Optical gyroscope with controllable dispersion in four wave mixing regime.

Eugeniy E. Mikhailov, Owen Wolfe, ShuangLi Du, Irina Novikova[1],
Simon Rochester, Dmitry Budker[2],

1

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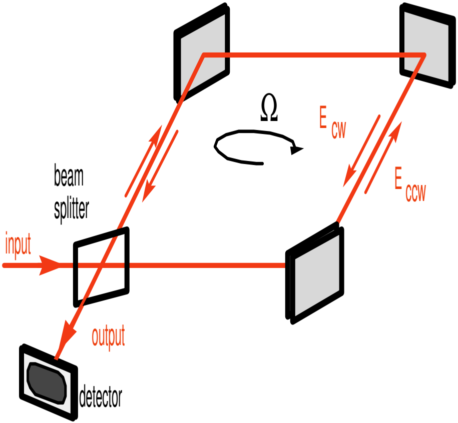
Rochester Scientific

DAMOP, 24 May 2016

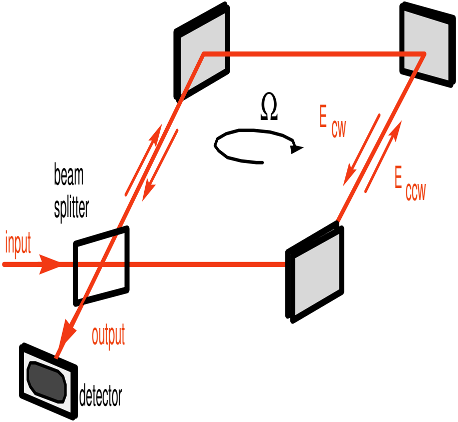
Sagnac effect and cavity response



$$\Delta p = \pm \Omega R t = \pm \frac{2A\Omega}{c}$$

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

Sagnac effect and cavity response



$$\Delta p = \pm \Omega R t = \pm \frac{2A\Omega}{c}$$

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

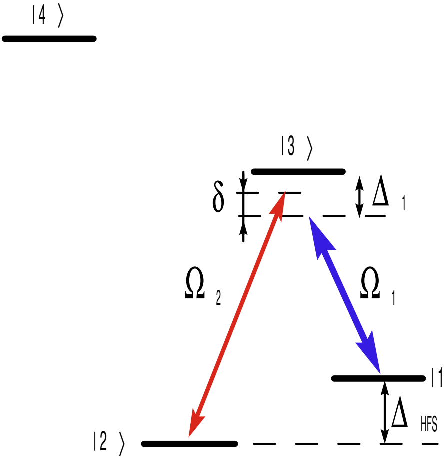
Group index

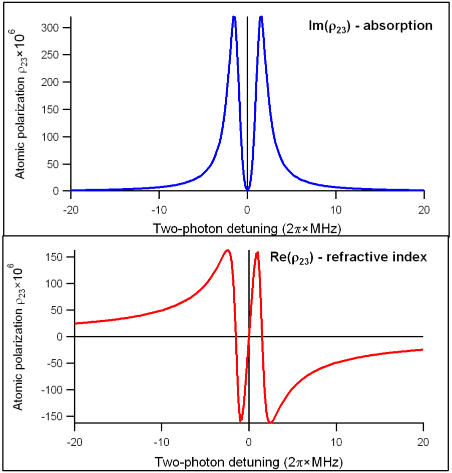
$$n_g(f) = n + f_0 \frac{\partial n}{\partial f}$$

$$v_g = c / n_g$$

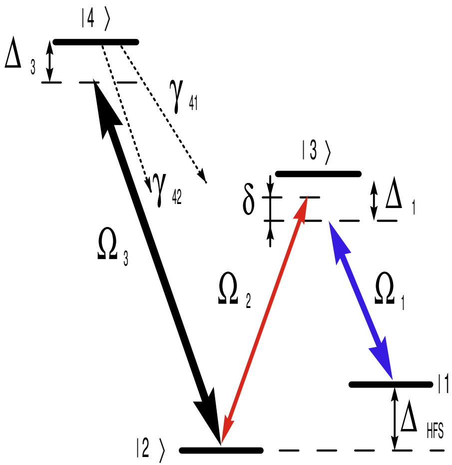
Cavity response enhanced if $n_g < 1$ i.e. under the fast light condition
Shahriar et al., PRA **75**, 053807 (2007)

