

# Oh

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A thesis presented for the degree of  
Bachelor of Science (Honours) (Physics)



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February 6, 2026

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Tous les fichiers svg :

# Dedication

For those who hate looking at a template with 500 lines of code and an extra 300 lines commented out.

# Declaration

# Acknowledgements

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# Chapter 1

## Introduction

### 1.1 Fermi gas preparation (+ Bose gas ?)

#### 1.1.1 TC

Comment on increasing power in TC (thésard marc chesnais)

#### 1.1.2 Zeeman cooling

#### 1.1.3 Blue MOT

##### 1.1.3.1 The physics

##### 1.1.3.2 How to optimize the superposition with the repumper

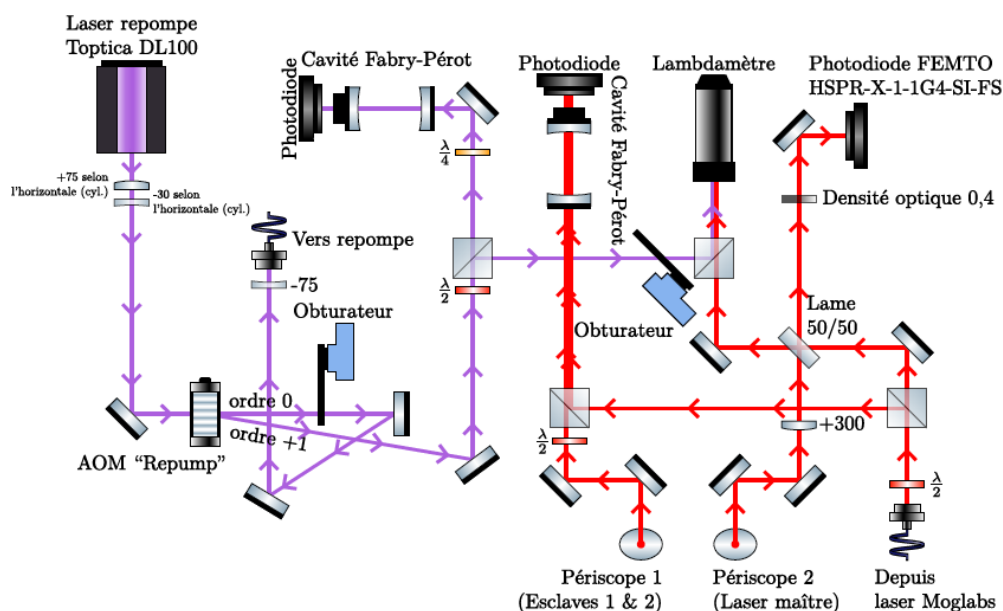


