Modification of dispersion and pulling sensitivity via four wave mixing in a ring cavity

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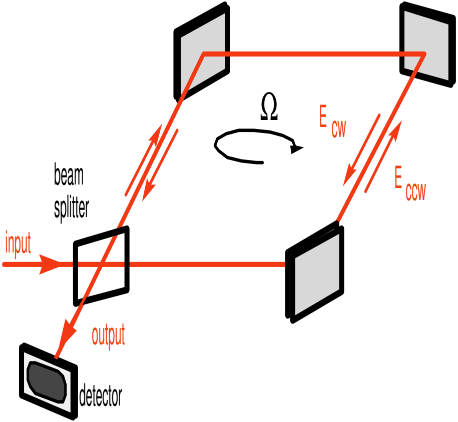
Rochester Scientific

DAMOP, 10 June 2015

Sagnac effect and cavity response



$$\Delta p = c\Delta t = \frac{4A\Omega}{c}$$

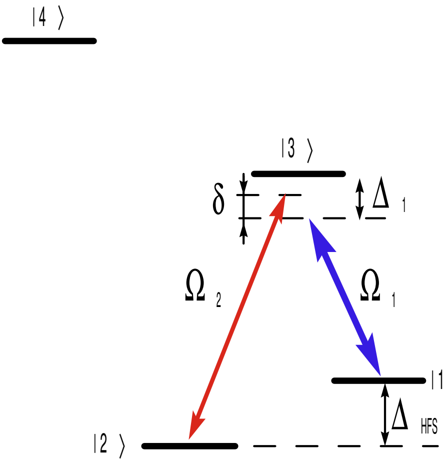
$$\Delta f = f_0 \frac{\Delta p}{p} \frac{1}{n_g} = \Delta f_{empty} \frac{1}{n_g}$$

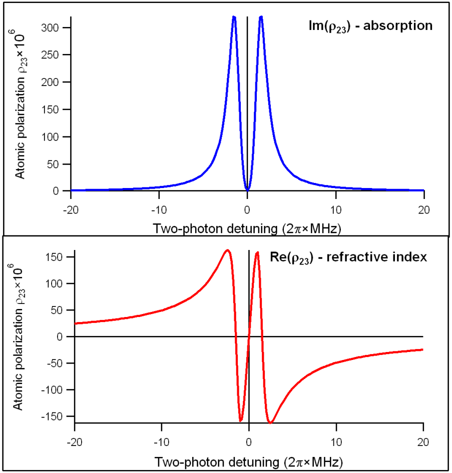
Group index

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

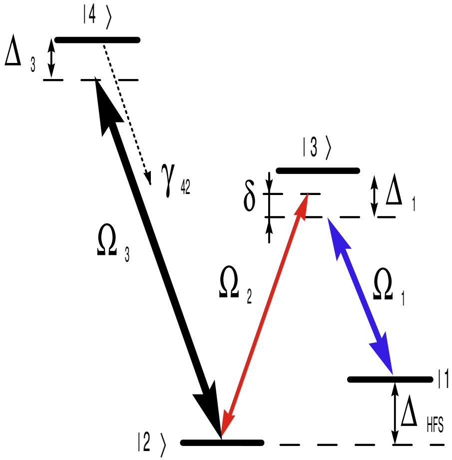
Cavity response enhanced if $n_g < 1$ i.e. under the fast light condition
Shahriar et al., PRA **75**, 053807 (2007)