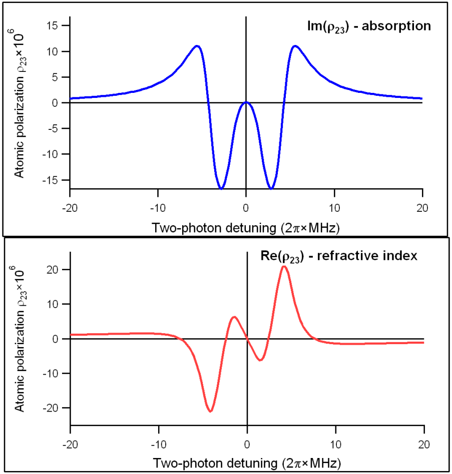
EIT - slow light





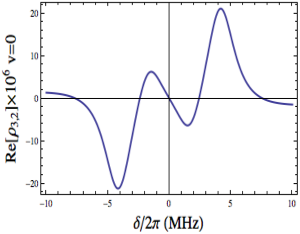
N-bar with four-wave mixing - fast and with gain

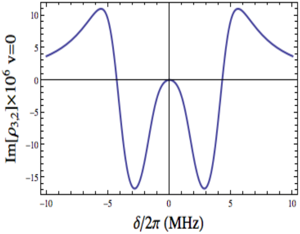




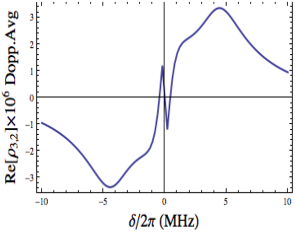
N-bar with Doppler averaging

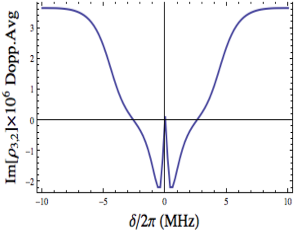
Refractive index | Absorption





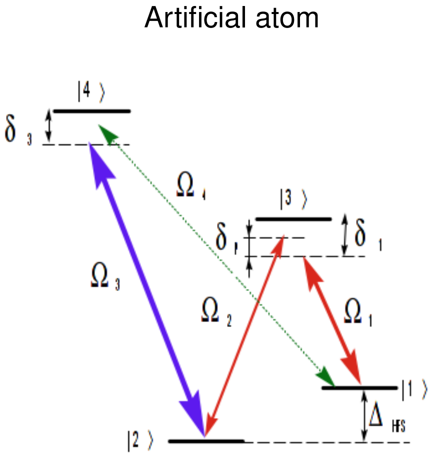
Stationary atoms

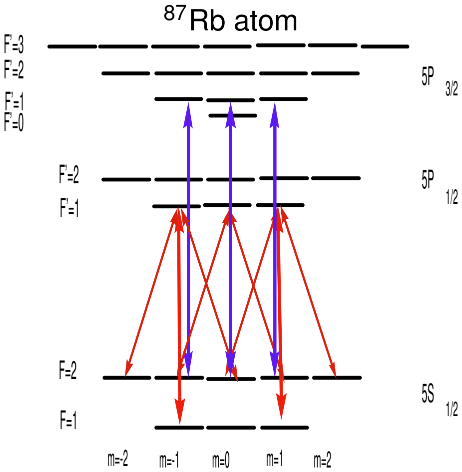




Room temperature
Doppler averaged

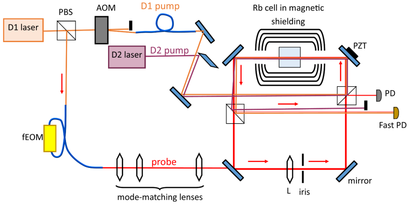
N-bar levels and fields diagram

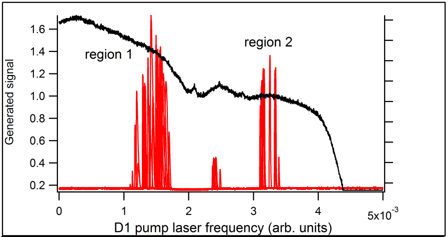




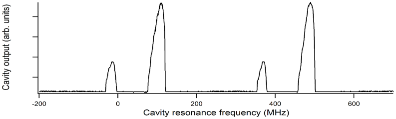
The first gyro setup and its performance

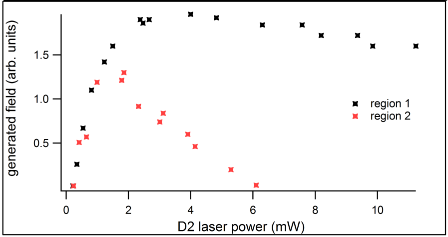
D$_1$ tuned around $F_g = 1 \rightarrow F_e = 1, 2$





