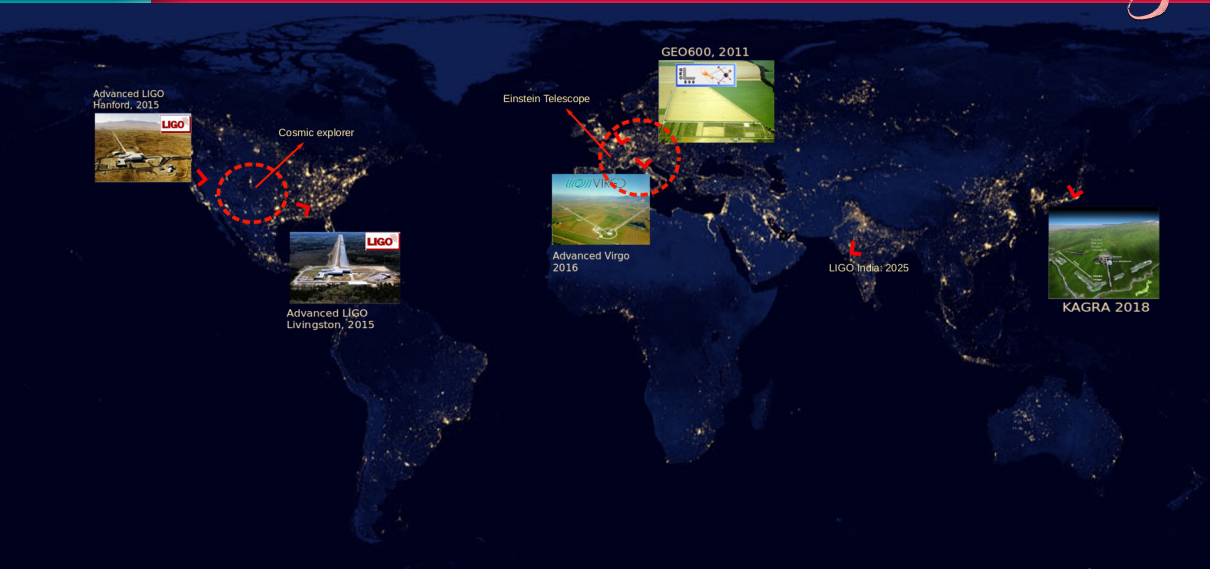
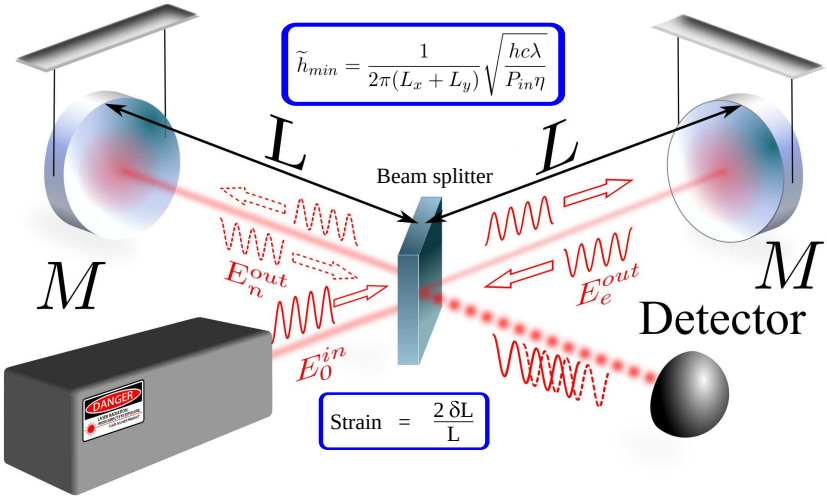
Gravitational wave detector network



