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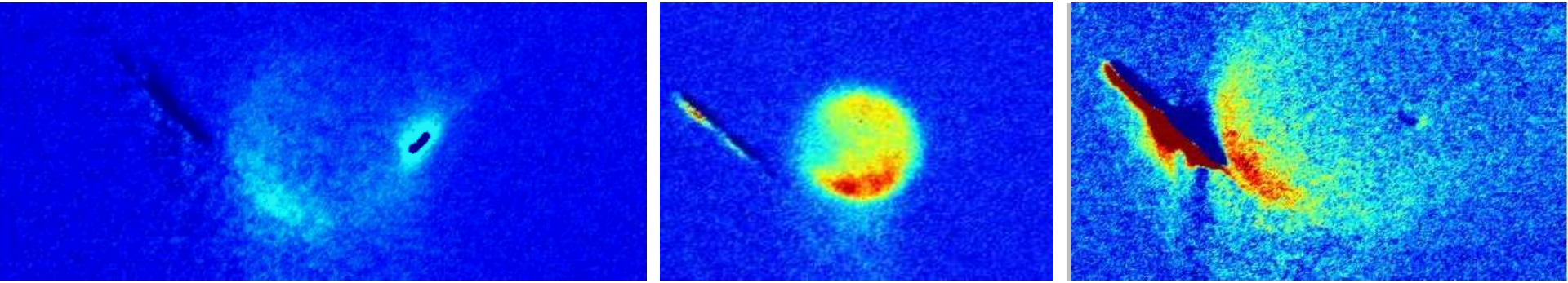

Inelastic Collisions of NO and NO_2

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Crossed-beam velocity map ion imaging with NO and NO_2

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- observing collisions between NO and NO_2 molecules to study the energy transferred during the collision
- laser beams used to excite and ionize state selected NO that has gained internal energy from a collision
- detect NO^+ ions in a velocity map image

How are molecules energetically different than atoms?

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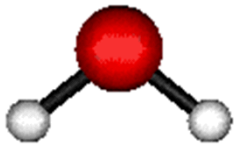
Translational Energy

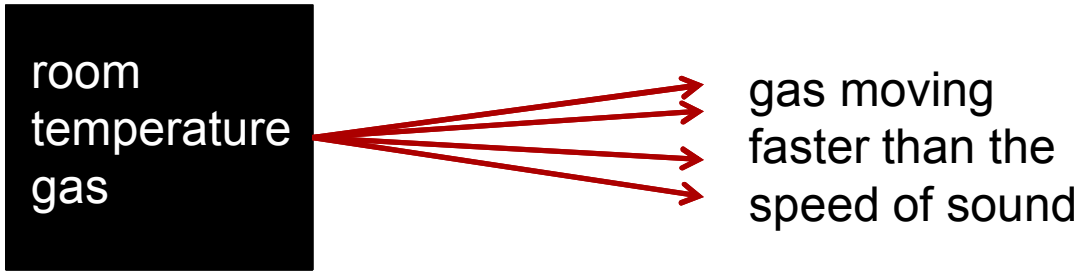
Internal Energy



How does this effect energy transfer in crossed-beam collisions?

- if colliding beam is an atom, the atom can only gain or lose translational energy
- if colliding beam is a molecule, it can gain or lose internal and/or translational energy

Creating internally cold molecules through supersonic expansion



- essentially all internal energy is converted to translational energy
- all gases coming out of this system will have the same kinetic energy

