

Oh

Pauline

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



School of Physics
Department of Science
The University of Sydney
Australia
February 7, 2026

Supervisor: Prof. Jane Professor

Co-Supervisor: Dr. Jack Supervisor

Co-Supervisor: Mr. June Supervisor

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

Contents

List of Figures

List of Tables

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

OH




Chapitres/repompeur.png

Figure 1.1: Caption

1.1.3.3 Comment on the hyperfine states (+boson 88)

1.1.3.4 Optical setup (blue + repump)



Chapitres/chaine bleue actualise.pdf

Figure 1.2: Caption

1.1.4 Repumper

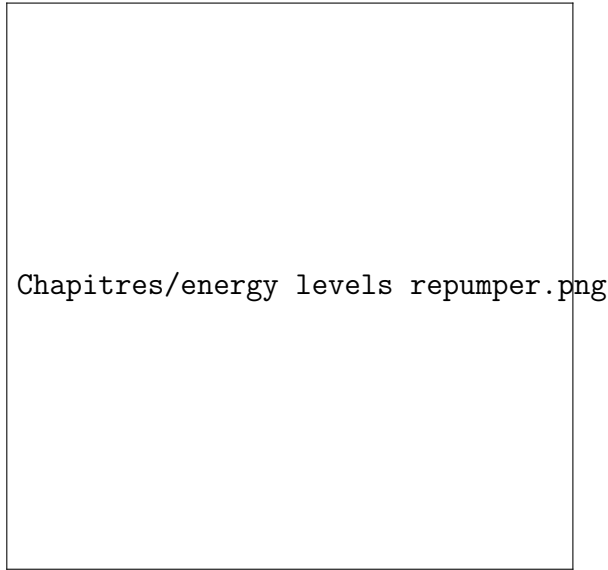


Figure 1.3: Caption

1.1.5 BB MOT

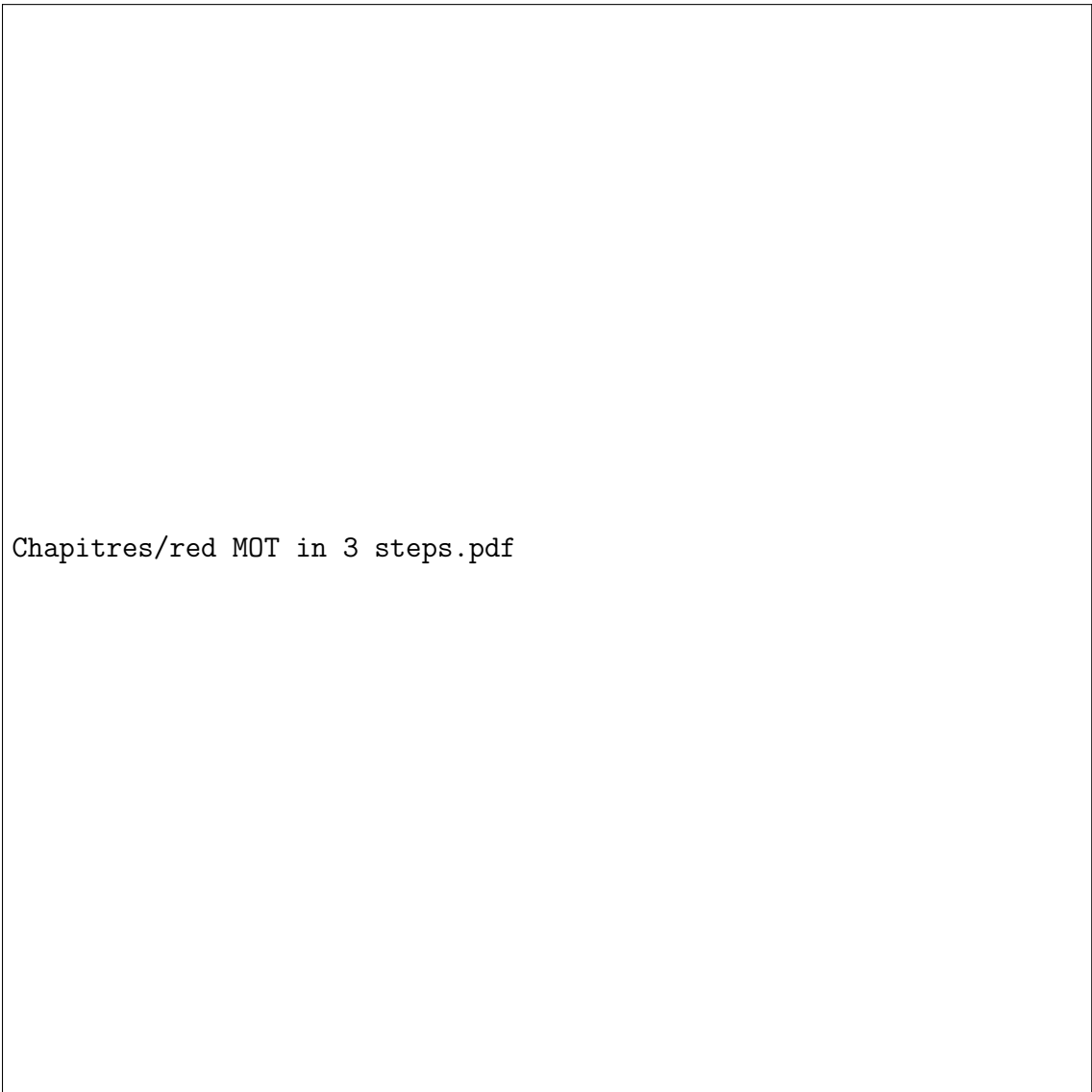


Figure 1.4: Caption

1.1.5.1 First step

1.1.5.2 Second step

1.1.6 Stir

Need a stir because :