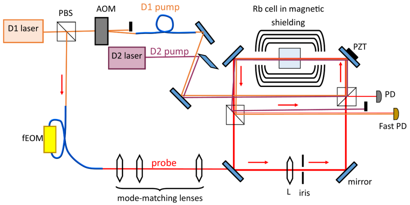
Finesse = 20

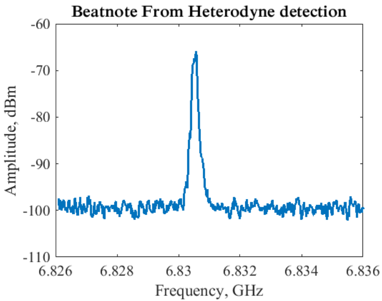




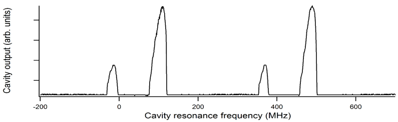
E. Mikhailov, *et al.* Optical Engineering, Issue 10, 53, 102709, (2014)

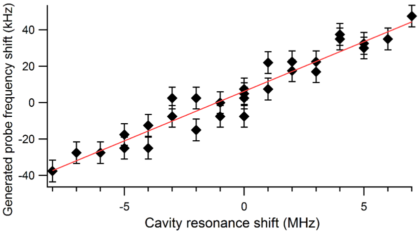
The first gyro setup and its performance





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





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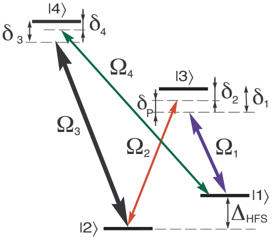
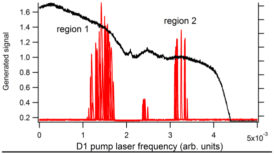
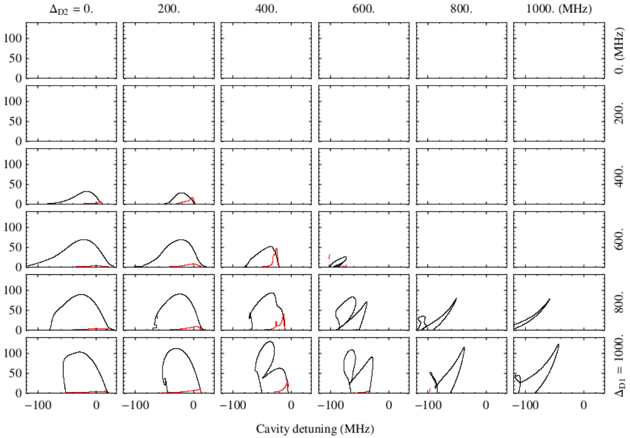
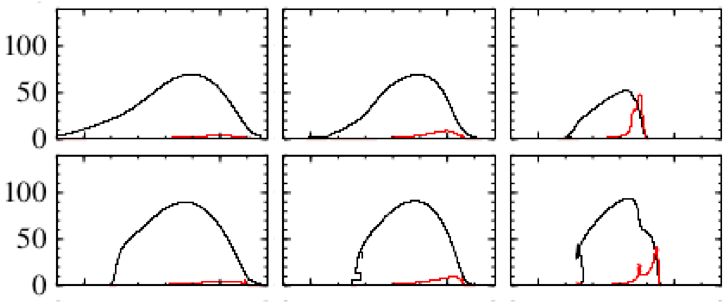
Gyro lasing: theory vs. experiment



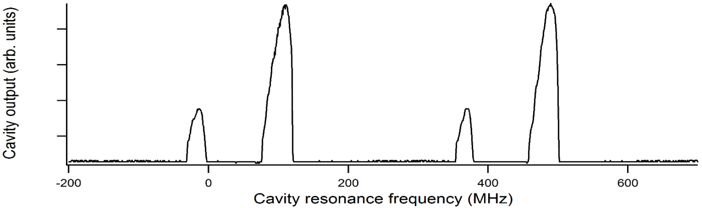




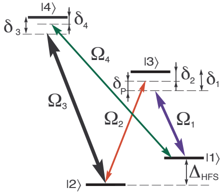
Gyro pulling and amplitude vs. gyro cavity detuning

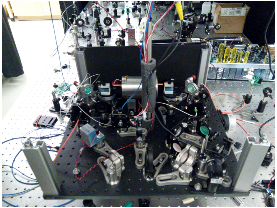


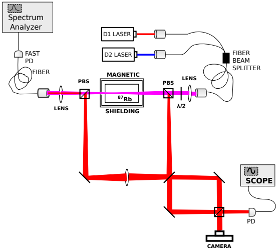
Cavity detuning span 150 MHz. Pulling ×100



Pulling factor with increased cavity finesse (20 → 70)