$$KE = \frac{1}{2}mv^2$$

- lighter gas molecules will travel faster

Comparing Ar and NO_2 as the colliding molecule

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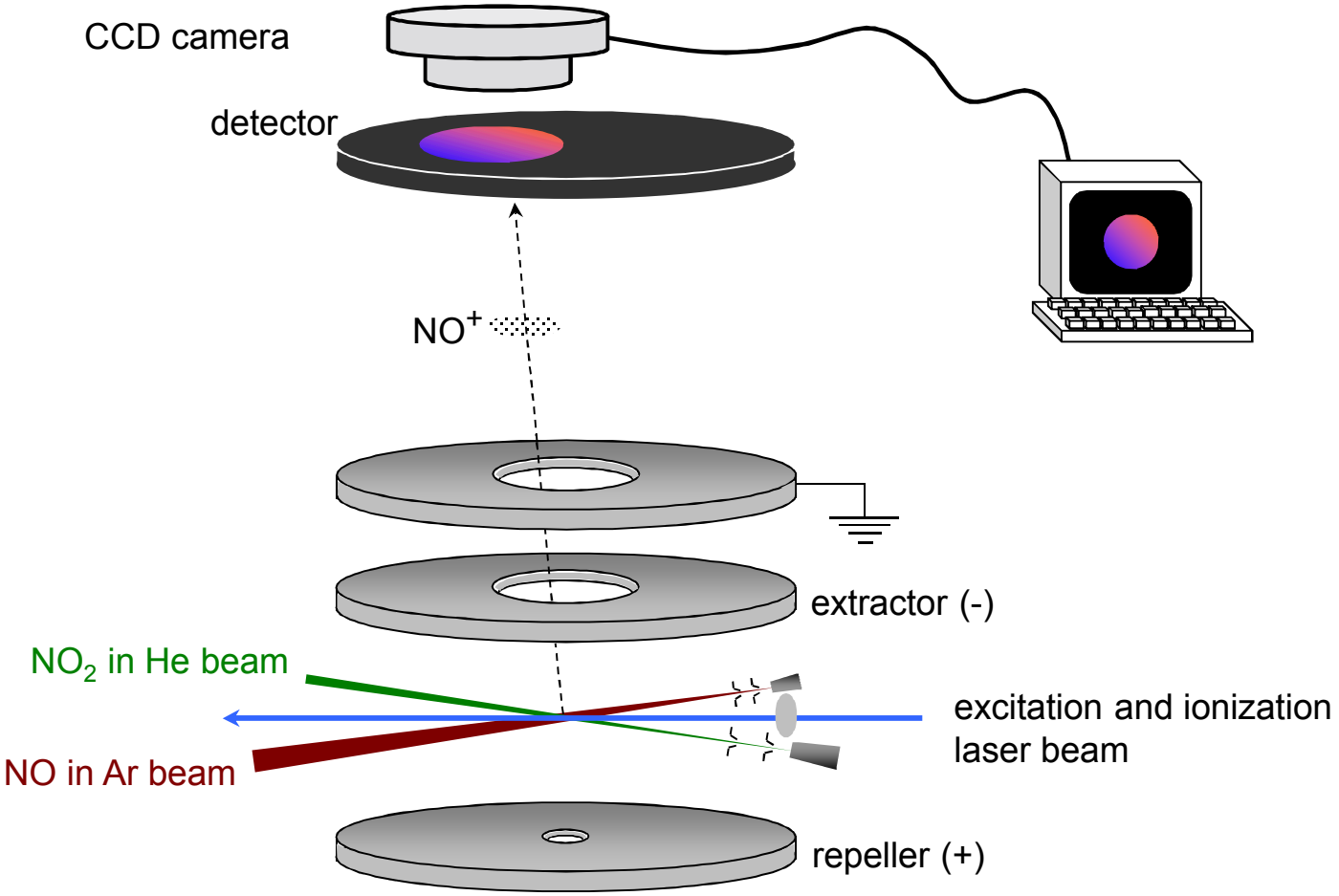
- masses of Ar and NO_2 are about the same (~40 and 46amu), but beam is 10% NO_2 in He, making the average mass 6.94amu
- lighter average mass of NO_2 beam means a higher velocity which makes a lot more energy available for the collision
- energy available from Ar is about 449cm^{-1}
- energy available from the NO_2 is about 1393cm^{-1}
- NO_2 has more than 3x the energy available for a collision!!!

