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ADRIATICO RESEARCH CONFERENCE on

LASERS IN SURFACE SCIENCE

11-15 September 2000

Miramare – Trieste, Italy

Deceleration and trapping of neutral dipolar molecules

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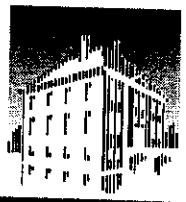

FOM-Instituut voor Plasmafysica Rijnhuizen

Deceleration and trapping of neutral dipolar molecules

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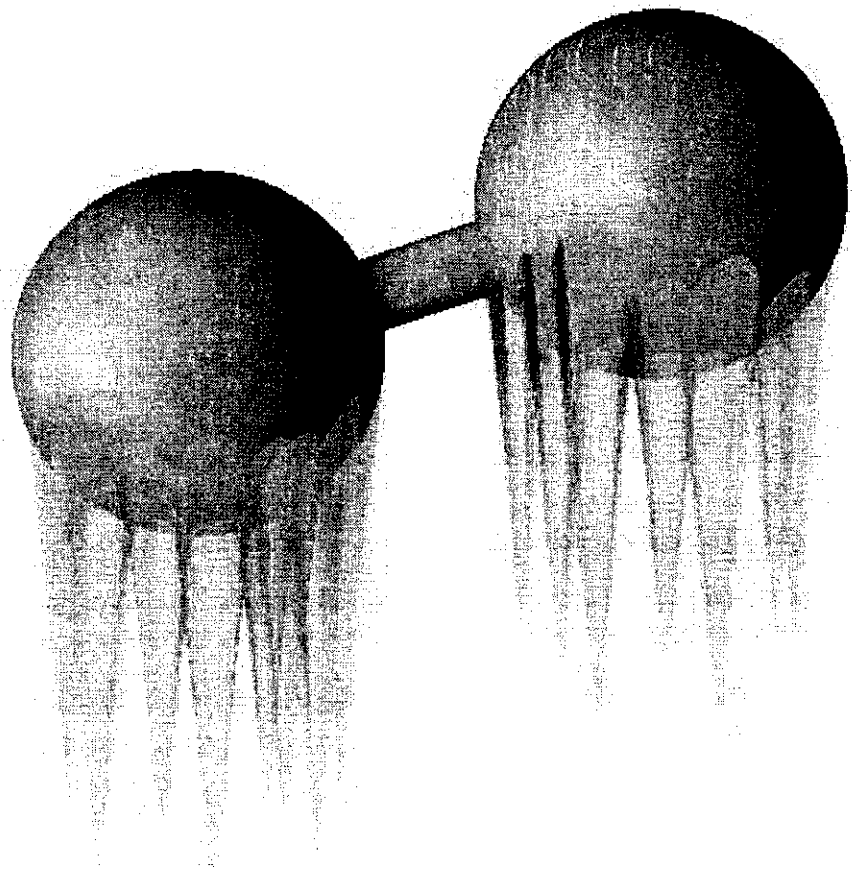
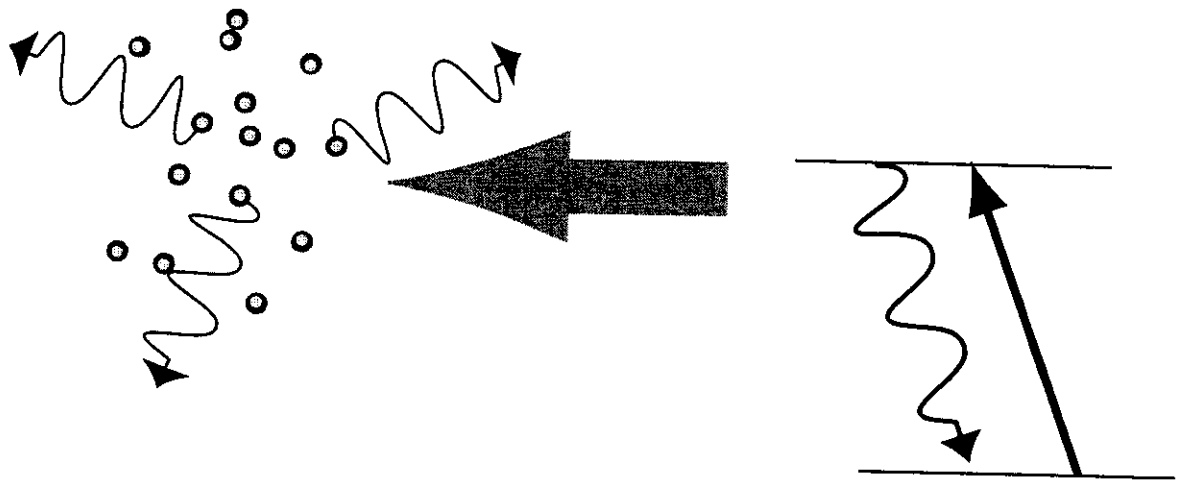