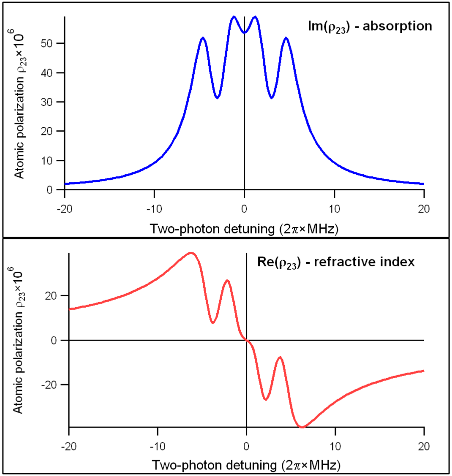
EIT - slow light



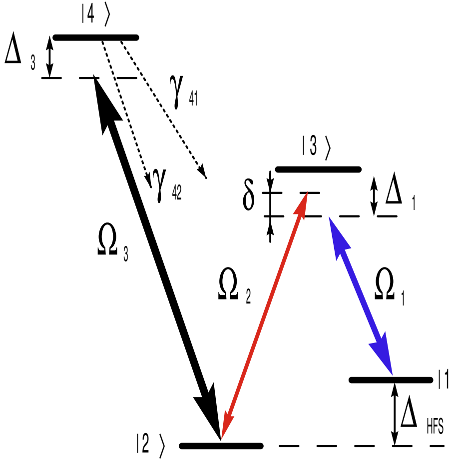


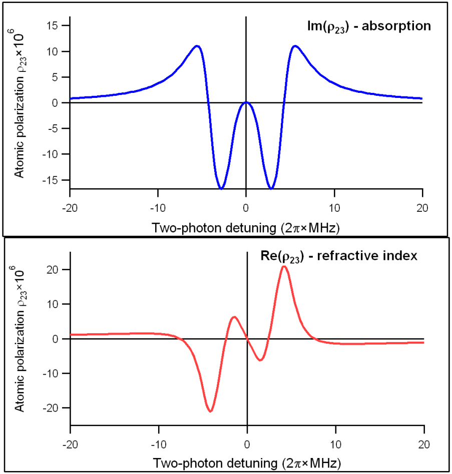
N-scheme, with forbidden transition - fast but no gain