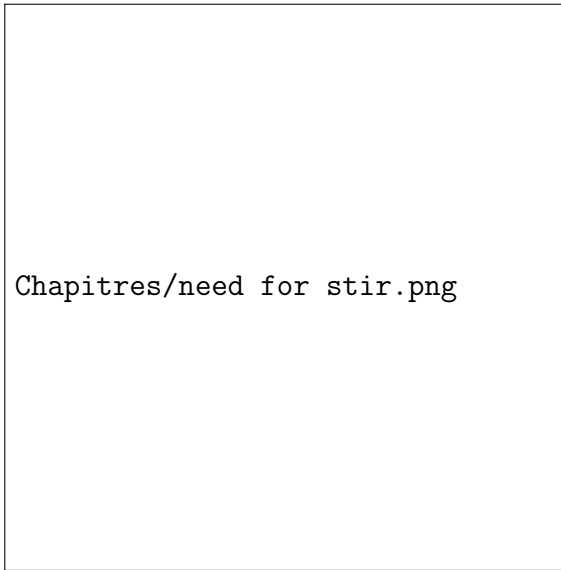


Figure 1.5: Caption



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



Chapitres/chaine rouge vieille.png

Figure 1.7: Caption

1.1.8 ODT and evaporation

1.1.8.1 Charging the crossing



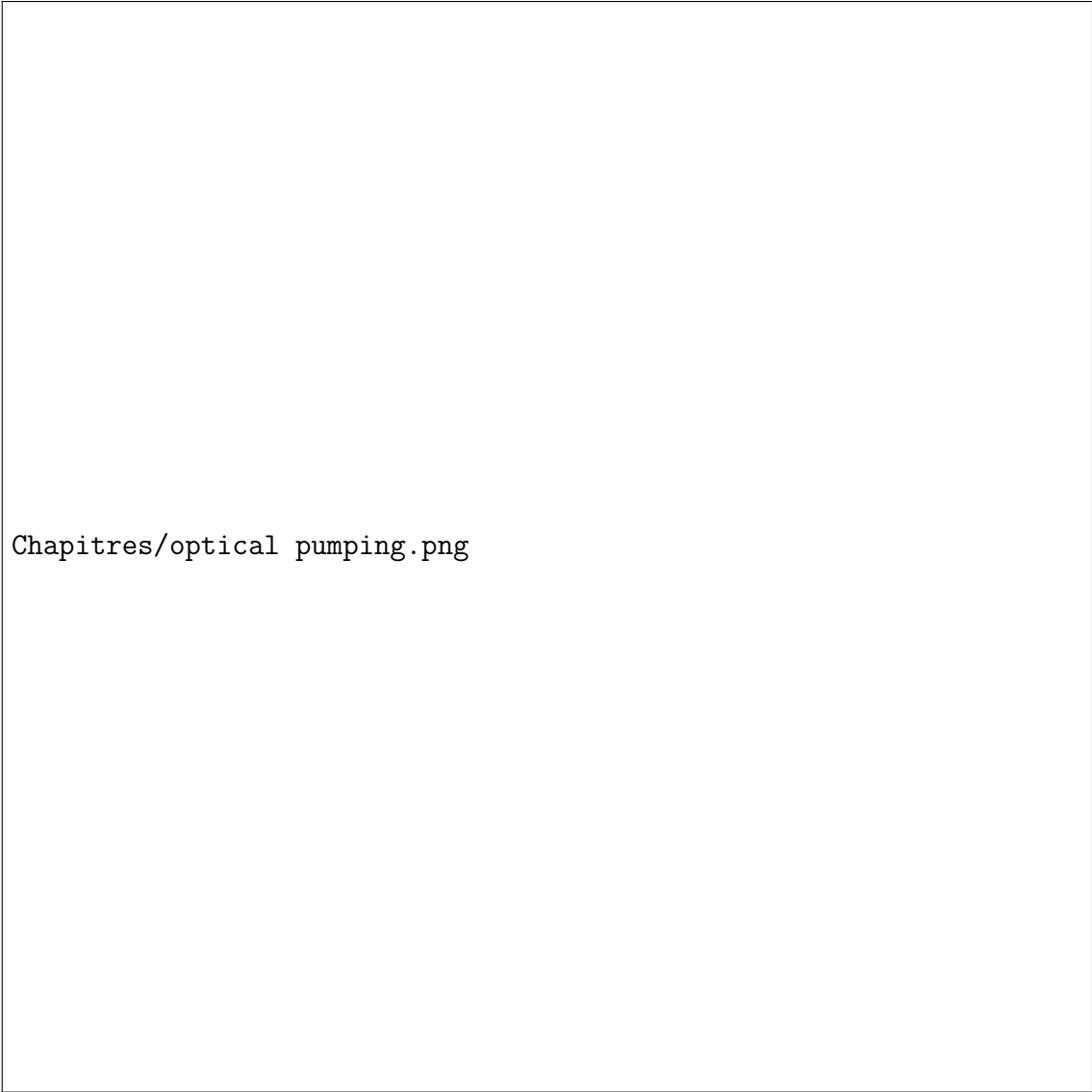
Figure 1.8: Caption

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



Chapitres/optical pumping.png

Figure 1.9: Caption

1.2 Spin measurement scheme