Figure 1.1: Caption

### 1.1.3.3 Comment on the hyperfine states (+boson 88)

### 1.1.3.4 Optical setup (blue + repump)

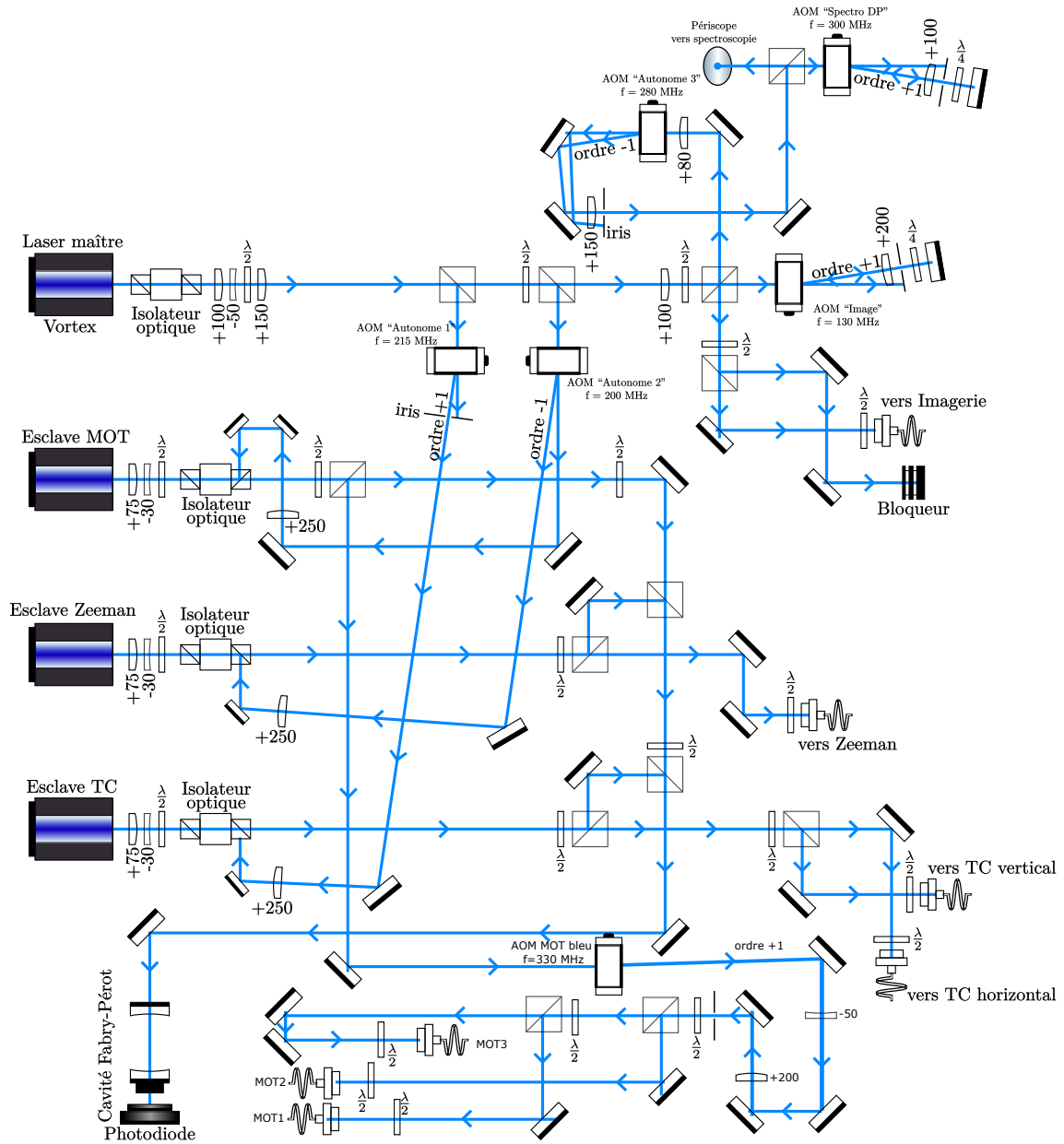


Figure 1.2: Caption

### 1.1.4 Repumper

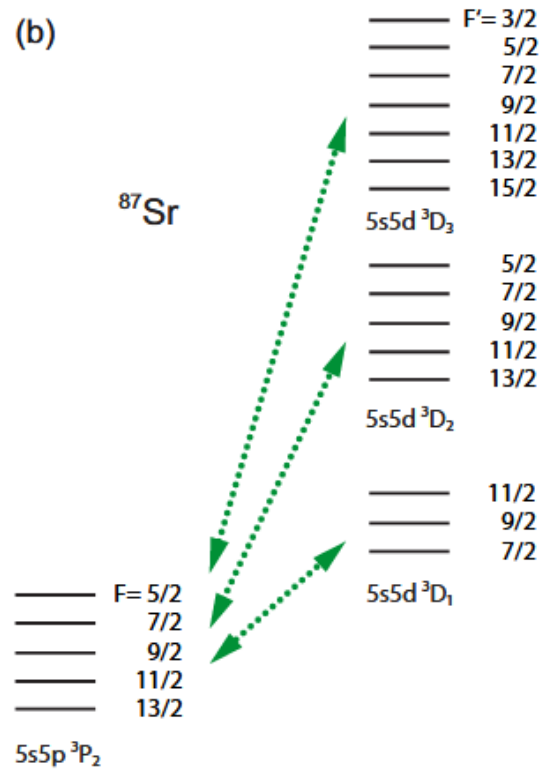


Figure 1.3: Caption

### 1.1.5 BB MOT

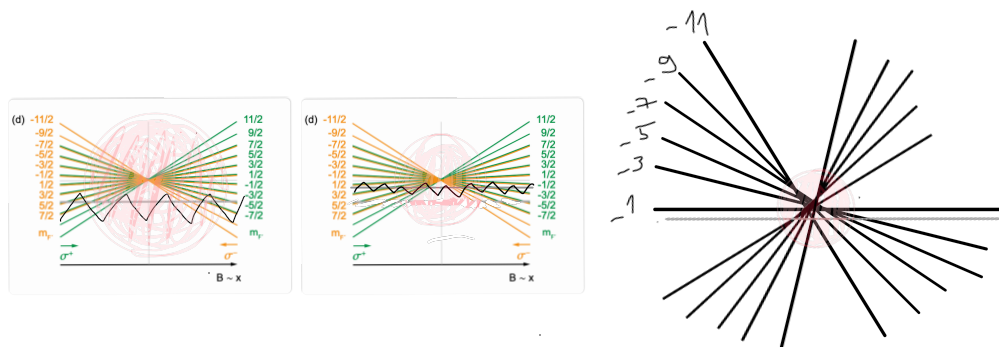


Figure 1.4: Caption

### 1.1.5.1 First step

### 1.1.5.2 Second step

### 1.1.6 Stir

Need a stir because :



Figure 1.5: Caption



Figure 1.6: Caption

### 1.1.7 Narrow MOT

cf p.43 S.Stellmer thesis

#### 1.1.7.1 Optimization of the narrow MOT (intensity, frequency, effect on the size of the cloud)

Include images of the cloud for different I and detuning ?

