Towards laser locking in the telecom range by spectroscopy of molecular gases

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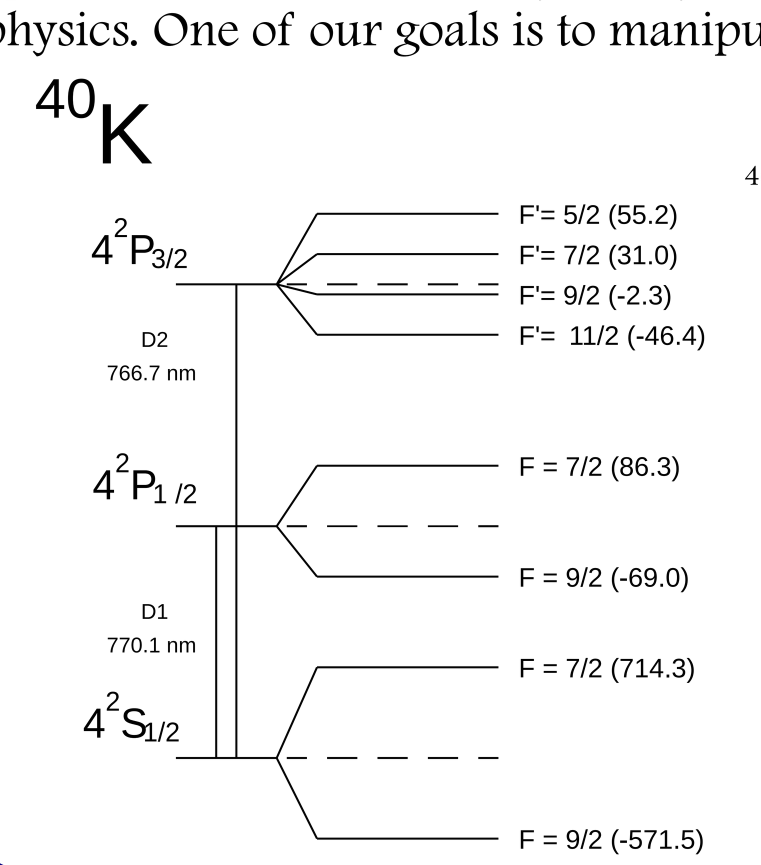
Motivation

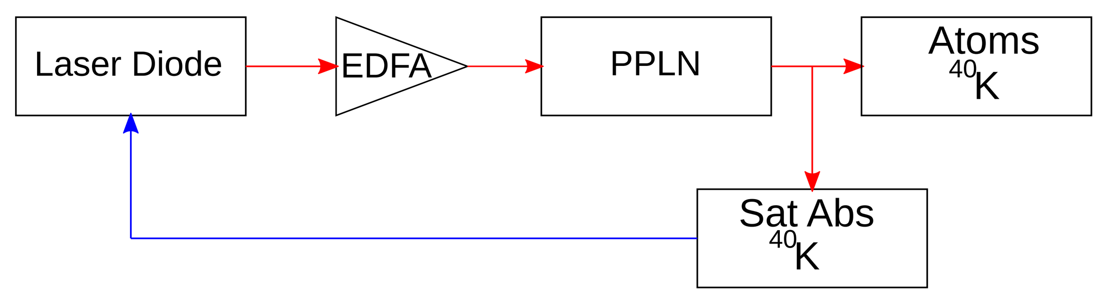
The AUFRONS (Ultra cold atoms in nanostructured optical potential) project aims at building near field optics / Ultra cold atoms hybrid systems to achieve stronger interaction between solid state and cold atoms physics. One of our goals is to manipulate cold fermionic species at the vicinity of a surface.