Chapitres/spin kick scheme.png

Figure 1.10: Caption

Chapter 2

Ramsey interferometers on qudit

2.1 Preparation of arbitrary dimension Hilbert space

2.1.1 Raman process

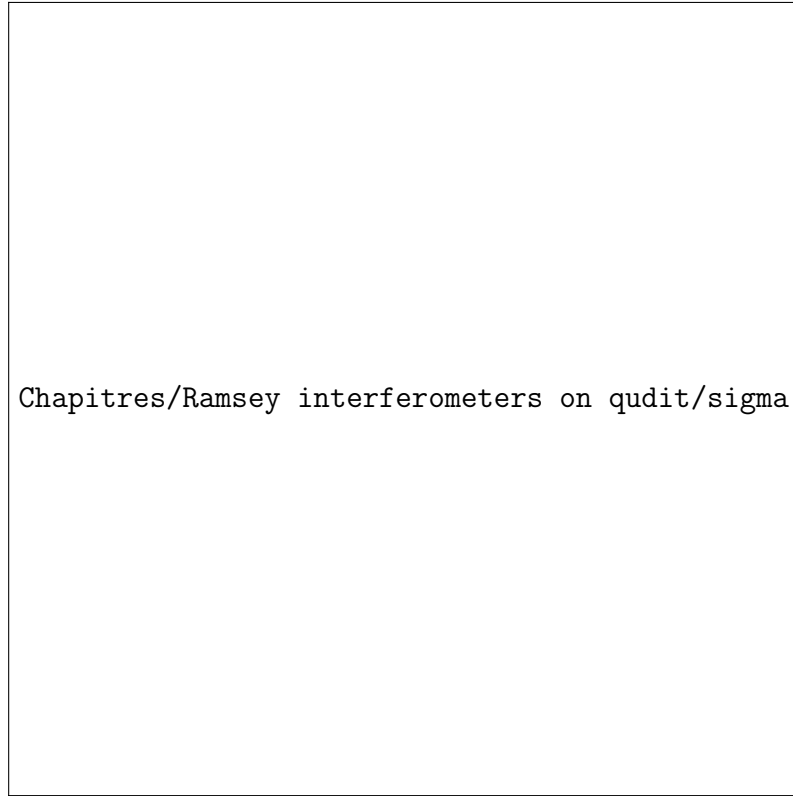
2.1.1.1 $\delta m_F = \pm 1$



Chapitres/Ramsey interferometers on qudit/images/raman scheme.png

Figure 2.1: Caption


2.1.1.2 $\delta m_F = \pm 2$



Chapitres/Ramsey interferometers on qudit/sigma sigma raman transition.