### 1.1.7.2 Optical setup

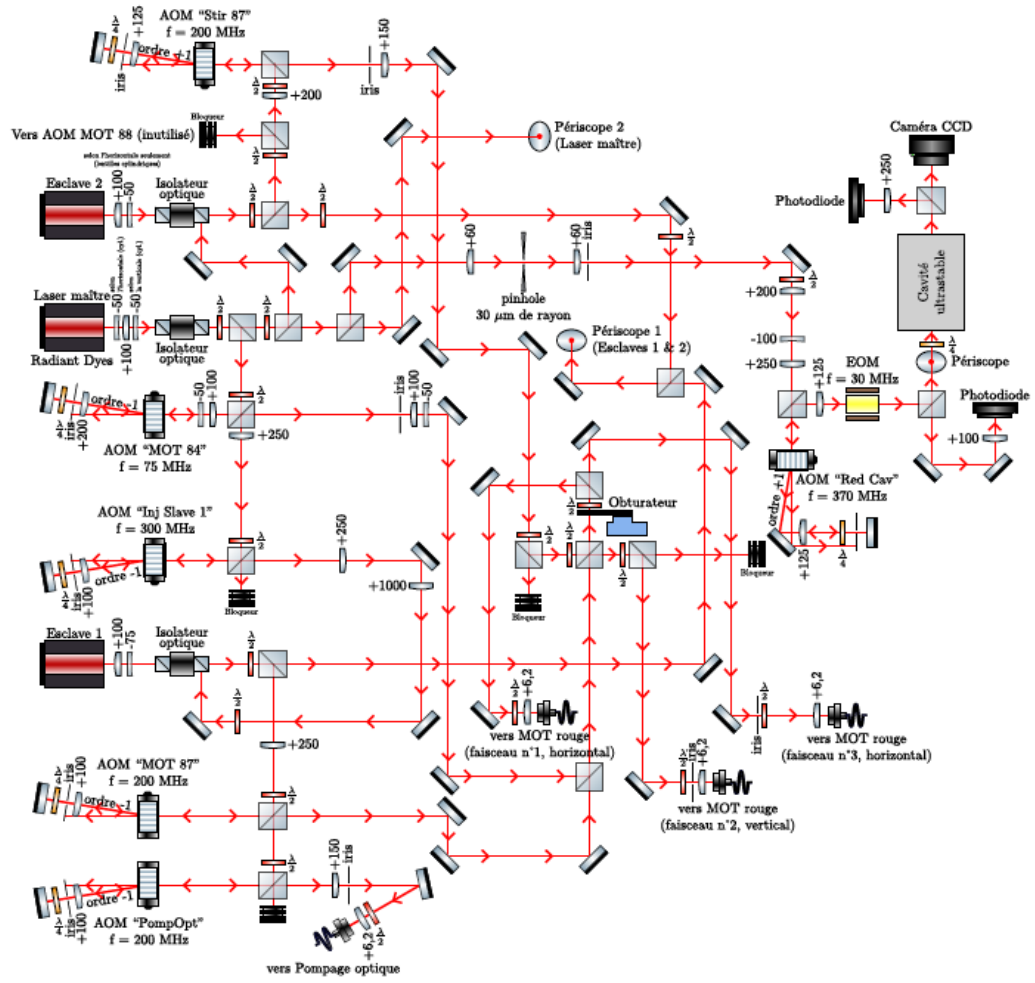


FIGURE 14 – Préparation des différents lasers rouges

Figure 1.7: Caption

### 1.1.8 ODT and evaporation

#### 1.1.8.1 Charging the crossing



Figure 1.8: Caption

#### 1.1.8.2 Optimization of the evaporation ramps : Dimple + reservoir, just reservoir, parameter to optimize (number of atoms, temperature)