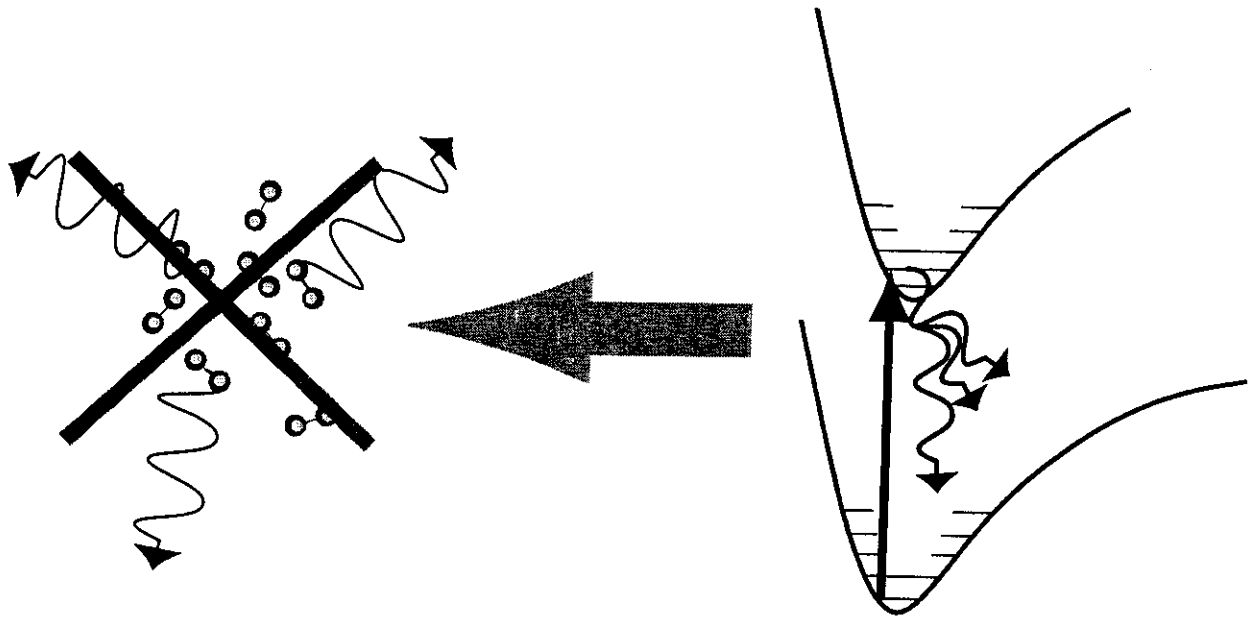
- Principle of Stark deceleration
- Decelerating metastable CO
- Decelerating and trapping ammonia-d3
- Conclusions & Future prospects