Figure 2.2: Caption

2.1.2 Moglabs chain without cavity



Chapitres/Introduction/Chanes optiques/raman transition.png

Figure 2.3: Caption

2.1.3 Purification of the laser spectrum with a FP cavity



Figure 2.4: Caption

blablablagtg

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



Chapitres/Ramsey interferometers on qudit/images/qubit interf.png

Figure 2.6: Caption

2.2.1.3 Discussion on inhomogeneities



Chapitres/Ramsey interferometers on qudit/images/noise analysis on qubit.png

Figure 2.7: Caption

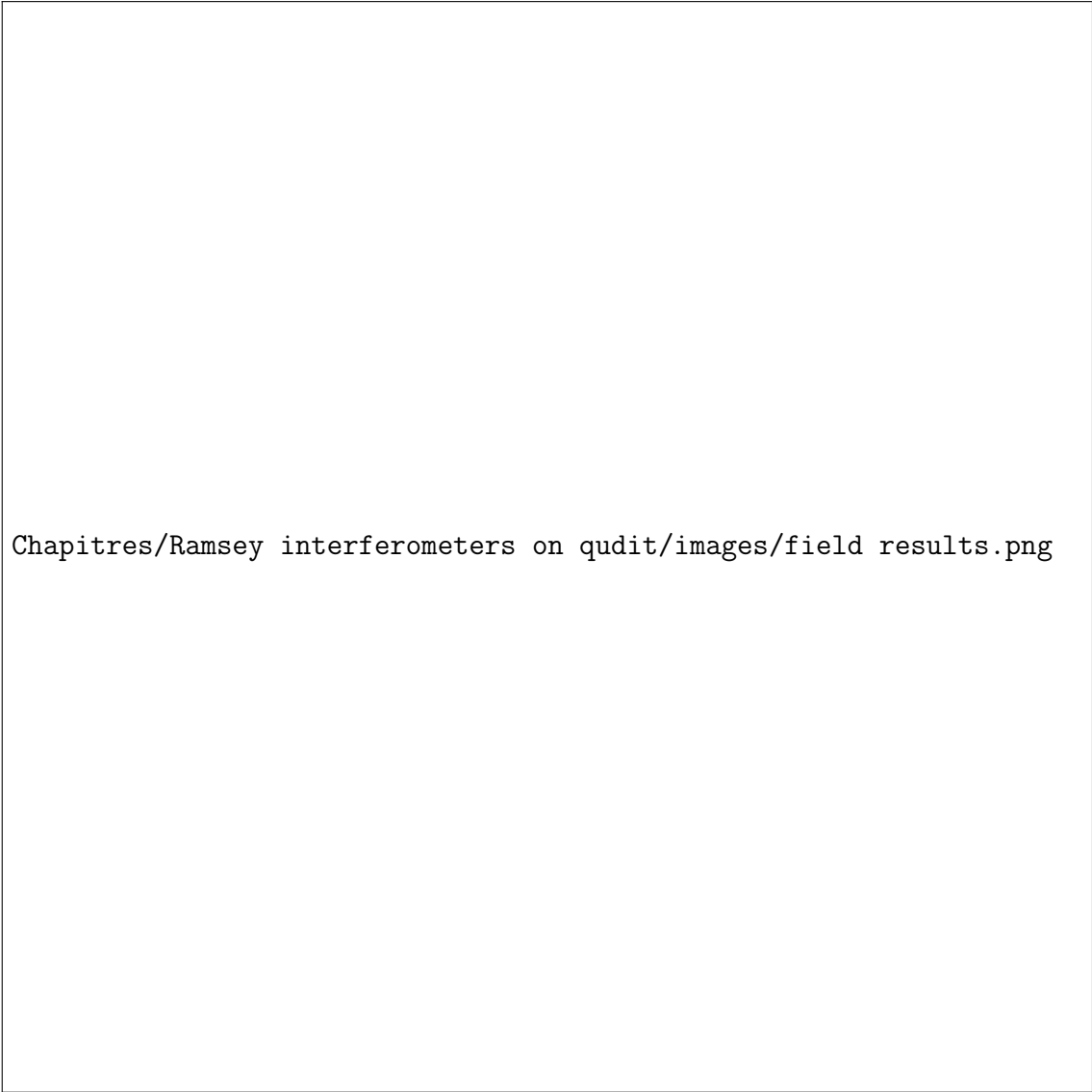