Comment on the LS it does to each state

#### 1.1.8.3 Optical setup

### 1.1.9 Optical pumping



Figure 1.9: Caption

## 1.2 Spin measurement scheme



Figure 1.10: Caption



# Chapter 2

## Ramsey interferometers on qudit

### 2.1 Preparation of arbitrary dimension Hilbert space

#### 2.1.1 Raman process

##### 2.1.1.1 $\delta m_F = \pm 1$

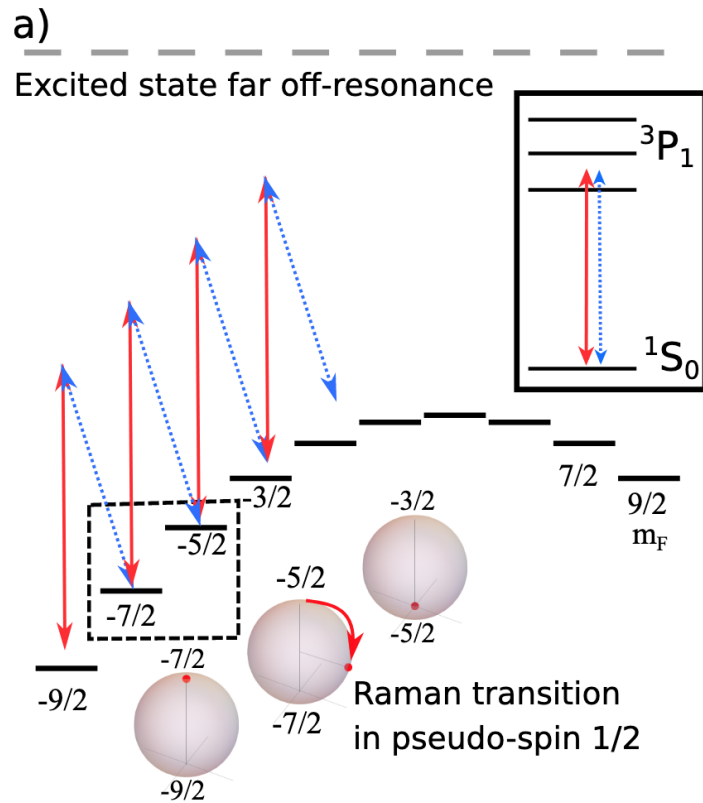


Figure 2.1: Caption

### 2.1.1.2 $\delta m_F = \pm 2$

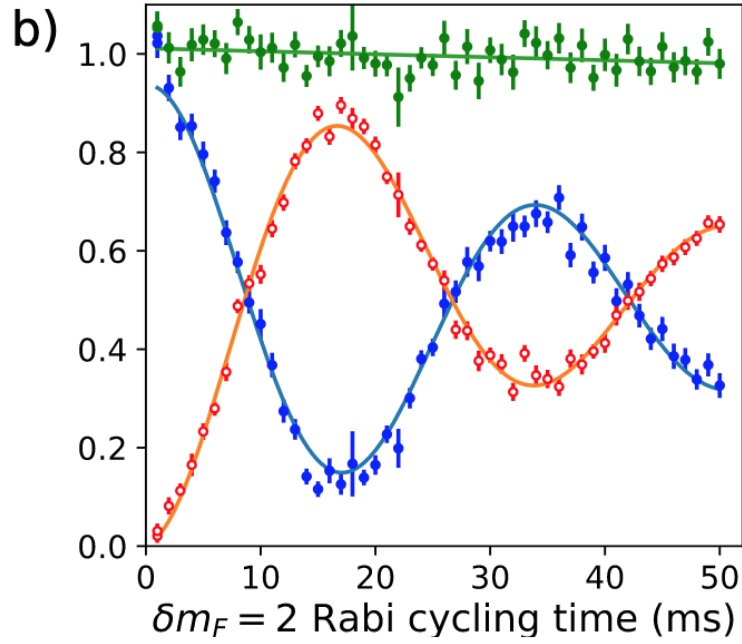


Figure 2.2: Caption

### 2.1.2 Moglabs chain without cavity

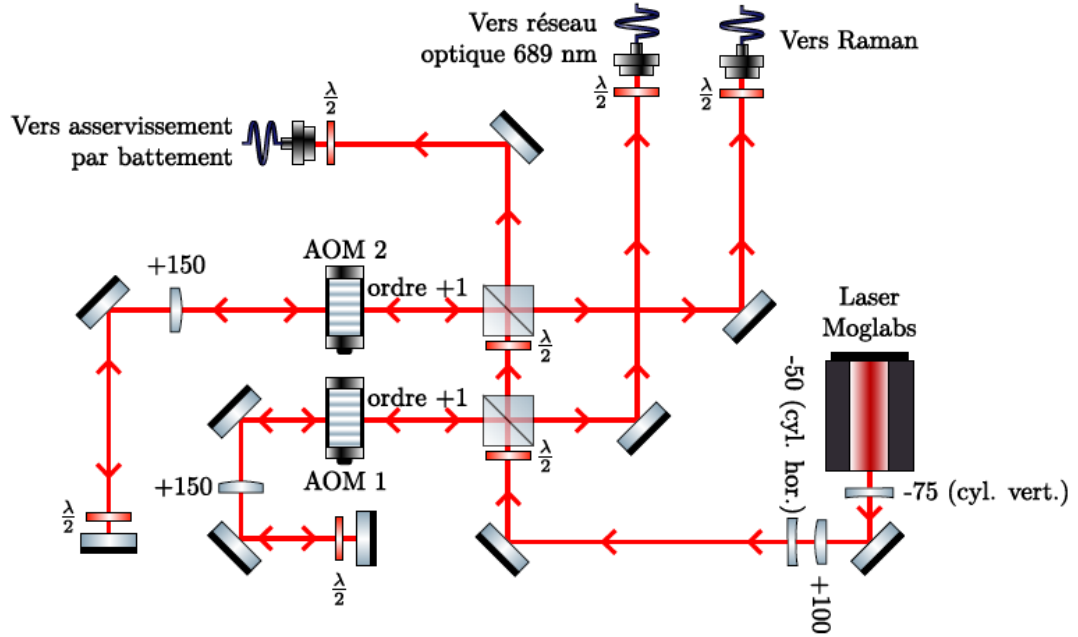


FIGURE 41 – Préparation du laser Moglabs à 689 nm.