Experimental setup for crossed molecular beam collision detection



Crossed molecular beam velocity map ion imaging apparatus

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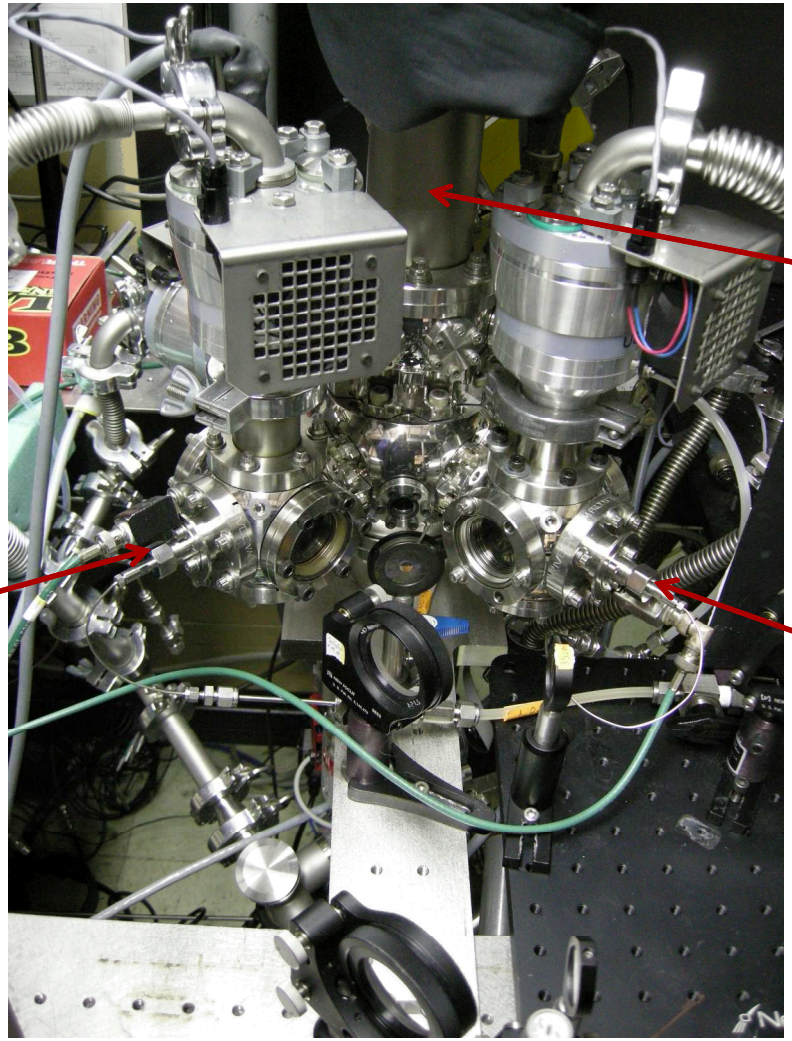
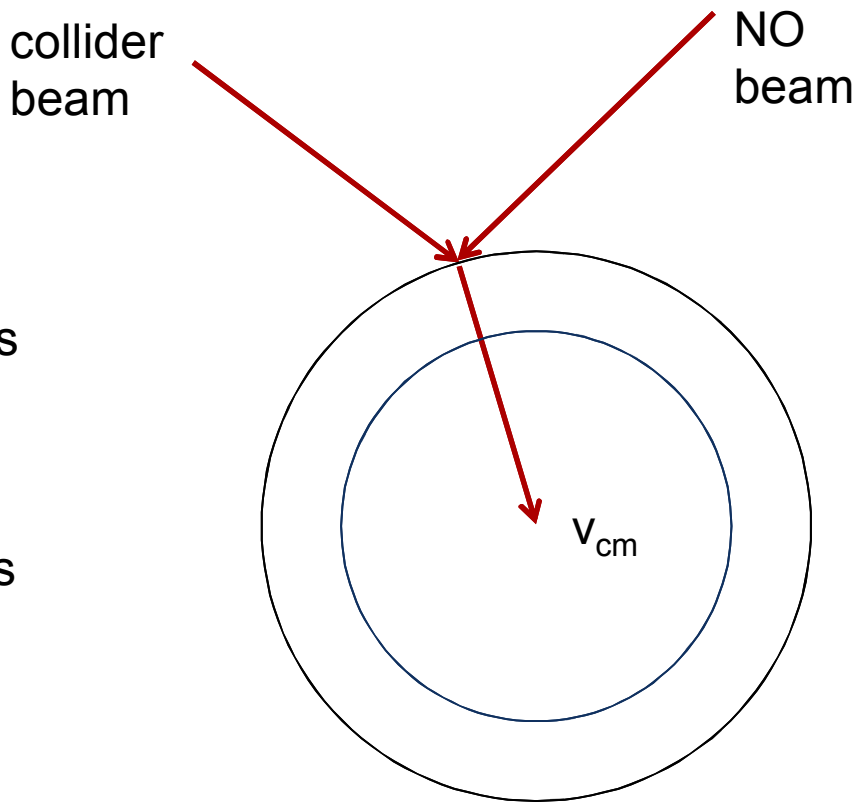