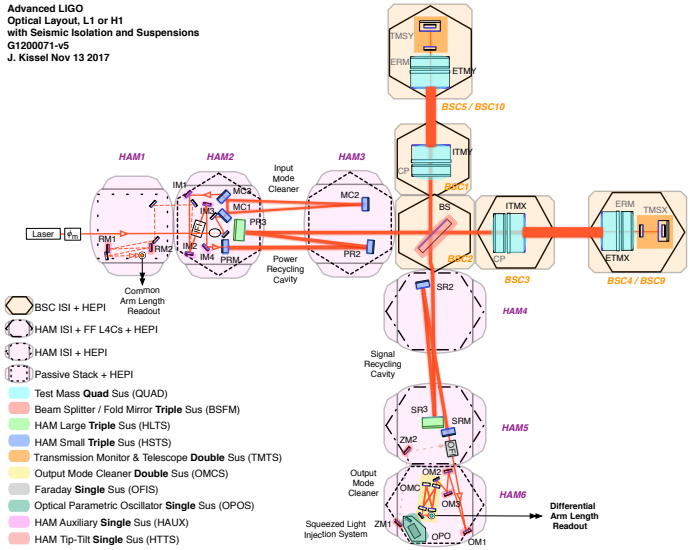
Slide courtesy: H.Lück, LIGO DCC: G1601727, NASA webpage: The earth at night

A gravitational wave detector



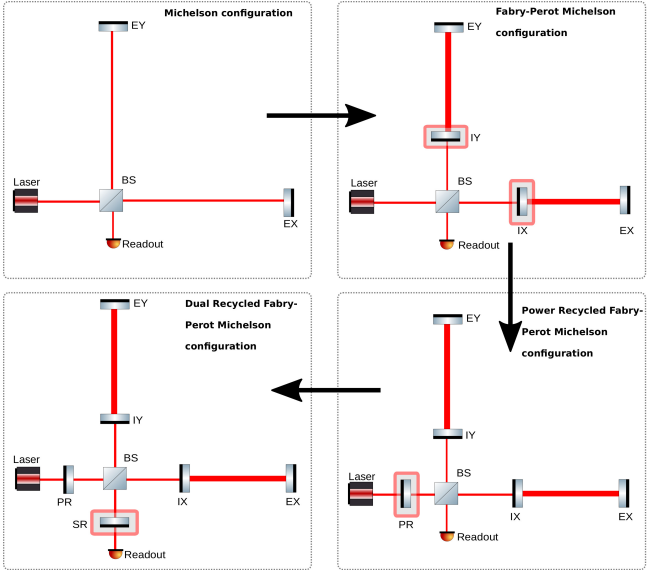
Slide courtesy: S.Danilishin

Advanced LIGO



Picture courtesy: J.Kissel, LIGO DCC: G1200071

An advanced gravitational wave detector

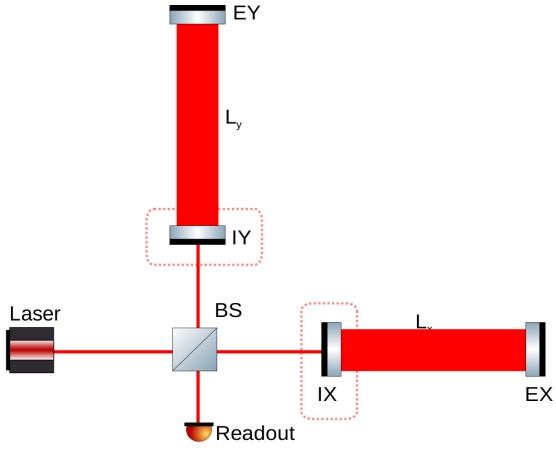


Fabry Perot Michelson

- To detect a 1kHz GW using a simple Michelson -> 75km
- Fabry-Perot cavity increases the stored power in the arm
- It also increases the accumulation time of the signal

$$\frac{L_{\mathrm{FP}}}{L_{\mathrm{MICH}}} = \frac{2F}{\pi}$$

$$h(f) = \frac{1}{8FL}\sqrt{\left(\frac{2hc\lambda}{P_{in}}\right)\left(1+\left(\frac{f}{f_p}\right)^2\right)}$$