Figure 2.3: Caption

### 2.1.3 Purification of the laser spectrum with a FP cavity

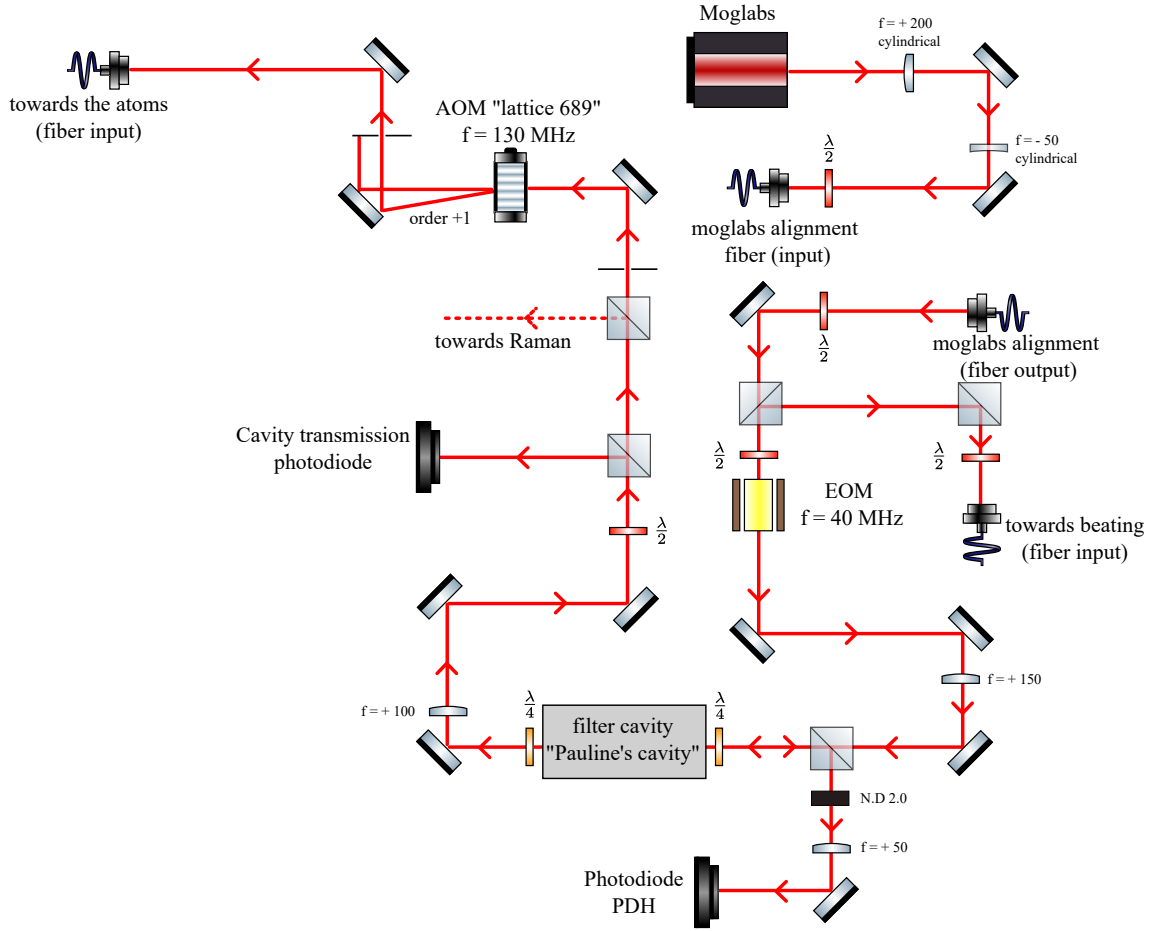


Figure 2.4: Caption

## 2.2 Interferometric sensing with multiple nuclear spin state

### 2.2.1 Driving long coherence time Rabi oscillations

#### 2.2.1.1 Rabi oscillations

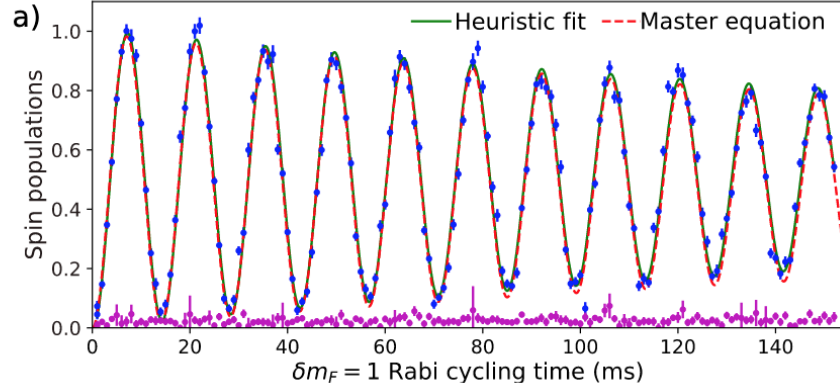


Figure 2.5: Caption

Comment on what the FP could add as a longer coherence time of the qubit

#### 2.2.1.2 Interferometer of $\text{su}(2)$ symmetry

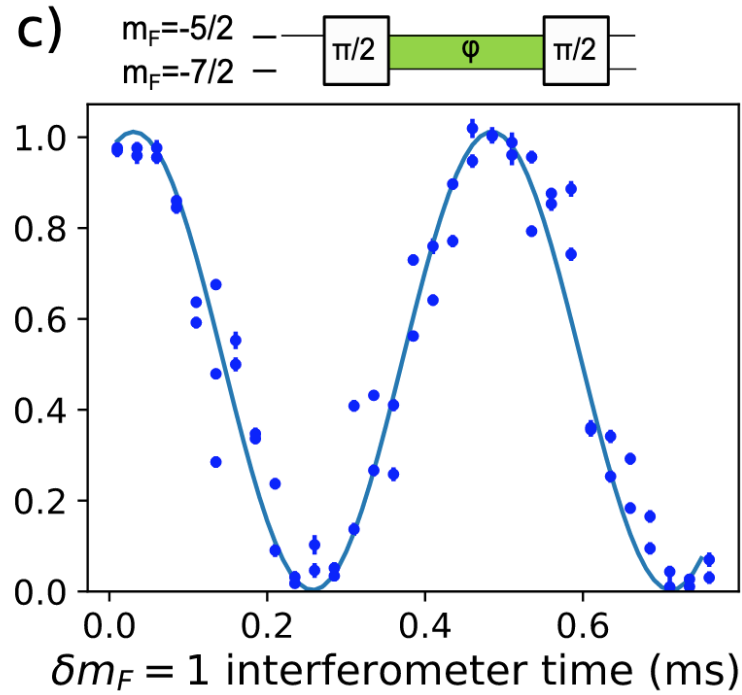


Figure 2.6: Caption

