From vibration insensitive laser to to the cavity length change enhanced sensitivity.

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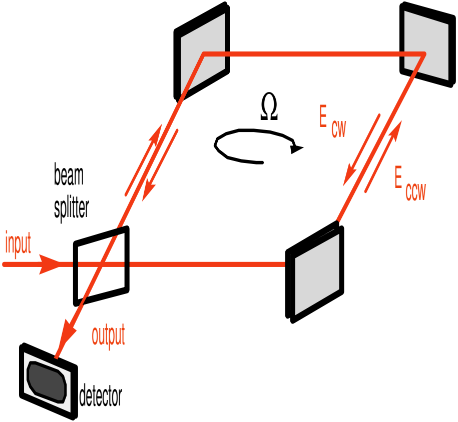
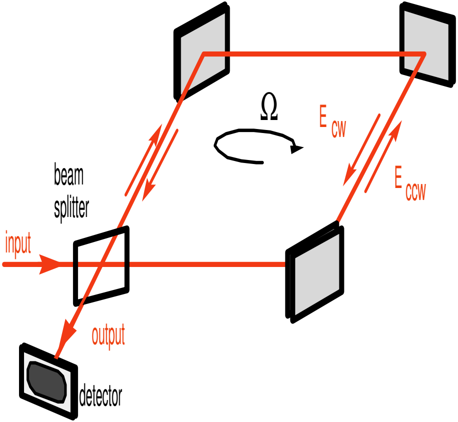
LPHYS, 16 July 2018

Dispersive cavity response



$$\Delta f = f_0 \frac{\Delta L}{L}$$



$$\Delta f = f_0 \frac{\Delta L}{L} \frac{1}{n_g} = \Delta f_{empty} \frac{1}{n_g}$$

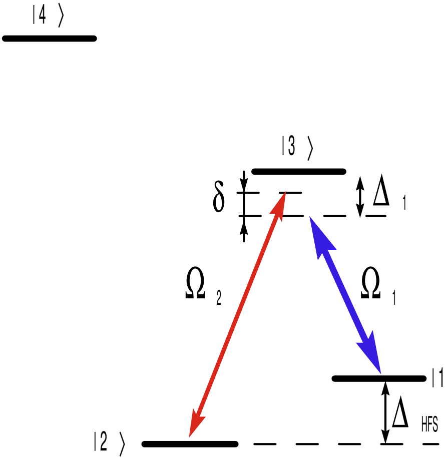
Group index

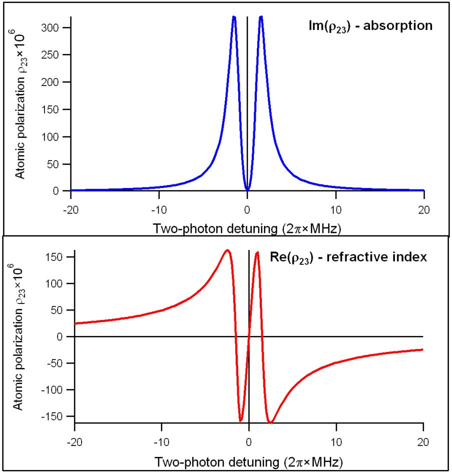
$$n_g(f) = n + f_0 \frac{\partial n}{\partial f}$$

$$v_g = c/n_g$$

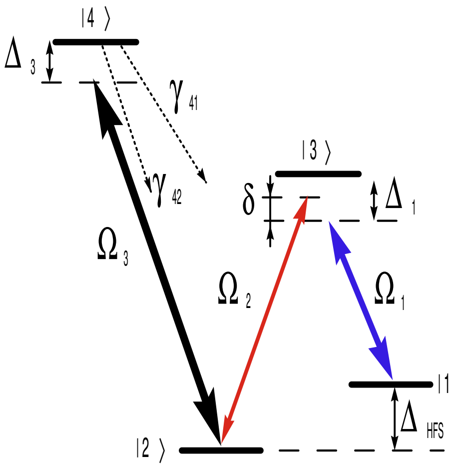
Cavity response enhanced if $n_g < 1$ i.e. under the fast light condition
Shahriar et al., PRA **75**, 053807 (2007)