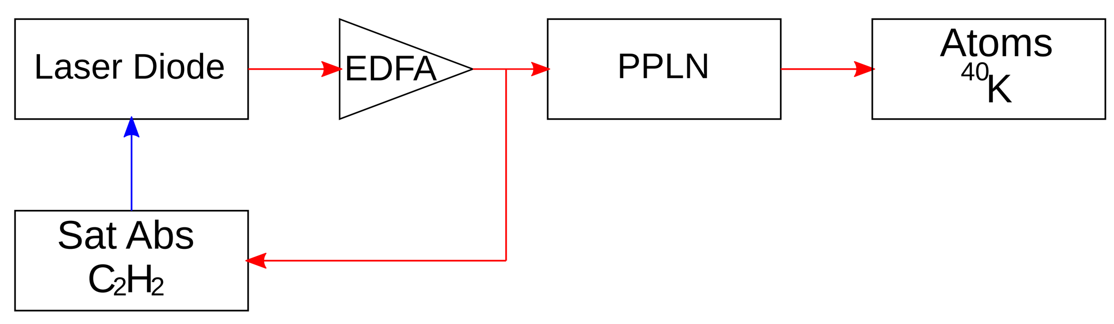
^{40}K : + transition frequency close to ^{87}Rb –> doubled telecom laser diodes
+ sympathetic cooling with ^{87}Rb
[1] + low field Feshbach resonances
– isotopic ratio (0,012 %)
– **hyperfine lines are close, difficult to lock onto**

C_2H_2 as rovibrational lines close to half the ^{40}K transition frequency
+ metrological transitions
[2] + narrow lines
+ can work at room temperature
+ no need for a second doubling stage
– low absorption

Potassium setup:

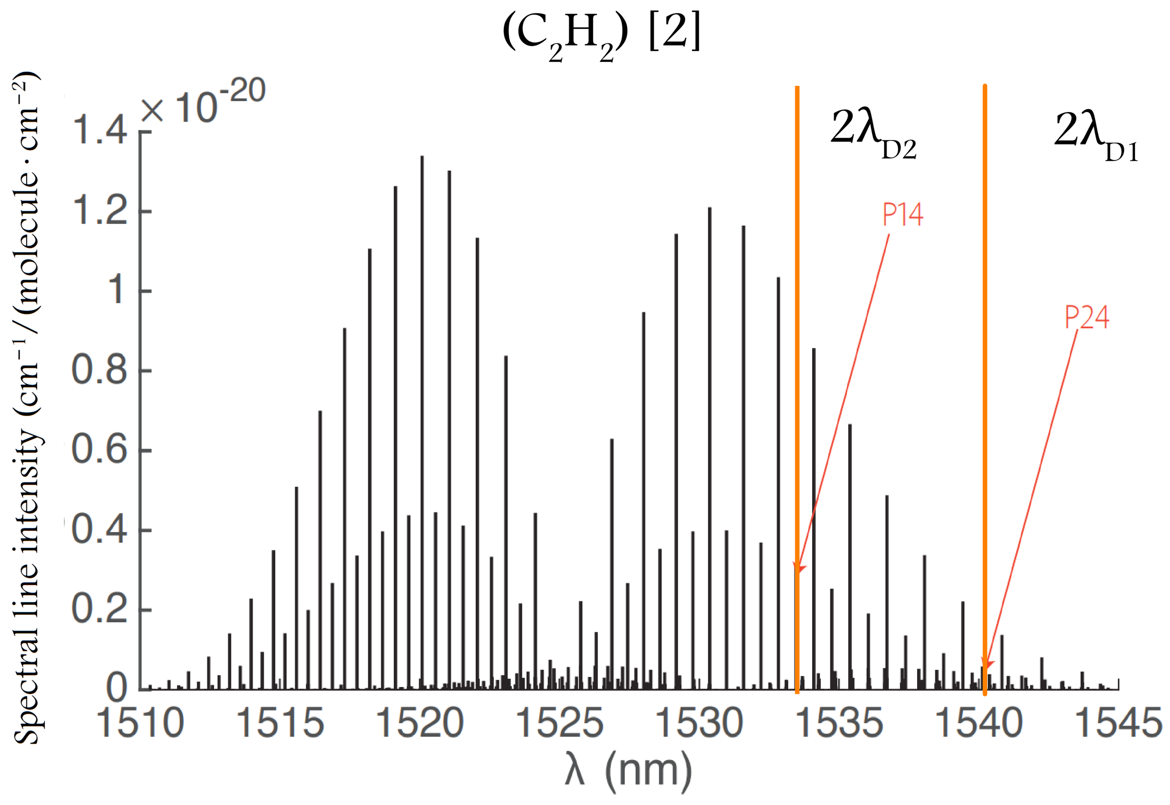


Acetylene setup:



Molecular Gases: Acetylene

Lines of interest for Potassium cooling (D1 and D2) using acetylene (C_2H_2) [2]