Velocity mapping of NO after a collision



- outer ring shows velocity map at J=0.5

- inner ring shows velocity map at a higher J state

Comparing images at J=12.5

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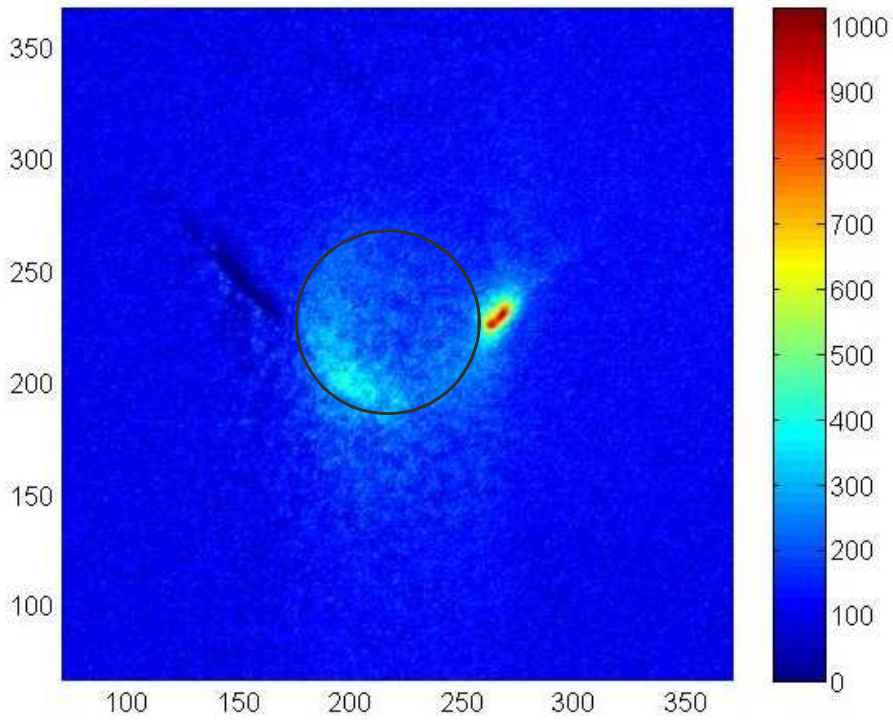
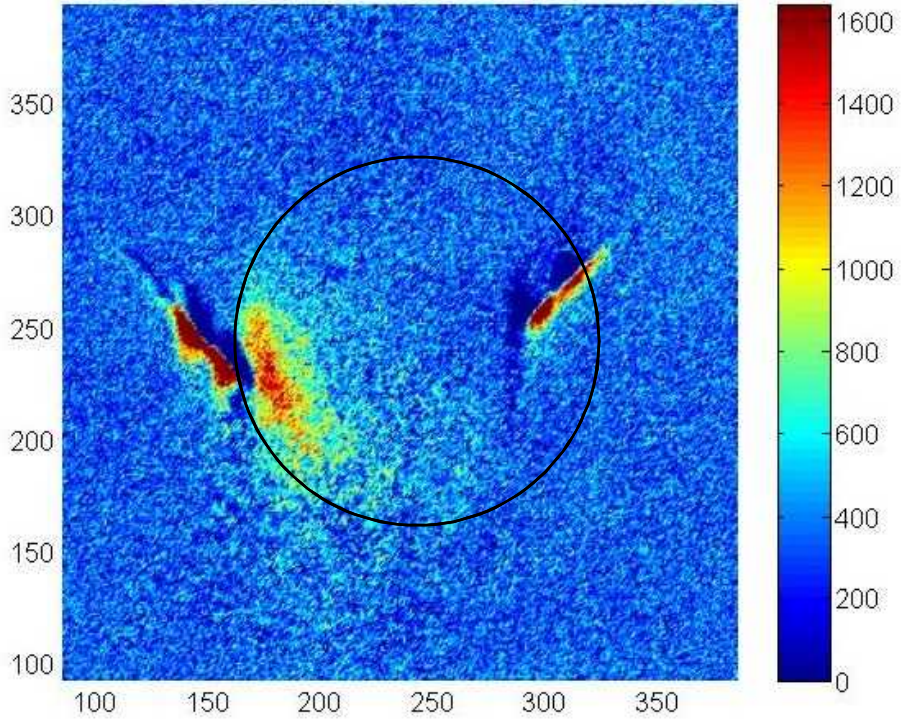
NO with Ar scattering