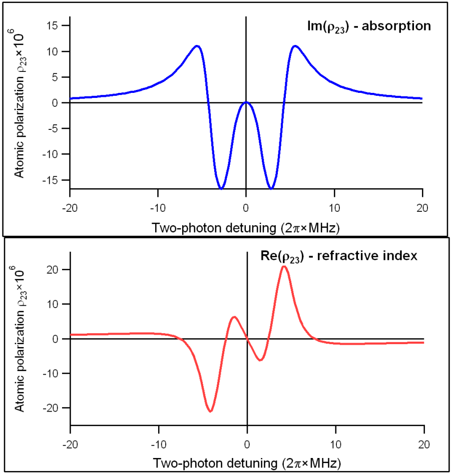
EIT - slow light





N-bar with four-wave mixing - fast and with gain

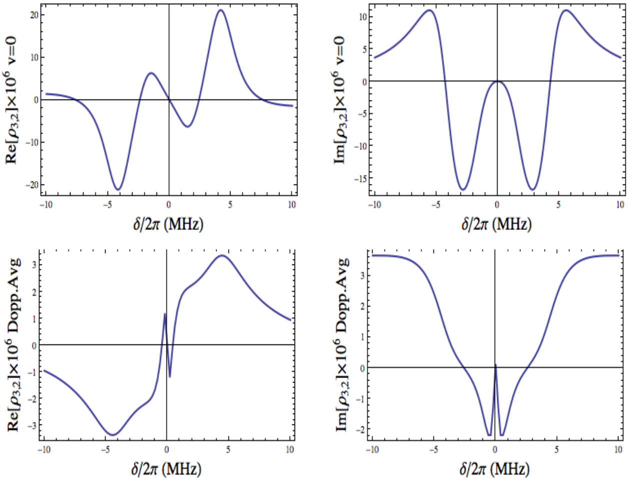




N-bar with Doppler averaging

Refractive index

Absorption

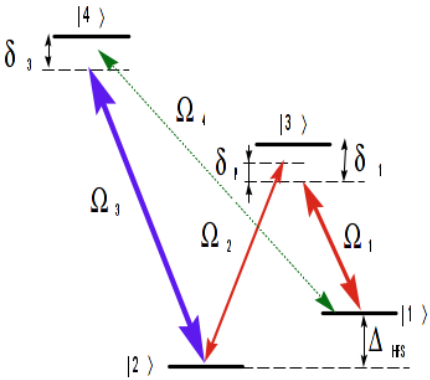


Stationary atoms

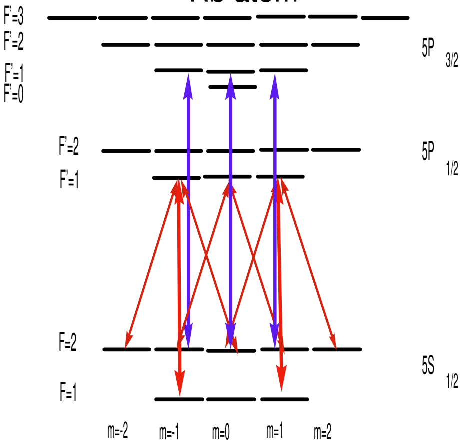
Room temperature
Doppler averaged

N-bar levels and fields diagram

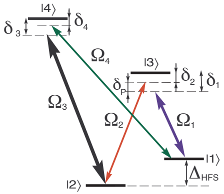
Artificial atom

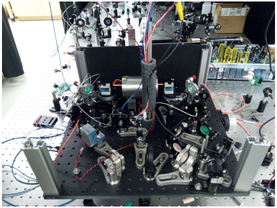


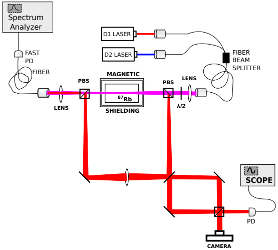
^{87}Rb atom



Setup and measured pulling factor



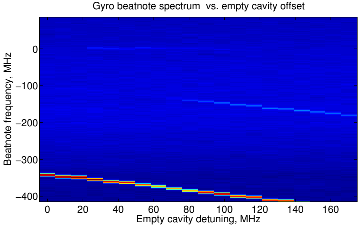