2.2.2 Measuring two quantites at a time

2.2.2.1 Physical principle



Figure 2.8: Caption

2.2.2.2 Results



Chapitres/Ramsey interferometers on qudit/images/field results.png

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

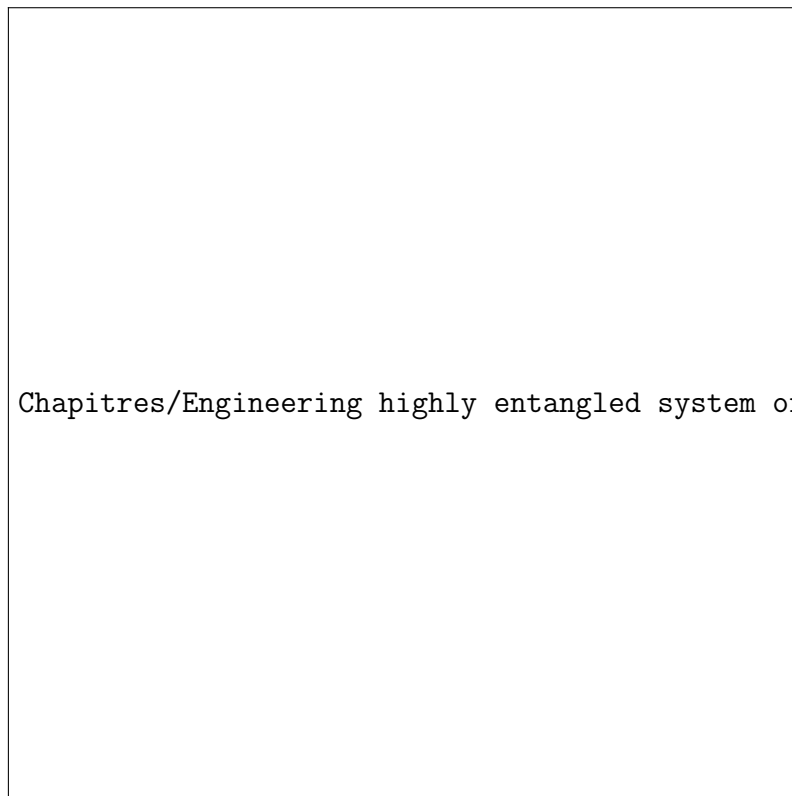
Chapter 3

Engineering highly entangled system of photoassociated ^{87}Sr atoms

Engineering Dicke states

3.1 Introduction on photoassociation

3.1.1 What is photoassociation



Chapitres/Engineering highly entangled system of photoassociated ^{87}Sr atoms

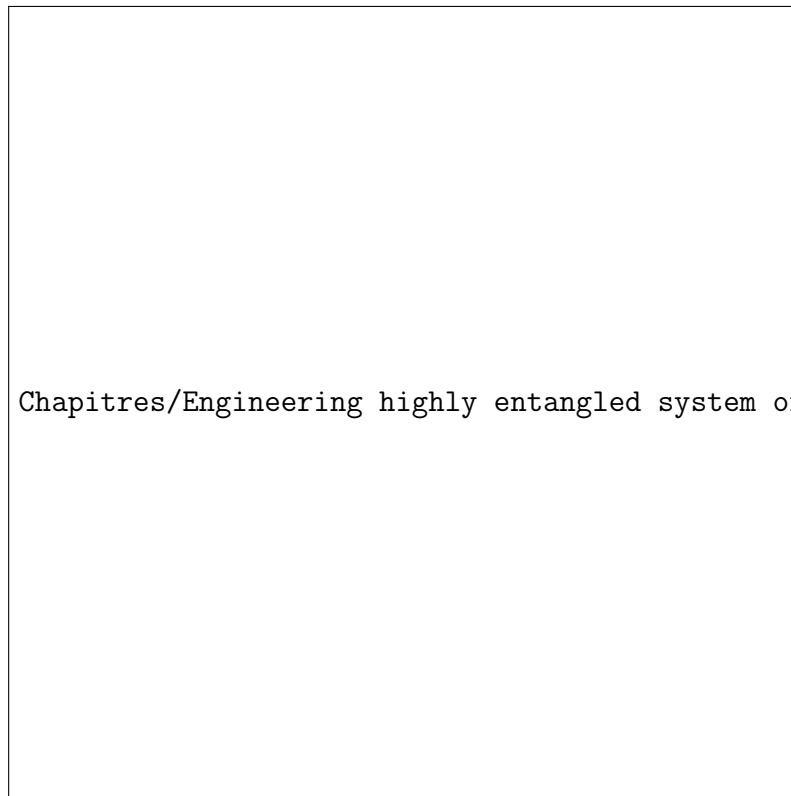
