

# Building Single Molecules from Single Atoms

A DISSERTATION PRESENTED  
BY  
YICHAO YU  
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Thesis advisor: Professor Kang-Kuen Ni

Yichao Yu

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ABSTRACT

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# Acknowledgments

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## Introduction



# 1

## Apparatus

### 1.1 COOLING AND OPTICAL PUMPING BEAMS

(MOT, OP, fiber back reflection)

(Mention Na Raman beam to be covered in later chapter?)

## 1.2 TWEEZER AND IMAGING

## 1.3 MOLECULAR RAMAN FREQUENCY GENERATION

(beam path, calibration)

# 2

## Computer control of the experiment

### 2.1 OVERALL STRUCTURE

### 2.2 FRONTEND

### 2.3 BACKENDS

(communication protocol)

2.3.1 FPGA BACKEND

2.3.2 NIDAQ BACKEND

2.3.3 USRP BACKEND

2.4 AUTOMATION OF SCAN

3

# Raman sideband cooling

3.1 THEORY

3.2 SETUP

3.3 CHALLENGE WITH LARGE LAMB-DICKY PARAMETER

3.4 SOLUTION: HIGH ORDER SIDEBANDS

3.5 SOLUTION: SIMULATION BASED OPTIMIZATION

3.6 COOLING PERFORMANCE

# 4

## Interaction of single atoms

### 4.1 SCATTERING LENGTH

(Importance/relation with binding energy etc.)

#### 4.2 ENERGY LEVELS OF TWO INTERACTING ATOMS IN AN ANISOTROPIC TRAP

#### 4.3 INTERACTION SHIFT SPECTROSCOPY

(motional sideband, scattering length result)

#### 4.4 SUMMARY AND OUTLOOK

(Motional state selection)



# 5

## Photoassociation of single atoms

### 5.1 ENERGY LEVELS

### 5.2 EFFECT OF THE TRAP

(light shift, broadening)

### 5.3 PHOTOASSOCIATION SPECTROSCOPY

( $v=0, 12, 14$ , etc)

# 6

## Two-photon spectroscopy of NaCs ground state

(N=2, different HF states)

# 7

Coherent optical creation of NaCs

molecule

# 8

## Conclusion