Laser cooling

- Laser cooling on atoms



- Laser cooling on molecules not possible



- 'Cold molecules' for:

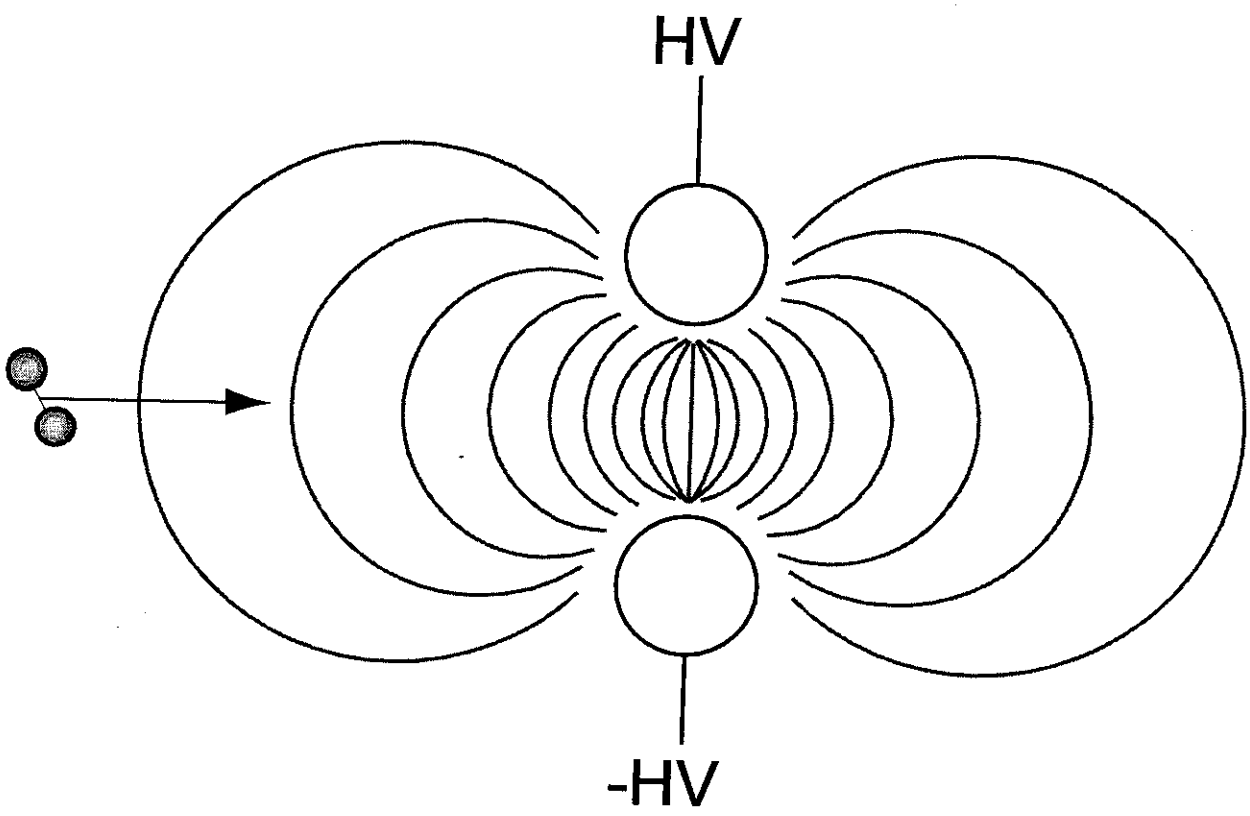
  -Cold molecule-molecule collisions
  -Molecular quantum collective effects
  -Doppler free spectroscopy
  -Molecular optics

- Two methods thusfar:

  -Buffer gas loading
  CaH, paramagnetic molecules

  -Photoassociation:
  Cs_2 , dipole-trap CO_2-laser

Principle of Stark deceleration



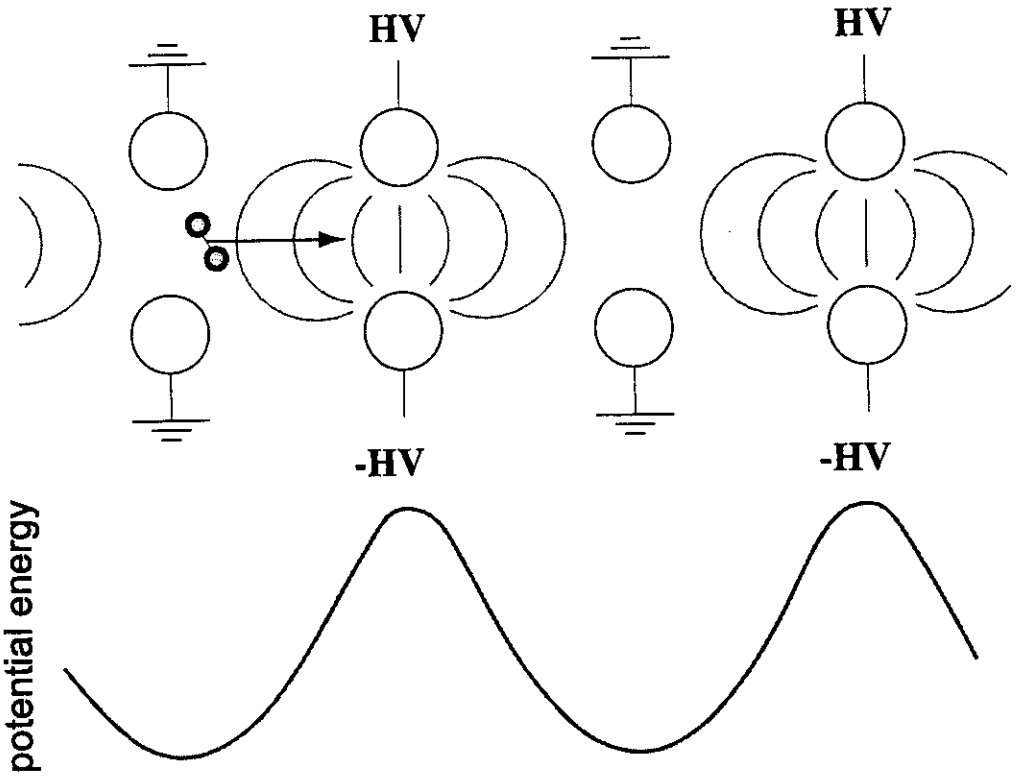
$$U_{pot} = W_{stark}$$

$$W_{stark} = -\vec{\mu} \cdot \vec{E}$$

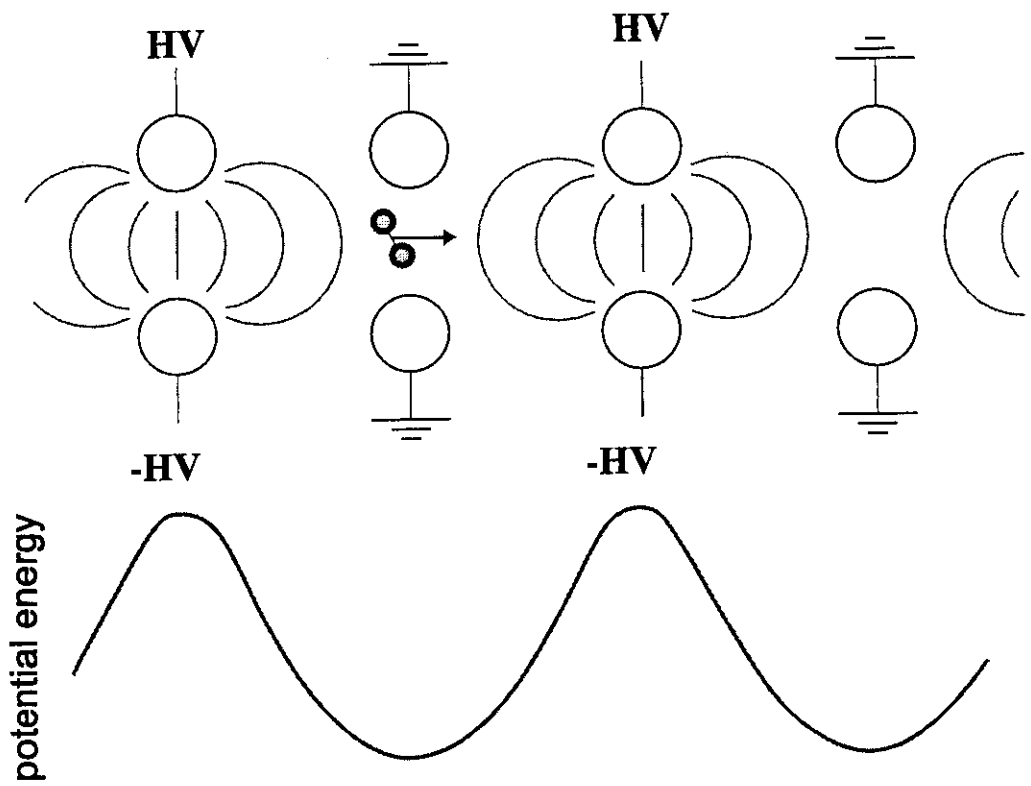
$$F_{dipole} = -\frac{\partial W_{stark}}{\partial x}$$