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

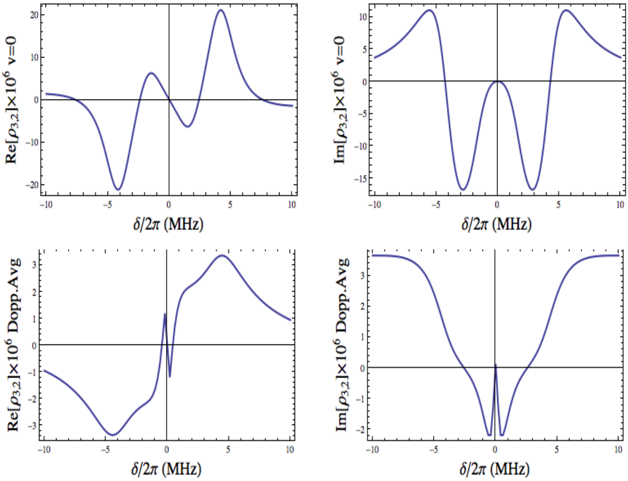




N-bar with Doppler averaging

Refractive index

Absorption

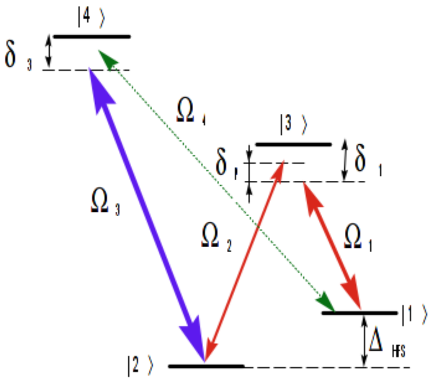


Stationary atoms

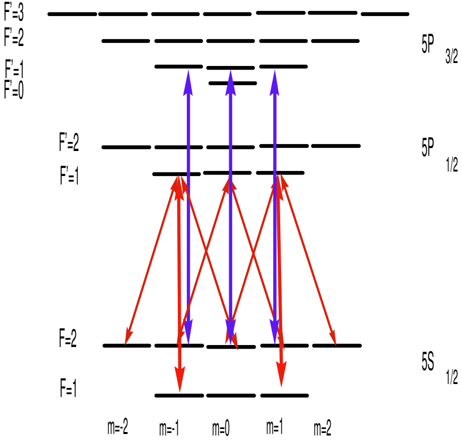
Room temperature
Doppler averaged

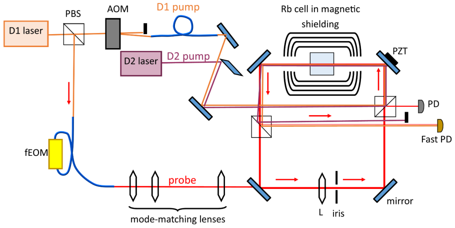
N-bar levels and fields diagram

Artificial atom

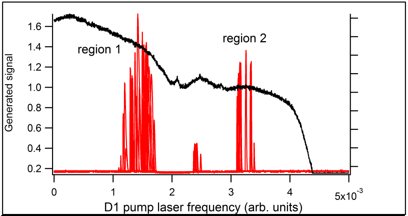


^{87}Rb atom

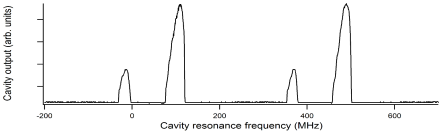


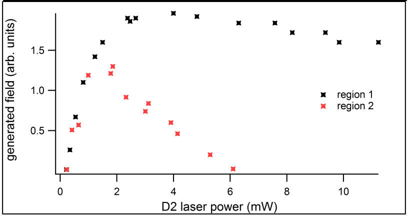


Ω_2 tuned around $F = 1 \rightarrow F' = 1, 2$



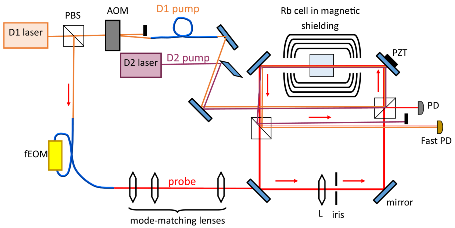
Finesse = 20



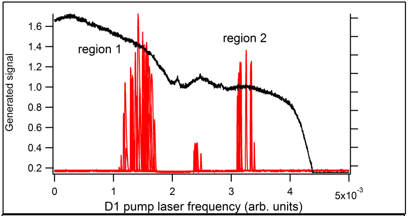


E. Mikhailov, *et al.* Optical Engineering, Issue 10, 53, 102709, (2014)

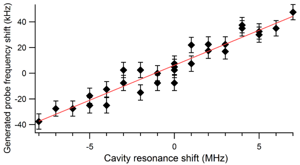
First gyro setup and its performance

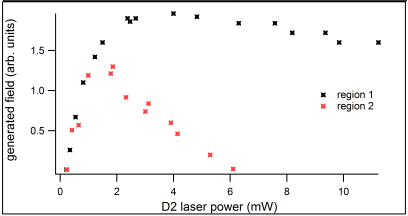


Ω_2 tuned around $F = 1 \to F' = 1, 2$



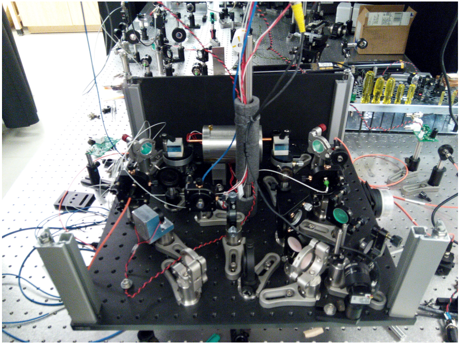
Finesse = 20 $\to$ Pulling $1/200$

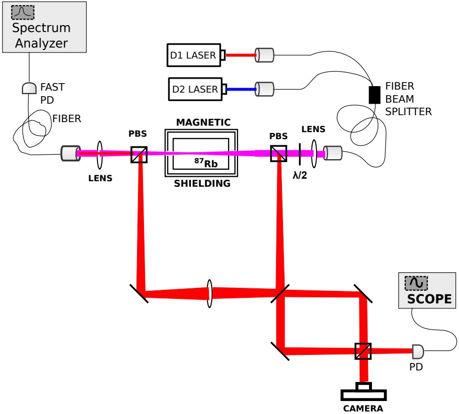