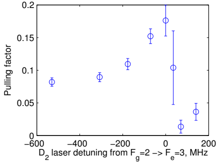


$$P.F. = \frac{\Delta f_{\text{dispersive}}}{\Delta f_{\text{empty}}}$$

$$= \frac{1}{n_g}$$

$$\Delta f_{\text{empty}} = f_0 \frac{\Delta L}{L}$$

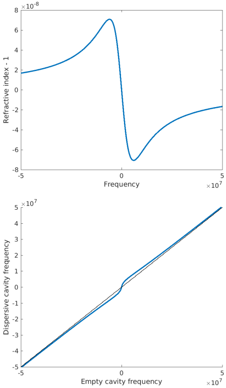




Cavity response in fast, slow, and super slow regimes

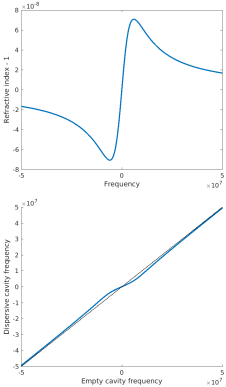
Fast

$dn/d\omega < 1$



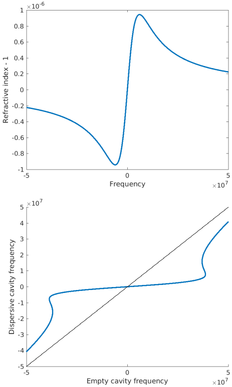
Slow

$dn/d\omega > 1$



Super slow

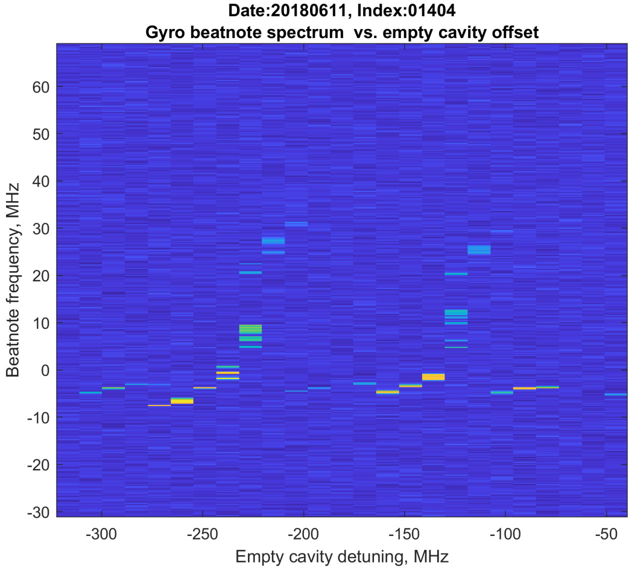
$dn/d\omega \gg 1$



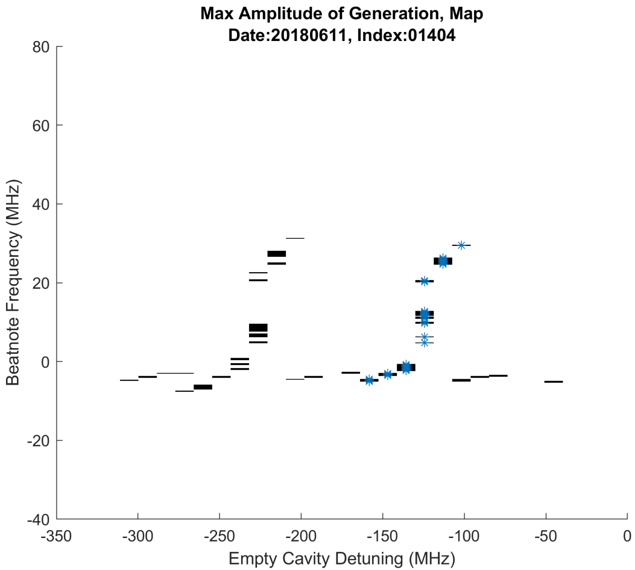
Lasing equation

$$n(\omega)L = m\lambda = mc\frac{2\pi}{\omega}$$