### 2.2.1.3 Discussion on inhomogeneities

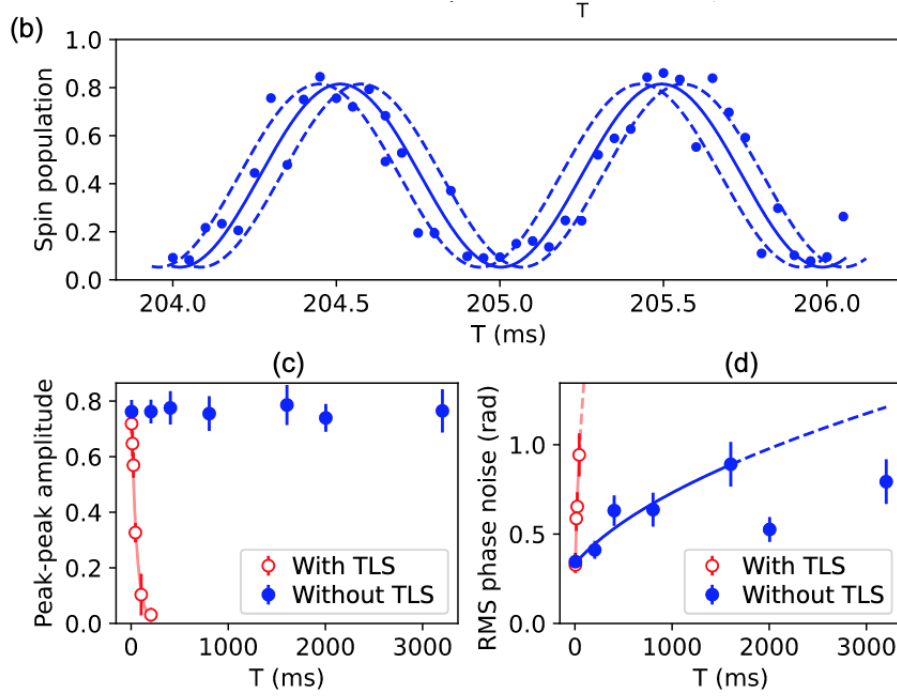


Figure 2.7: Caption

## 2.2.2 Measuring two quantities at a time

### 2.2.2.1 Physical principle

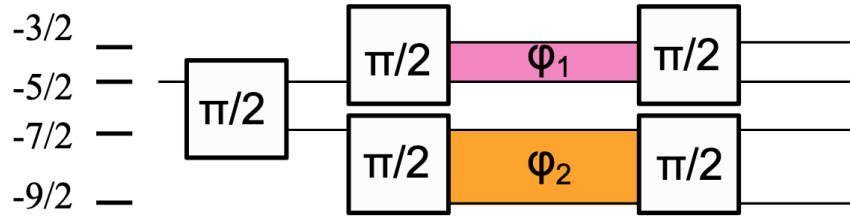


Figure 2.8: Caption

### 2.2.2.2 Results

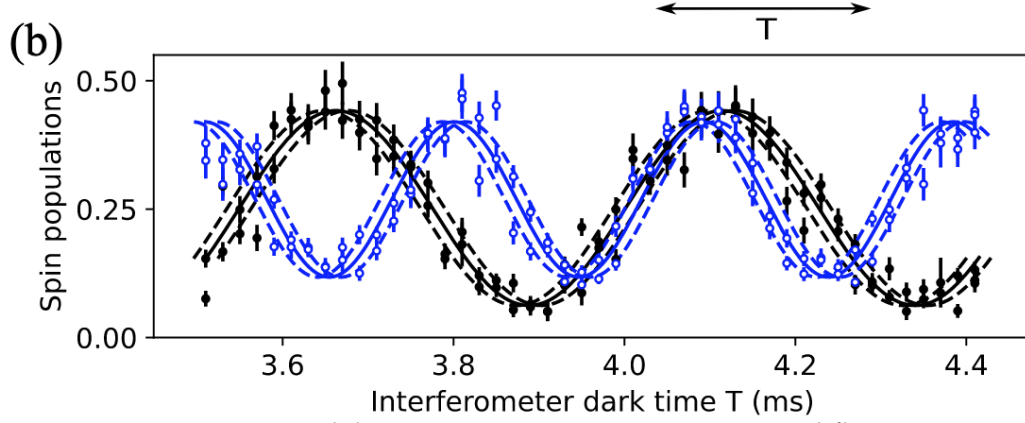


Figure 2.9: Caption

### 2.2.3 Measuring two non commuting observables

#### 2.2.3.1 Principle

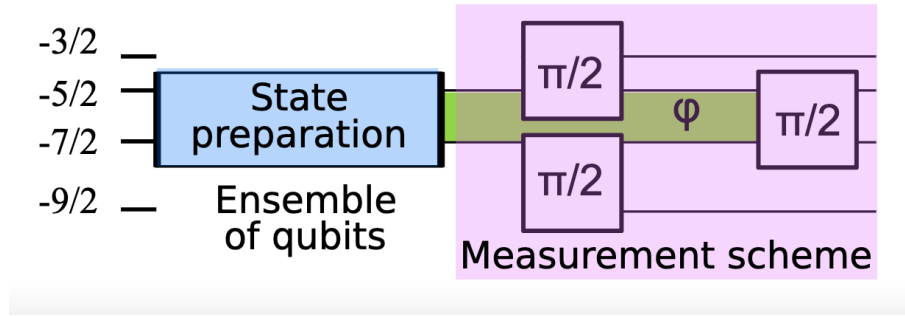


Figure 2.10: Caption

## 2.3 SU(N) symmetry (ce qu'il faudrait pr la tester e.g densité gaz, alimentation bobines -¿ comment faire mieux que les chiffres actuels