	$2\lambda_{D1,D2}$ (nm)	$\lambda_{C2H2,P24/P14}$ (nm)	Frequency Gap (GHz)
D1/P24 Transition	1540.216	1540.125	11.456
D2/P14 Transition	1533.402	1533.461	7.522

Acetylene Spectroscopic Parameters

• S = Spectral line intensity (cm⁻¹/(molecules · cm⁻²) [2]
(cm⁻¹: wavenumber; molecules · cm⁻²: Column density)

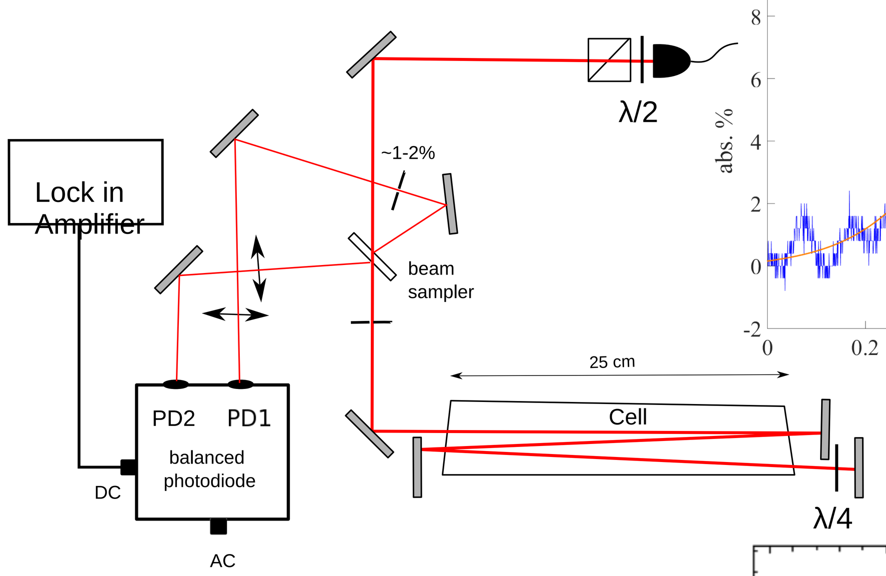
• Optical Density is given by $OD = S \times line\ profile \times \frac{P}{k_B T} L$ Doppler FWHM ≈ 472 MHz

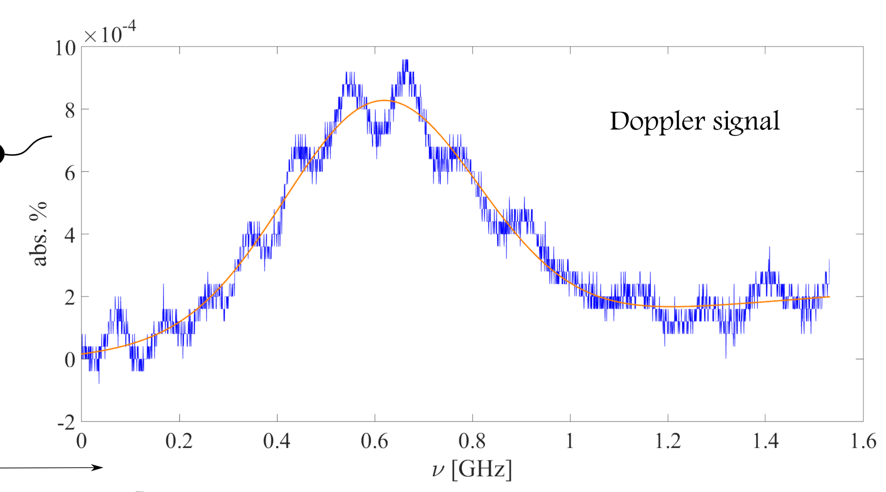
• $\Gamma_{tot} = \Gamma_{nat} + \Gamma_{pressure} + \Gamma_{transit}$