E. Mikhailov, *et al.* Optical Engineering, Issue 10, 53, 102709, (2014)

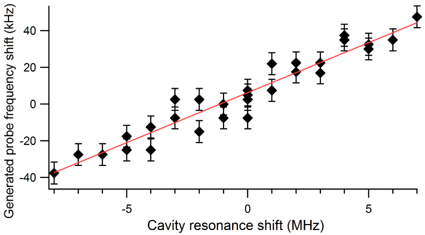
New gyro setup



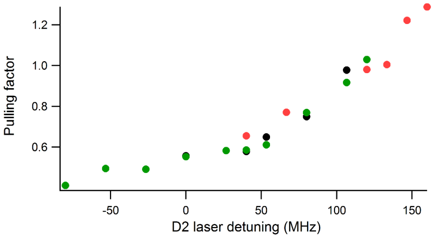


Gyro pulling - response to cavity length change

Old



New

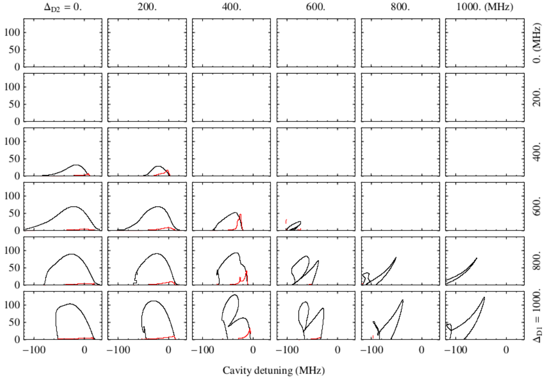


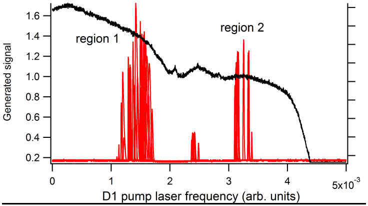
Pulling drastically improved by mainly two factors

- Higher finesse 20 $\rightarrow$ 70
- Higher pumping powers

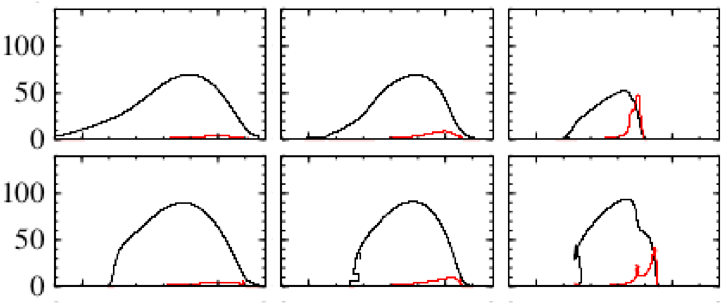
Higher pulling happens at D_2 detuning where lasing tends to stop

Gyro lasing vs. pumps detuning

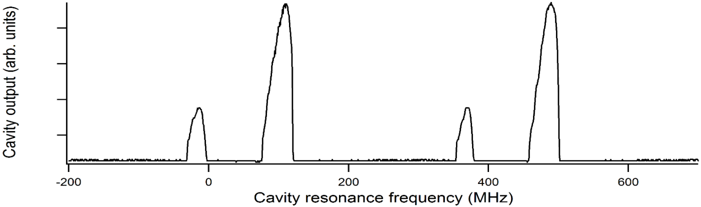




Gyro pulling vs. lasing location



Pulling ×100

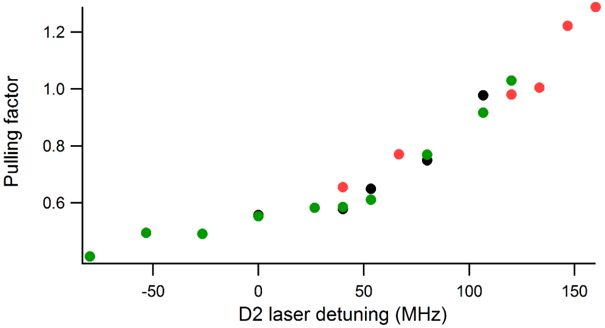


People

Irina Novikova, Matt T. Simons, Hunter Rew, Owen Wolfe (WM),
Dmitry Budker, Simon Rochester (Rochester Scientific).

Summary

- We demonstrated feasibility of fast laser
- Our laser has pulling factor exceeding 1



- We are working on the gyro locking at high pulling (steep slope) locations

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