## Chapter 3

# Engineering highly entangled system of photoassociated $^{87}\text{Sr}$ atoms

Engineering Dicke states

### 3.1 Introduction on photoassociation

#### 3.1.1 What is photoassociation

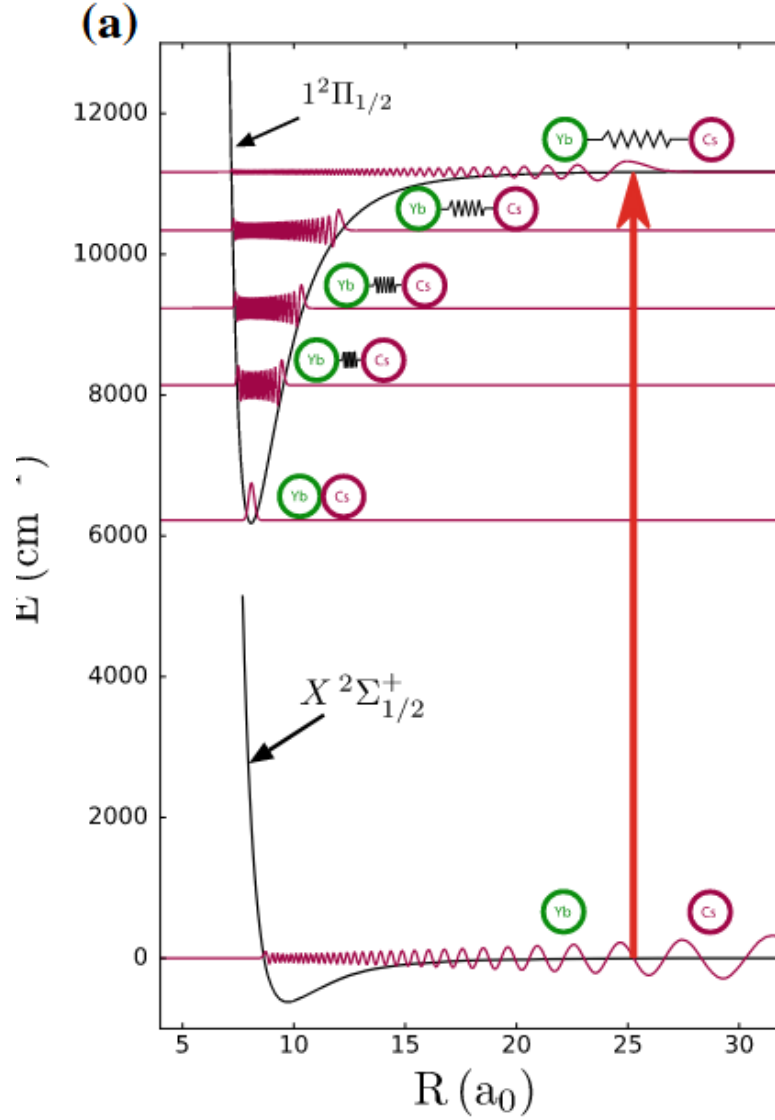


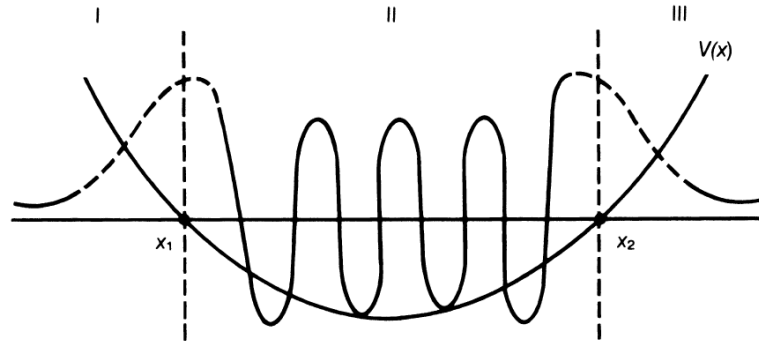
Figure 3.1: Caption



### 3.1.2 Molecular formalism/vocabulary (condon radius, optical length...)

### 3.1.3 Internal energy states

#### 3.1.3.1 WKB approximation



**FIGURE 2.1.** Schematic diagram for behavior of wave function  $u_E(x)$  in potential well  $V(x)$  with turning points  $x_1$  and  $x_2$ .

