Building Single Molecules from Single Atoms

A DISSERTATION PRESENTED
BY
YICHAO YU
TO
THE DEPARTMENT OF PHYSICS

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN THE SUBJECT OF
PHYSICS

HARVARD UNIVERSITY
CAMBRIDGE, MASSACHUSETTS
MARCH 2021

Thesis advisor: Professor Kang-Kuen Ni Yichao Yu

Building Single Molecules from Single Atoms

Abstract

Contents

Acknowledgments

,

0

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)

3

Raman sideband cooling

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)

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