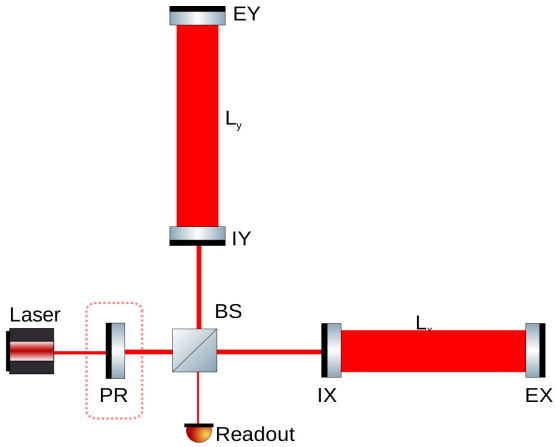


Power recycled Fabry Perot Michelson

- How do we increase the laser power in the ifo?
- Additional mirror in the input path
- Optical recycling! Increased laser power going into ifo!
- Compound cavity with, high finesse cavity from input side (Common ARm Motion)
- For GW, just an arm cavity (Differential ARm Motion)

$$G_{PR} = \left(\frac{t_{PR}}{1 - r_{PR}\, r_{MICH}} \right)^2$$

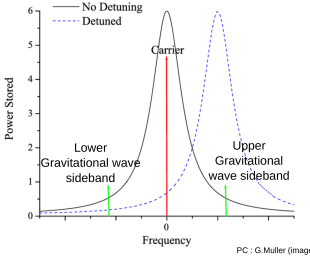
$$h(f) = \frac{1}{\sqrt{G_{PR}}}\, h(f)_{FPMI}$$



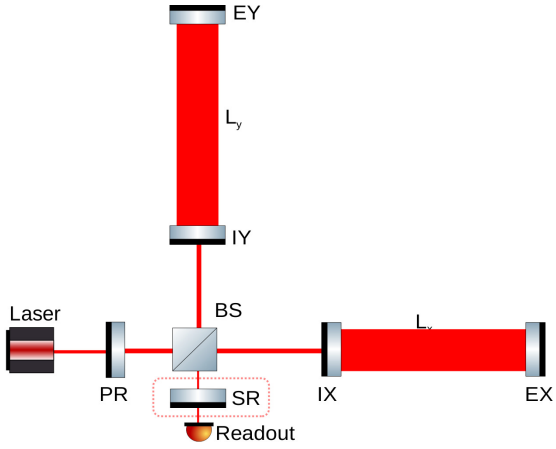
Slide idea: K.Arai, LIGO DCC: G1601926

Signal recycling

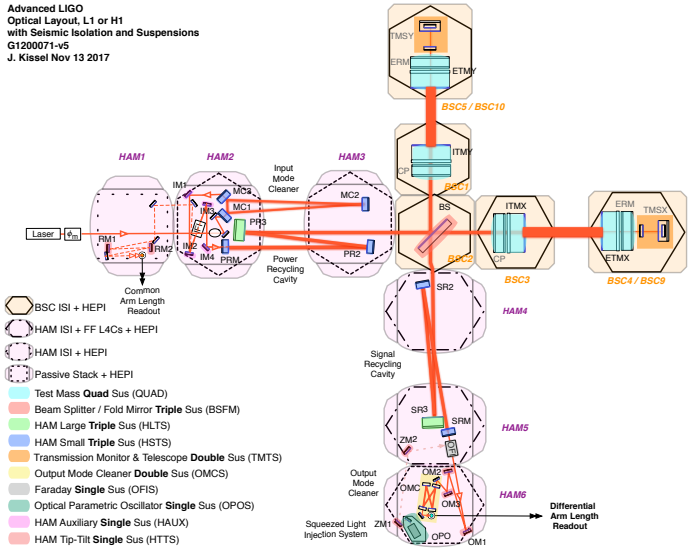
- Idea similar to power recycling,increase storage time of an interferometer for GW signals
- Signal sidebands can be 'recycled' by adding a mirror in the output path
- SR tunes the bandwidth of the interferometer
- Optimize the sensitivity curve depending on the noise shape; Dynamic signal tracking



PC : G.Muller (image modified)



Advanced LIGO



Picture courtesy: J.Kissel, LIGO DCC: G1200071