Introduction

- Overview of thesis - experiment to measure a range of acceleration

Theory

- Describe general principles of light-matter interaction
- Specific cases for laser cooling (doppler/sub-doppler) and Raman transitions
- Lead into atom interferometry
- Perhaps split this into two shorter chapters

Overview

- Describe chapter

Light-Matter Interactions

Figures

- [ ]

Content

- [ ]

Laser Cooling of Rubidium-87

Figures

Raman Transitions in Rubidium-87

Figures

- Energy level diagram
- Origin of light shift

Content

- Two-level equation derivation
- Light shift

Light Pulse Atom Interferometry

Figures

- Space-time diagram

Content

MOTMaster

Overview

- New MOTMaster software to control experiment
- Control system diagram
- Interfacing with muquans/msquared lasers
- Acquiring data from experiment --- axelsuite

Motivation

Interfacing with Hardware

Hardware Abstraction

Voltage Pattern Generation

Timed Serial Communication

Voltage Acquisition

External Control

Building a Sequence

Experimental Sequence Structure

Cooling and Trapping in a MOT

Chapter Outline

The Navigator Vacuum Chamber

The 2D MOT system

Figures

- Setup diagram
- Plot loading rate

Content

- Explain need for 2D MOT side-arm
- Describe components
- Performance of the 2D MOT

The 3D MOT system

Figures

- Diagram of 3D MOT collimator
- Diagram of coils inside chamber

Content

- Explain physical characteristics of the MOT

- Describe steps involved in loading the 3D MOT

CCD Imaging

Figures

- Location of camera

Content

- Calculation of atom number from fluorescence

Generating MOT light

Muquans Laser Control

Figures

- Diagram of Muquans system
- Spectroscopy plots
- Plot of AOM response vs control voltage
- Plot of EOM repsonse vs control voltage

Content

- Describe how the Muquans laser generates MOT light

Frequency Control

Figures

- Plot power vs drive frequency for EOM and AOM

Content

- Describe how the laser controls the frequency and power of

the MOT light - cooling and repump
- Explain calibration of output to give linear ramp (maybe move to molasses)

Real-Time Communication

Figures

- Glossary of commands (for appendix)

Content

- Describe serial communication interface
- Hardware and software triggering

Controlling the MOTs

Optical Fibre Network

Figures

- Fibre network diagram

Content

- Describe need for

Magnetic Field Control

Figures

Content

Characterising the 3D MOT

3D MOT Loading Rate

Temperature

Preparing Atoms for Interferometry

Chapter Outline

- Discuss loading atoms in 3D MOT from 2D
- Characterisation of the moving frame optical molasses
- Various schemes for preparing atoms into (\ket{1,0). {\textit mention velocity selection here or in next chapter?

Cooling in Optical Molasses

Real-time Frequency Control

Optimising the Temperature

State Preparation

Schemes for Preparation

Optical Pumping Scheme

Including Microwave Transitions

Wind-Freak Synthesiser

Preparing Atoms for Interferometry

Chapter Outline

- Discuss loading atoms in 3D MOT from 2D
- Characterisation of the moving frame optical molasses
- Various schemes for preparing atoms into (\ket{1,0).

Cooling in Optical Molasses

Real-time Frequency Control

Optimising the Temperature

State Preparation

Schemes for Preparation

Optical Pumping Scheme

Including Microwave Transitions

Wind-Freak Synthesiser

Acceleration-Sensitive Interference

Chapter Outline

- Raman spectrum, identifying each transition
- Characterisation of velocity-selective pulse and each interferometer pulse using Rabi oscillations.
- Making a three-pulse atom interferometer
- Improving acceleration sensitivity and correlating vibrations using MEMS

Raman Optical System

Raman Beam Collimator

Retro-reflection Assembly

The MEMS Accelerometer

Driving Raman Transitions

Frequency and Phase Control

Atom Detection

Optical System

Measuring the Interferometer Phase

Individual Pulse Characterisation

Velocity-Selective Pulse

Interferometer Pulses

Three-Pulse Atom Interference

Measuring Accelerations

Vibration Sensitivity

Outlook

Combining with classical accelerometers

- Discuss schemes for combining multiple sensors - Kalman filtering
- Extend this to inertial navigation
- Steps towards overcoming sensitivity-bandwidth trade-off.

Extending to senstivity along three axes

- New chamber design
- Improvements to MSquared laser
- Required knowledge of gravitational axis for accurate navigation