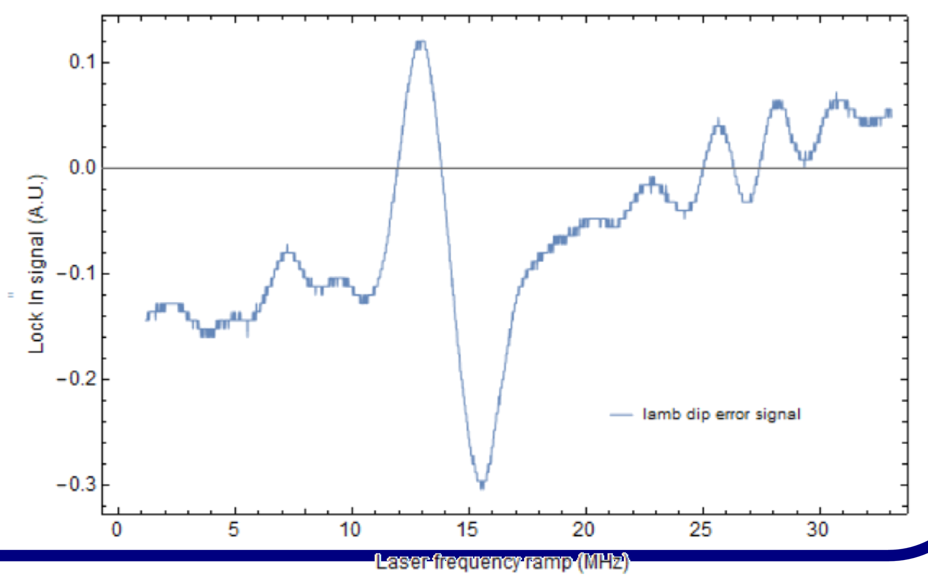
$I_{sat} \propto \Gamma_{tot}^{\ 2}$

$$\Gamma_{nat} = 5\,Hz$$
$$\Gamma_{pressure} = (234\,kHz/Pa) \times P$$
$$\Gamma_{transit} = \frac{0{,}19}{w_0}\sqrt{\frac{2 k_B T}{m_{C_2H_2}}},\ w_0\ waist\ radius$$