Principle of Stark deceleration

Time 1

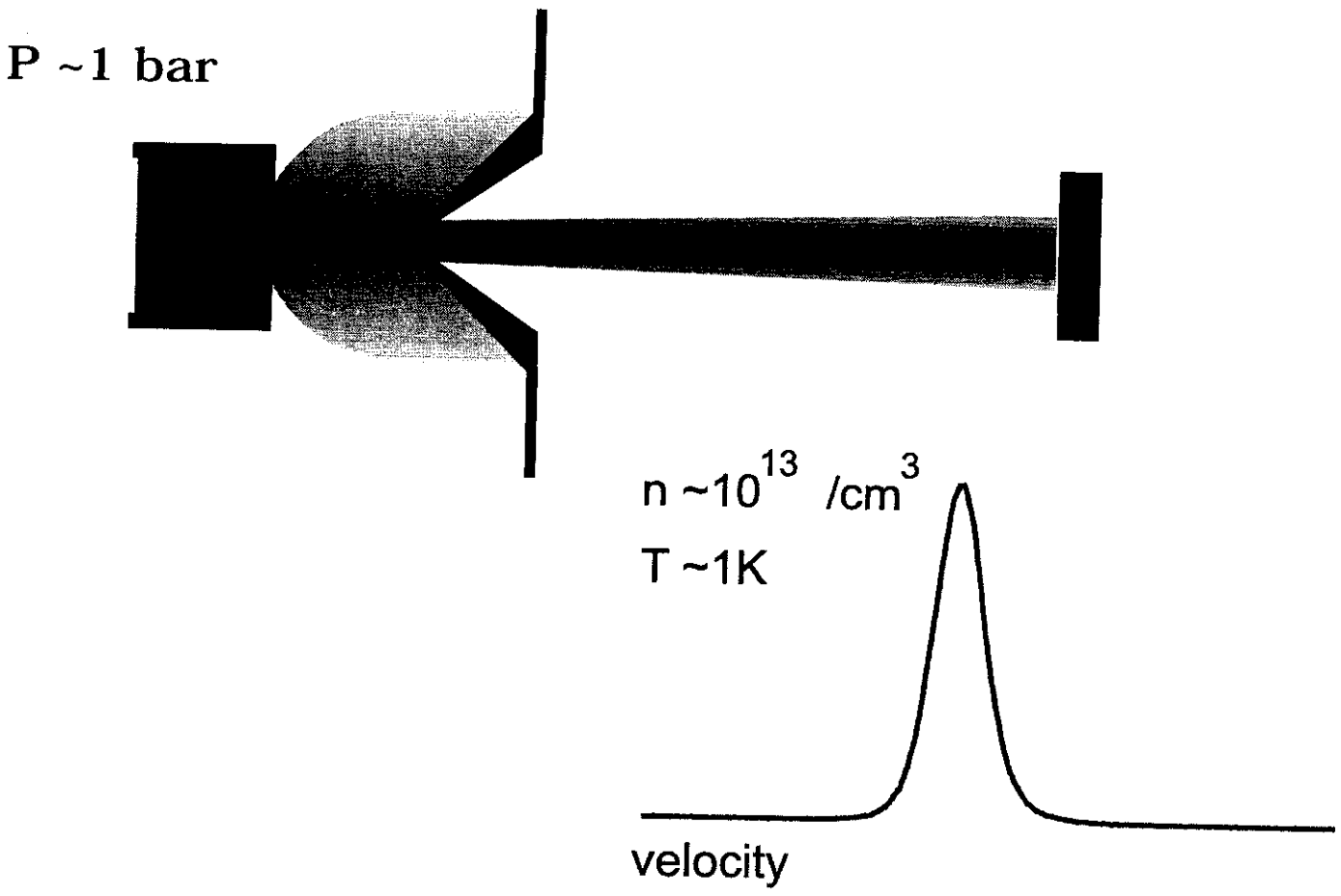


Time 2



Molecular beam

