Why cold molecules?

- Fundamental tests (3-dipole, chirality, variation of fundamental constants)
- Photochemistry (photoassociation)
- Quantum properties (dipole), molecular collective quantum systems BEC.BCS
- Quantum Reactions and control
- Frequency standards and ultracold chemistry
- Quantum Information, ...

Need ultra-cold molecules in v=J=0

Cold molecules made of cold atoms [1]

- Magnetoassociation (Feshbach Resonance) 2002-2003
  (R. Grimm, C. Salomon, W. Ketterle, D. Jin, G. Rempe, ...
- Collision with another partner, 3-body recombination
  (E. Cornell, C. Gabannini, R. Grimm, 1998-2003,...)
- Photoassociation, (Pillet 1997, ...)

All form cold molecules but with high vibration

Kievit Lab

- Ultra-cold [1]
  - Laser cooling of atoms: reduction of velocity through accumulation of light momentum.
- Laser manipulation of molecules [2]
  - laser sources and spectral-shaping techniques as main tool to cool down and control all degrees of freedom
- Toward the ro-vibrational cooling of ultra-cold molecules

References:

Optical pumping and vibrational cooling [6,7]

- Photoassociation
  - 2 atoms absorb a photon
- State X1Σ\(^g\) + State a3Σ\(^u\) +

Both detection schemes are performed in the same frequency range

*REMPI: Resonantly Enhanced Multi-Photon Ionization

Optical pumping and vibrational cooling [6,7]

- State X1Σ\(^g\)
- State a3Σ\(^u\)

Transfer (80%) of vX (vX) toward vC = 0

Spectral shaping of pumping laser

Accumulation in dark state vX = 0

Spectral shaping of pumping laser

Transfer (80%) of vX (vX) toward vX = 0

Molecules photoassociated in a3Σ\(^u\) through S\(_2\) (P\(_1\))

Scheme for state conversion

Scheme for depletion measurement

Measuring the rotational population

- Studies of rotations and rotational cooling.
- Molecular trapping.