Bulk Cell





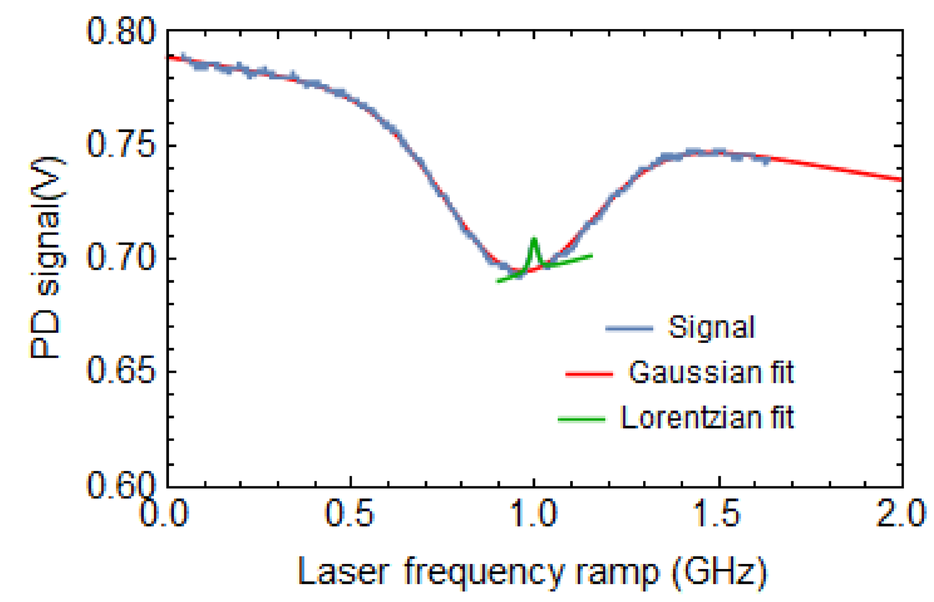


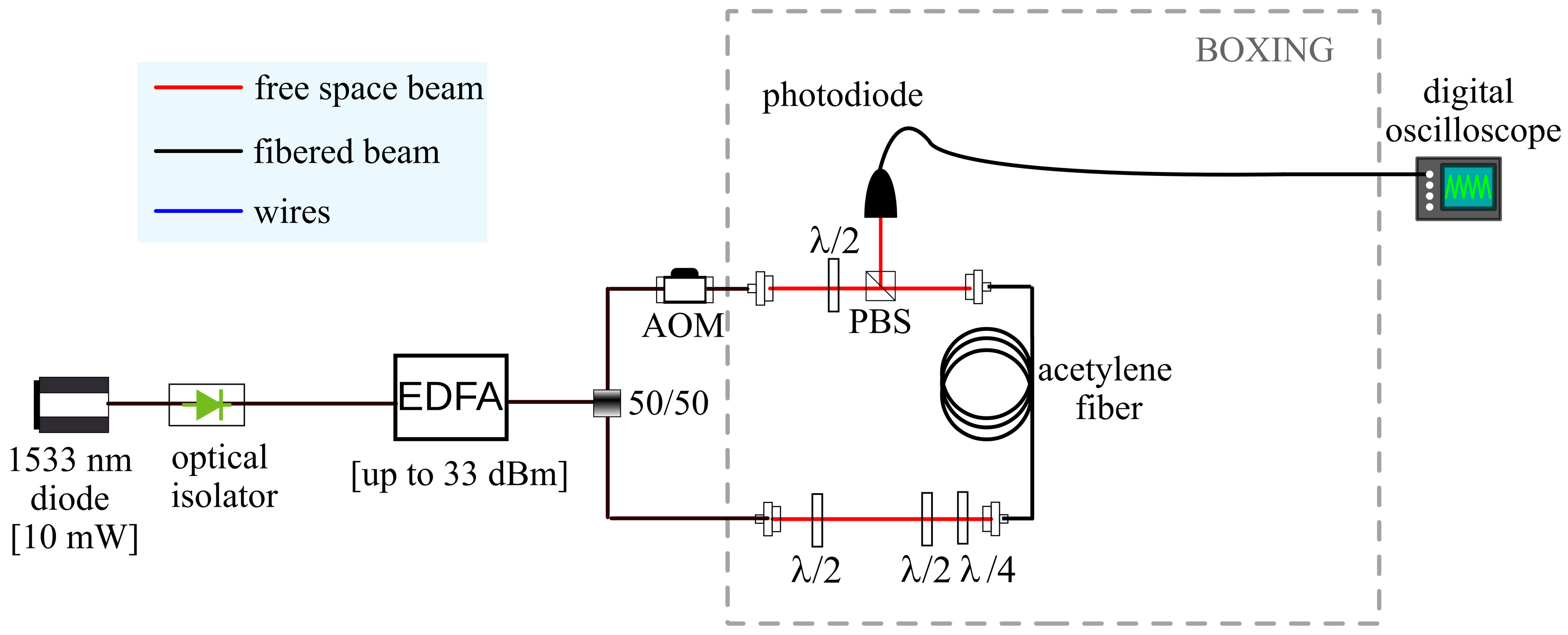
[3]

Γ_{tot} = 188 kHz
Doppler FWHM = 465 MHz
P = 0,12 Pa
Length = 7m
Waist = 0,5 mm

Fiber Cell [4]

Length = 7m
MFD = 22 µm
P = 6 Pa
Γ_{tot} = 6MHz
Γ_{meas} = 22MHz
Sat Abs Amplitude: 16% of Doppler
P_{sat} ≈ 20 mW [5]

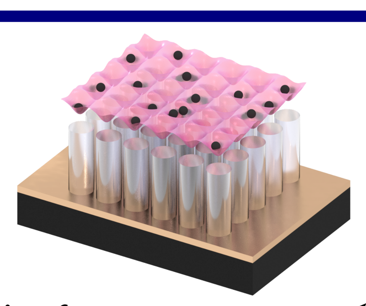




Perspectives

Experiment :

- Comparing bulk and fiber cells
- Herriott Cell
- Comparing the setups with ^{87}Rb reference via frequency comb
- Application for Potassium cooling



References

[1] T. Tiecke. Properties of Potassium. http://www.tobiastiecke.nl/archive/PotassiumProperties.pdf, (2011).
[2] HITRAN. Data base spectroscopy
[3] J. Hald et al, Opt. Lett. **19**(3), 2052–2063 (2011)
[4] M.Triches et al, Opt. Lett. **23**(9), 11227-11241 (2015)
[5] J. Henningsen et al, Opt. Exp. **13**(26), 10475-10482 (2005)

Collaborations

Xlim:
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Acknowledgements

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