Figure 3.1: Caption

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

oui non

3.1.3 Internal energy states

3.1.3.1 WKB approximation



Chapitres/Engineering highly entangled system of photoassociated 87Sr a

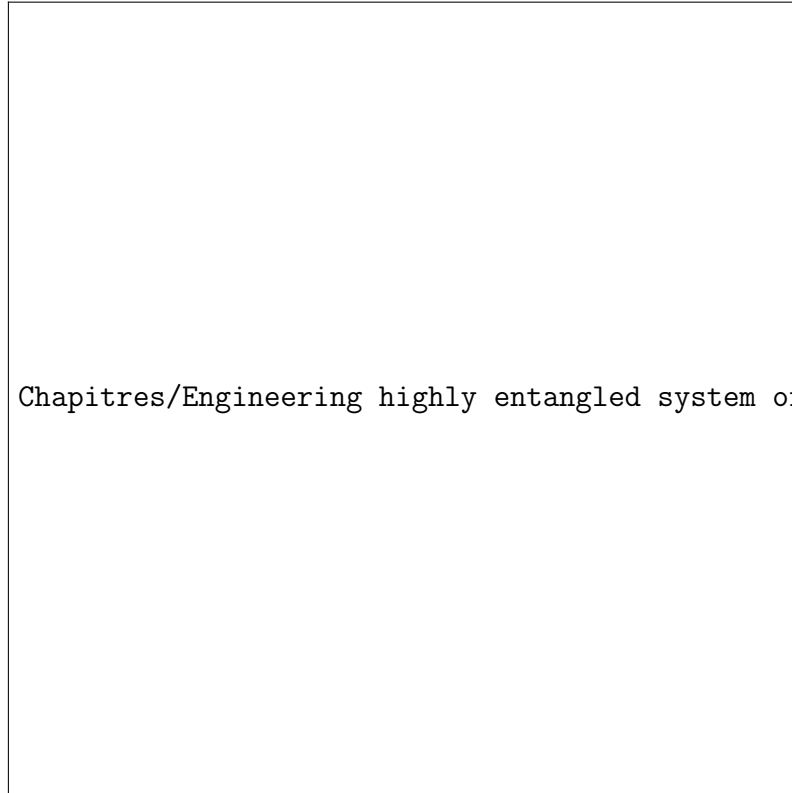
Figure 3.2: Caption

3.1.3.2

3.1.4 External energy states

3.2 About photoassociation on other species

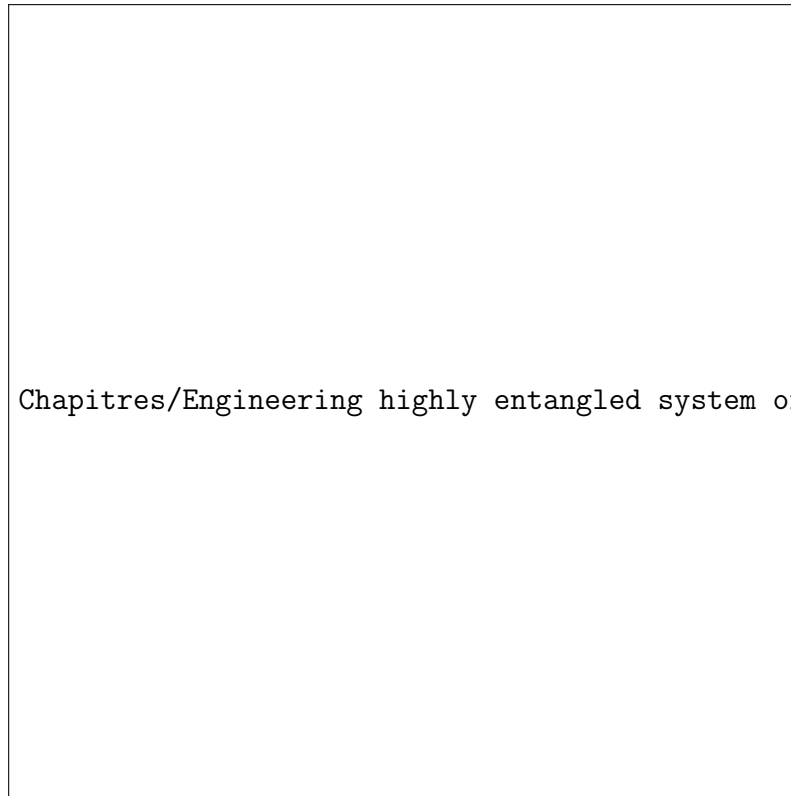
3.2.1 Mass scaling (^{88}Sr)



Chapitres/Engineering highly entangled system of photoassociated ^{87}Sr atoms

Figure 3.3: Caption

3.2.2 Ytterbium: hfs



