1. Motivation
   1. Few body phyusics with many testable results reachable via atomic physics
      1. Universality
      2. Efimov physics
      3. Halo states
         1. History and theory
         2. Magneto association
      4. New regimes of PAS and find new
   2. Similar to optically controlled magnetic feshb ach resonance
      1. Chin 16
      2. Rempe, Duhr Nature phys 2009 DOI: 10.1038
   3. Zeno
2. Experimental Section
   1. Mention that two were used but the basic architecture is the same.
   2. Vacuum system
      1. Overview
      2. Mention breaking vacuum and getting back
      3. Nozzle redesign
      4. Info about off center collimating tube
   3. Laser systems (focusing just on the sample preparation, not the PAS beams)
      1. Blue
         1. 922 diagram and characteristic outputs along the table
            1. MOT and Zeeman
         2. Locking systems (specifically addition of slow lock, code for slow lock?)
         3. Frequency setpoints and ranges
         4. BOP and alternative setup
      2. Red
         1. Boson diagram and usage
            1. Trapping
            2. spectroscopy
         2. Fermion diagram and usage
            1. Trapping
            2. Spectroscopy
      3. Repumper
      4. Green (put this entirely in its own chapter)
         1. Should I put all the lattice characterization here?
         2. Trap modeling program
            1. Comparison between theory and experiment
      5. Infra-red
      6. Absorption imaging system
         1. Overview
         2. Link to imagefit appendix
         3. Overview of PCA
      7. Unintegrated systems
         1. Pico motor
         2. Movable mirror
         3. Fermion trap synth
      8. AC zero crossing line trigger
   4. Typical trapping sequence
      1. Timing diagram
      2. Typical results for atom trapping at different points in the sequence for different isotopes
3. PAS Background
   1. Standard Theory
      1. B&J (single and two-photon)
      2. Limitations
   2. Halo molecules (This may want to be in the motivation section)
      1. Physical picture
      2. Simple theory and slightly more advanced theory
   3. Experimental details
      1. Schematic of excitation
         1. Optical setup for PAS beams
            1. Dual frequency generation
            2. Fiber
            3. Photodiode monitor and power balance
            4. Scan limitations
         2. Intensity calibration
      2. Consideration of signal contrast
4. Binding Energy of the Halo Molecule
   1. Trap parameters
   2. fitting function (messy integral)
      1. model
      2. truncation effects
      3. where should density discussion come in?
   3. data and best analysis
   4. limitations to data?
      1. Insufficient density determination due to oddities of trap geometry (include pictures of trap geometry?)
   5. Alternative fitting method (rising edge)
   6. Shifts
      1. 689 AC Stark
         1. Frank-condon factor
      2. Density-dependent shift
         1. Connection to Efimov physics
      3. Trap AC Stark
   7. Comparison with theory for halo state
5. High Intensity PAS of Halo Molecule
   1. Trap parameters
   2. AC Stark
   3. Multi-photon resonances
      1. Data
      2. Physical picture
   4. Advanced theory
6. Lattice
   1. Experimental schematic
   2. Basic profiles
   3. Characterization
      1. Kaptiza-dirac
         1. Theory and results
      2. Sideband cooling
      3. Heating problems
   4. Next steps
7. Conclusion
   1. Studied fascinating few body systems
      1. Novel halo molecules
         1. Measured binding energy
         2. New regime of photoassociation
         3. New method of halo molecule creation
   2. Next steps (with halo) – rich system with lots of physics
      1. Density dependent shift -> Efimov physics
      2. Large AC stark shift suggest control of scattering length
      3. Gateway to efficient population of rovibrational ground state
      4. Control particle interactions via atom-photon mixed states? This was the point of needing the lattice and trying to do PAS on a halo state (or at least we can say it was)
   3. Next steps (more generally)
      1. Create halo molecules in a lattice potential
         1. Could reduce loss mechanism since we have gamma\_arb
         2. Study inherent lifetime
      2. Optical control of scattering length within a lattice potential
         1. Potential to study Interesting many body states
            1. Zeno
            2. Rapid quenches
8. Other projects I’d like to document somehow
   1. 922 PZT replacement and history Appendix or note during description of 922 system)
   2. Expansion of the background fitting to PCA (could go in the experimental section)
      1. Mi kinda talked about it but specifically addressing it in as Principal component analysis
   3. Manual for the imagefit analysis routine (appendix)
   4. Manual for the labview routine (appendix)
      1. how to update spinal column, point of md5
   5. Beam fitting program and data taking template (appendix)
   6. Beam propagation program (appendix)
   7. Lattice (appendix)
      1. How to calculate the bloch and wannier functions
      2. Code for fitting the Kapitza-Dirac
      3. How to calculate the complete lattice potential
         1. Trap frequency calculations and comparison to harmonic oscillator
         2. Global model for calculating the trap geometry from oscillation data
   8. Bragg beam setup on table
   9. Considerations for getting a new computer setup running the apparatus(appendix)
      1. SpinCore API issues (particularly talking to both pulseblasters)
      2. PixelFly issues (getting the driver correct)
      3. Channel names of all the DAQs in NI-MAX
      4. FPGA setup
      5. Process to upgrade Labview code (particularly the renaming spinal\_column issue)
   10. Addition of chamber supports
9. Motivations
10. Experimental
    1. laser systems
11. Pas background
    1. Bohn and Julienne
       1. Point out assumption of untruncated
          1. Show derivation of the momenta distribution leading to B&J theory
             1. Do this by starting derivation of K
       2. Discussion of sophisticated theory will be later
    2. Experimental setup
12. Low energy PAS
    1. All data
    2. Numerical model
       1. Discuss different limitations
       2. Tell story about looking at various analyses leading to our final characterization of the system
13. High energy PAS
    1. Selective data
    2. Floquet theory
14. Lattice
    1. setup
    2. Measurements and results
15. Conclusion

Specifically address summary of my work