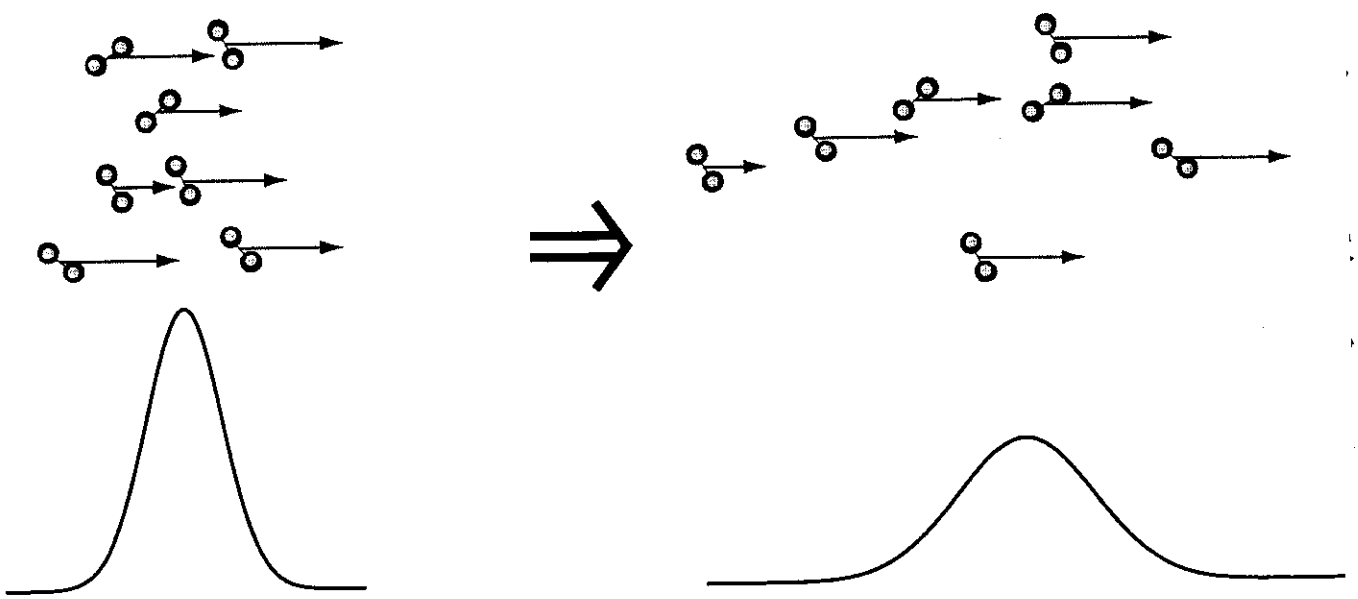
- Rotational and translational cooling in a pulsed supersonic expansion