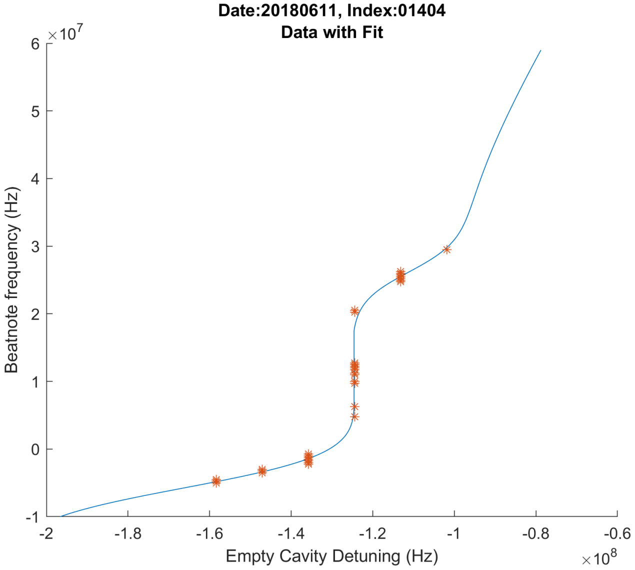
Beatnote map with “high” pulling factor



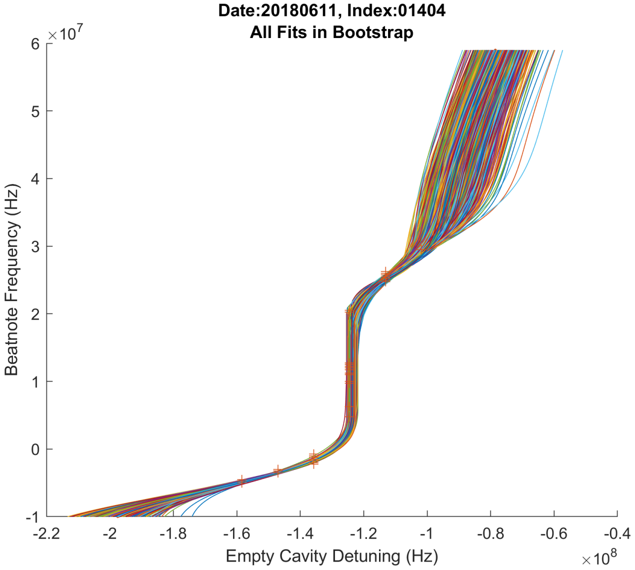
Beatnote map with “high” pulling factor



Beatnote map with “high” pulling factor

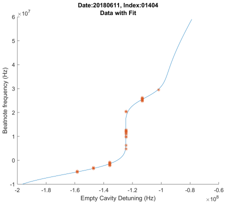


Beatnote map with “high” pulling factor

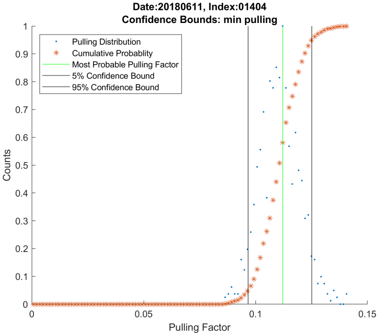


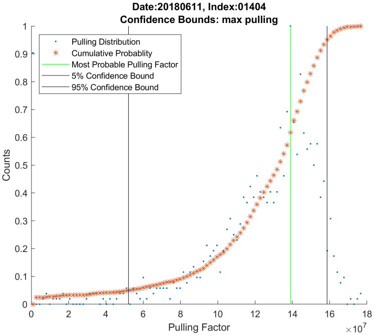
Confidence in "high" and "low" pulling factors

Low PF$= 0.112$
with 90% bounds
$(0.096, 0.125)$



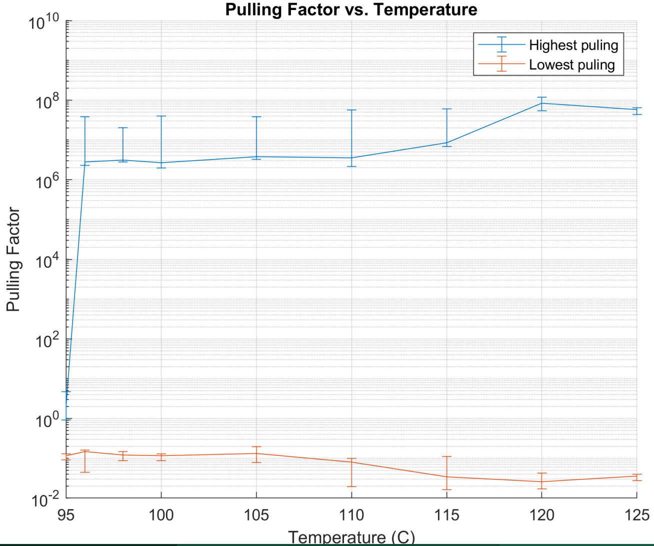
High PF$= 120 \times 10^6$
with 90% bounds
$(52 \times 10^6, 158 \times 10^6)$