Figure 3.2: Caption

### 3.1.3.2

### 3.1.4 External energy states

## 3.2 About photoassociation on other species

### 3.2.1 Mass scaling (88Sr)

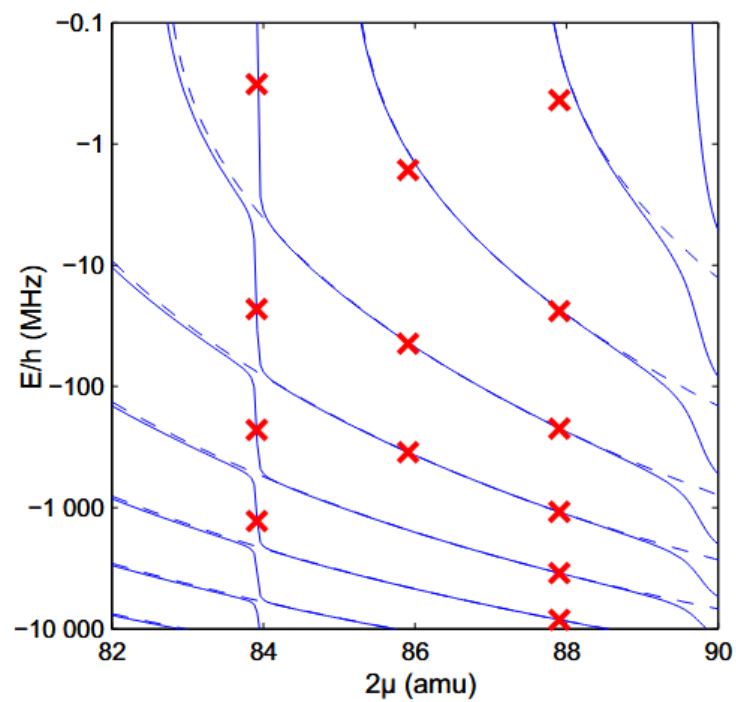


Figure 3.3: Caption

### 3.2.2 Ytterbium: hfs

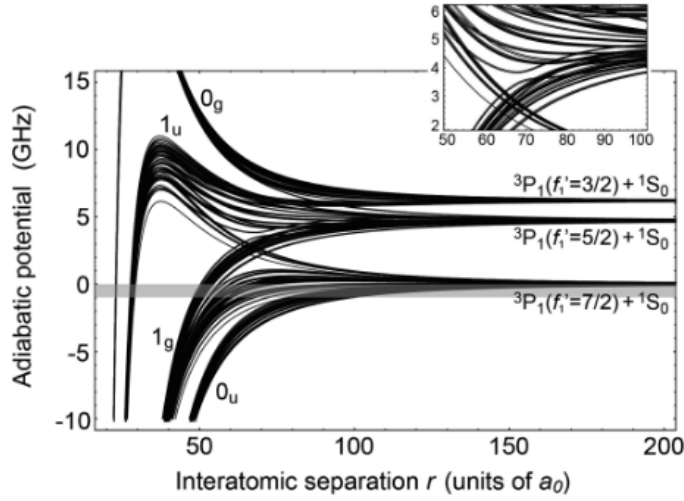


FIG. 2. Adiabatic molecular potentials for a  $^{173}\text{Yb}_2$  dimer in the  $^1S_0 + ^3P_1$  channel as functions of the interatomic separation  $r$ . The molecular potentials for 205 different  $(T, F, R)$  configurations are displayed, which are accessible via PA from the initial  $s$ -wave colliding atoms in the  $^1S_0 + ^1S_0$  channel. At large  $r$ , the potentials converge to three asymptotic branches which correspond to excited atomic states with hyperfine numbers of  $f'_1 = 3/2$ ,  $5/2$ , and  $7/2$ . Some of the potentials have a local minimum (inset), possibly hosting purely long-range bound states [14]. The energy offset is adjusted to the  $f'_1 = 7/2$  asymptote. The shaded region indicates the spectral range of our measurements.

Figure 3.4: Caption

## 3.3 Experimental setup

## 3.4 $^{88}\text{Sr}$ Results

Lopt, power broadening, thermal broadening...

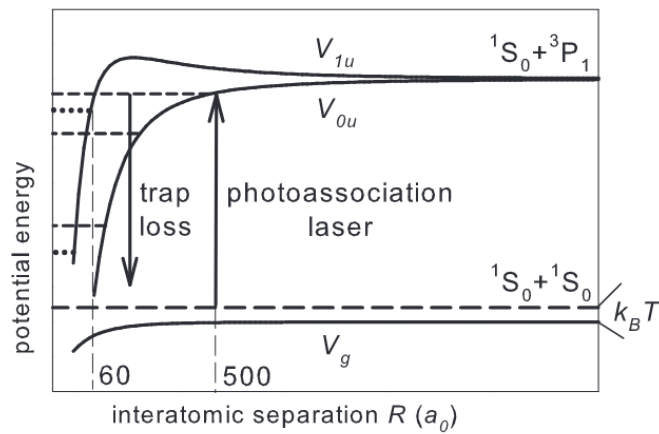


Figure 3.5: Caption

### 3.4.1 Technical issues of inhabilitation of photoassociation

#### 3.4.1.1 Laser width

## 3.5 <sup>87</sup>Sr molecules

Lopt

questions sur nb quantique / choix de pompage optique

### 3.5.1 Physical sources of inhabilitation of photoassociation

#### 3.5.1.1 On $F = 9/2$ : predissociation

#### 3.5.1.2 Coupling to more energetic state from the IR

#### 3.5.1.3 Node of wavefunction for some vibrational states

### 3.5.2 Energy landscape of <sup>87</sup>Sr-<sup>87</sup>Sr molecules

# Conclusion

# Bibliography

# Appendix A

## Algorithms