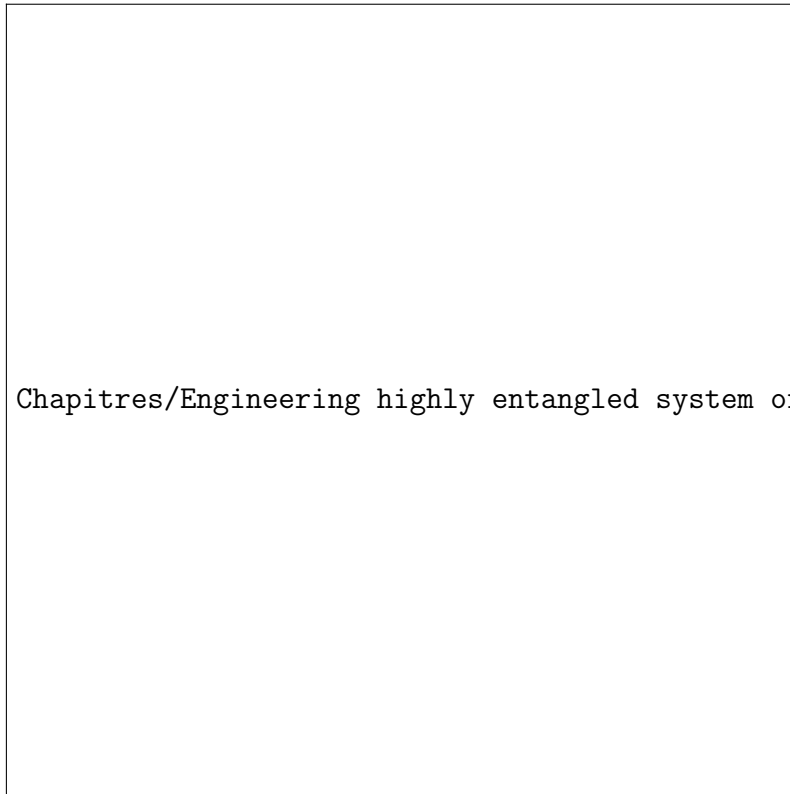
Chapitres/Engineering highly entangled system of photoassociated 87Sr a

Figure 3.4: Caption

3.3 Experimental setup

3.4 88Sr Results

Lopt, power broadening, thermal broadening...



Chapitres/Engineering highly entangled system of photoassociated ^{87}Sr atoms

Figure 3.5: Caption

3.4.1 Technical issues of inhabilitation of photoassociation

3.4.1.1 Laser width

3.5 ^{87}Sr molecules

Lopt oui 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 ^{87}Sr - ^{87}Sr molecules

Conclusion

Appendix A

Algorithms