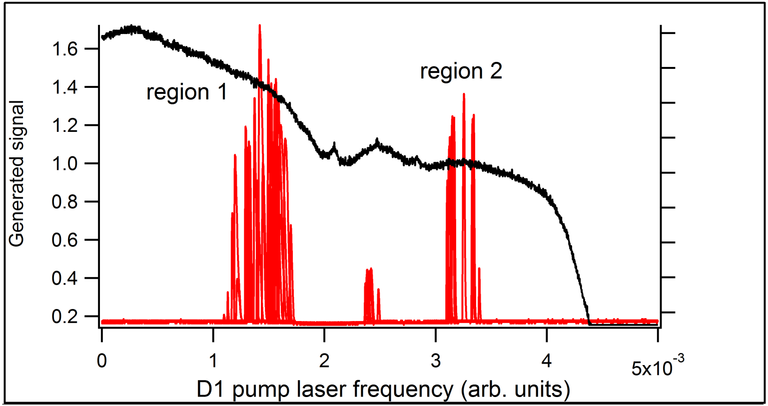


Pulling factor vs temperature

Total power 70 mW, $\text{Power}_{D1}/\text{Power}_{D2} = 1/3$

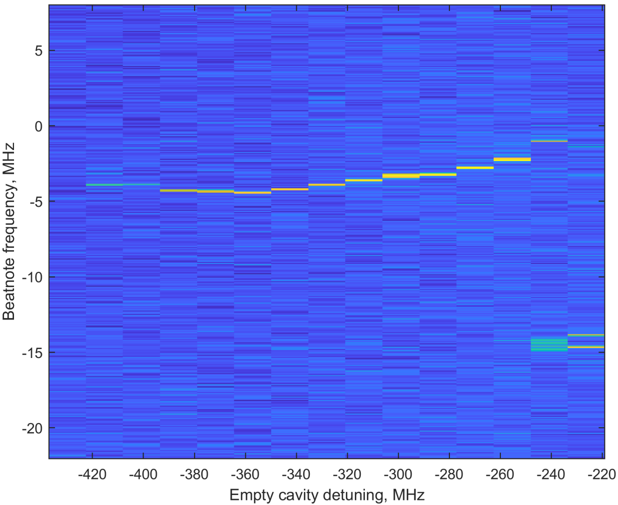


Pulling factor vs detuning dependence

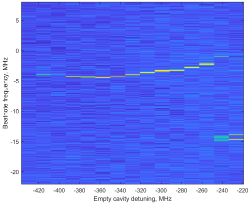


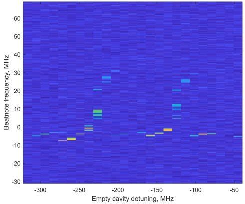
- Region 1: Pulling factor ≤ 1 (no discontinuities), high laser output
- Region 2: Large pulling $\gg 1$
- Region 3 (middle): vibration free regime

Laser insensitivity to cavity motion

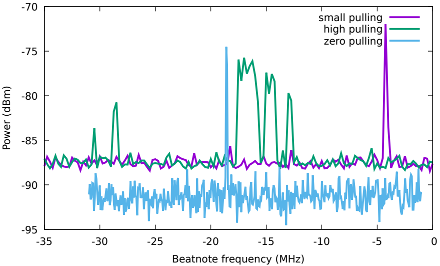


Beatnotes width comparison





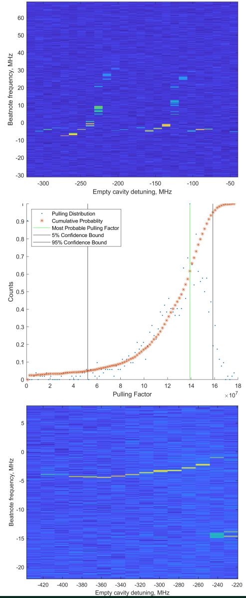
Quantum linewidth $\sim 1/n_g^2 = (P.F.)^2$



Vibrations-broadened linewidth $\sim 1/n_g = P.F.$

People

Summary



- We obtained enhanced cavity response as high 10^8 and potentially reached ∞
- Under certain condition the laser output does not depend on cavity length, i.e. we have vibration insensitive laser