5 iterations

NO with NO_2 scattering



100 iterations

Comparing images at J=15.5

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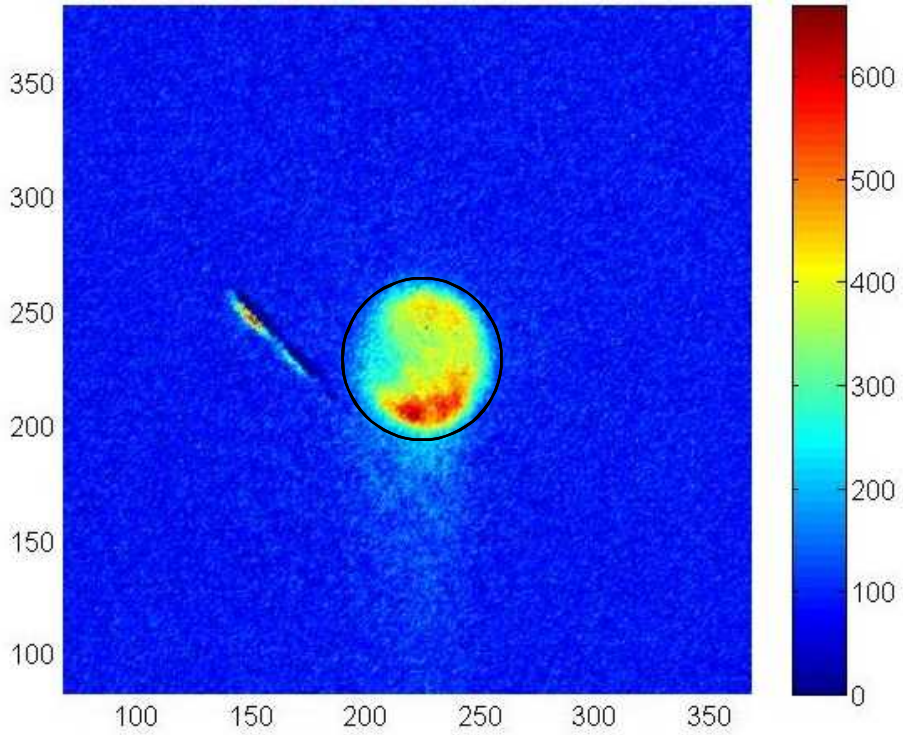
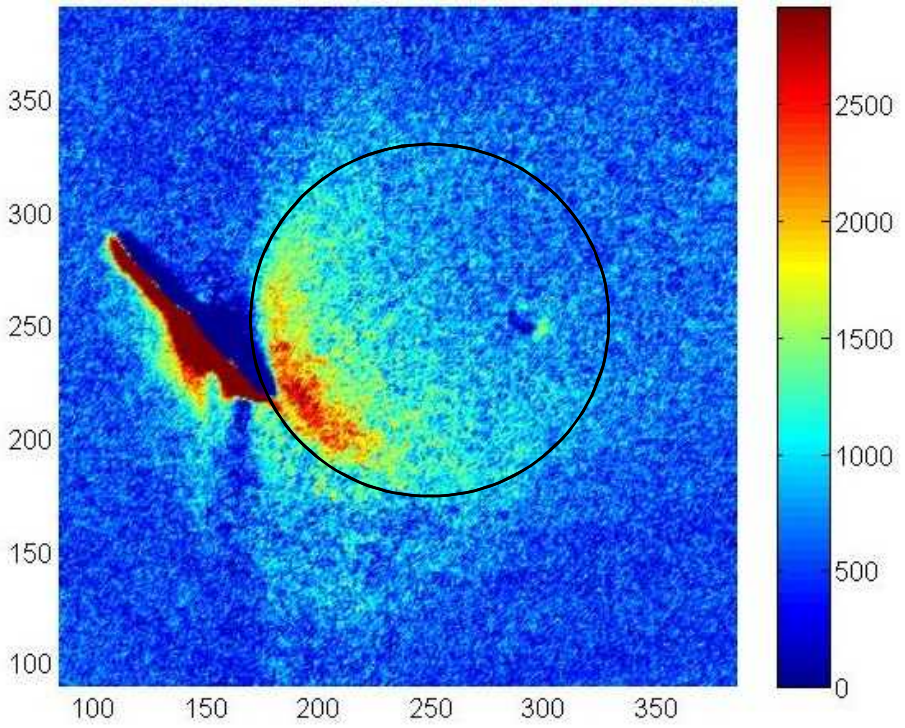
NO with Ar scattering



5 iterations

NO with NO_2 scattering



100 iterations

What can we learn from the velocity map ion images?

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Difference energy of colliding beams has multiple effects on the scattering of NO

- radius of circle with Ar scattering is much smaller because less energy
- even at a high rotational state, NO is forward scattered
- the blurring effect seen in the Ar + NO image is due to the correlation between a high rotational state and more back scattering
- the blurring effect seen in the NO_2 + NO image is due to NO_2 picking up energy from the NO during the collision

Future Work

- analyze the data collected of NO and NO_2 collision energy transfer
- excite NO_2 before collision by sending in another laser

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