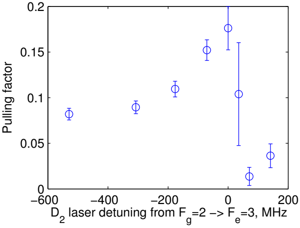


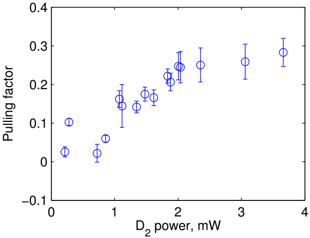




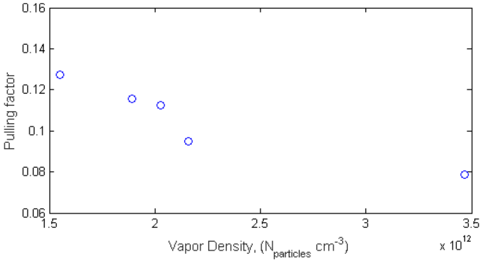
$$P.F. = \frac{\Delta f_{\text{dispersive}}}{\Delta f_{\text{empty}}}$$

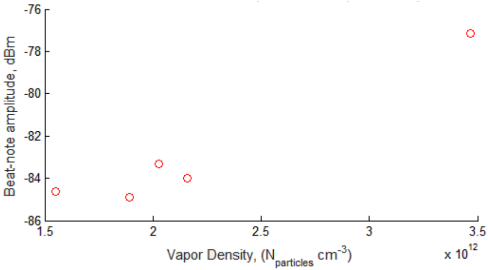
$$\Delta f_{\text{empty}} = f_0 \frac{\Delta L}{L}$$





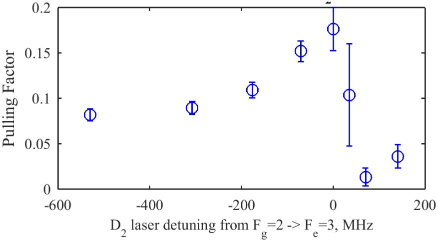
Dependence on ^{87}Rb vapor density

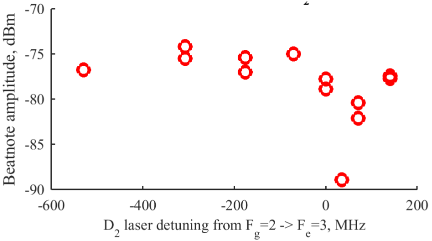




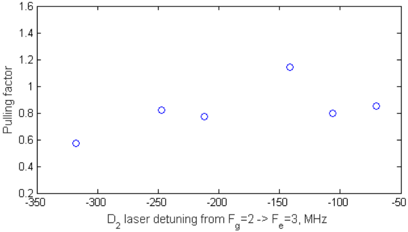
High power regime: dependence on D_2 detuning

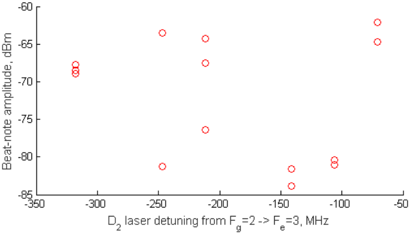
Pumps power $\approx$ 6 mW



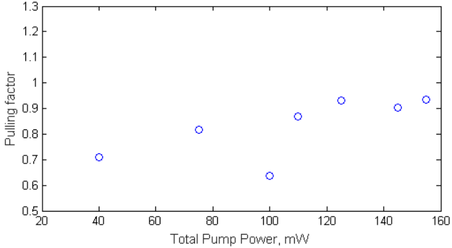


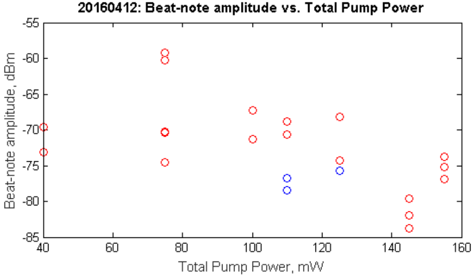
Pumps power $\approx$ 180 mW





Dependence on total pumps power

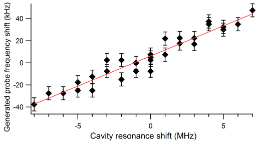


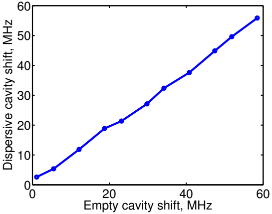


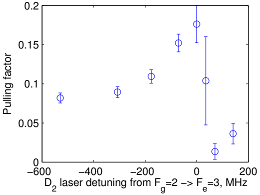
People

Irina Novikova, ShuangLi Du, Owen Wolfe (WM),
Dmitry Budker, Simon Rochester (Rochester Scientific).

Summary







- Improved puling factor: $0.05 \to 0.3$ with increased finesse ($20 \to 70$)
- Increased pump lasers power (6 mW $\to$ 200 mW) improved pulling factor to 0.93
- Setup has widely tunable response influenced by
  - pump lasers power and detuning
  - density of ^{87}Rb atoms
  - cavity finesse
- this allows us to tune the response of the system on demand

We are grateful for financial support to
NAVAIR