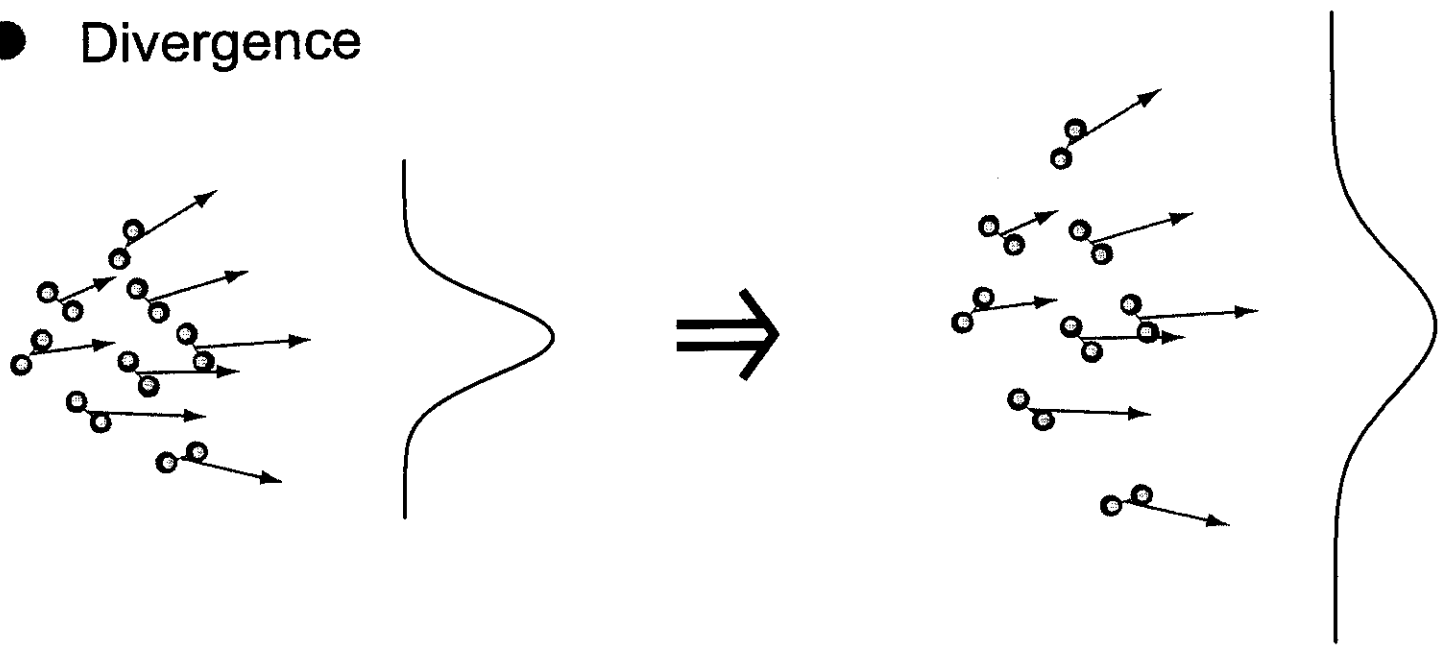
- Velocity in lab frame: 250 - 2000 m/s

Attenuation of the molecular beam

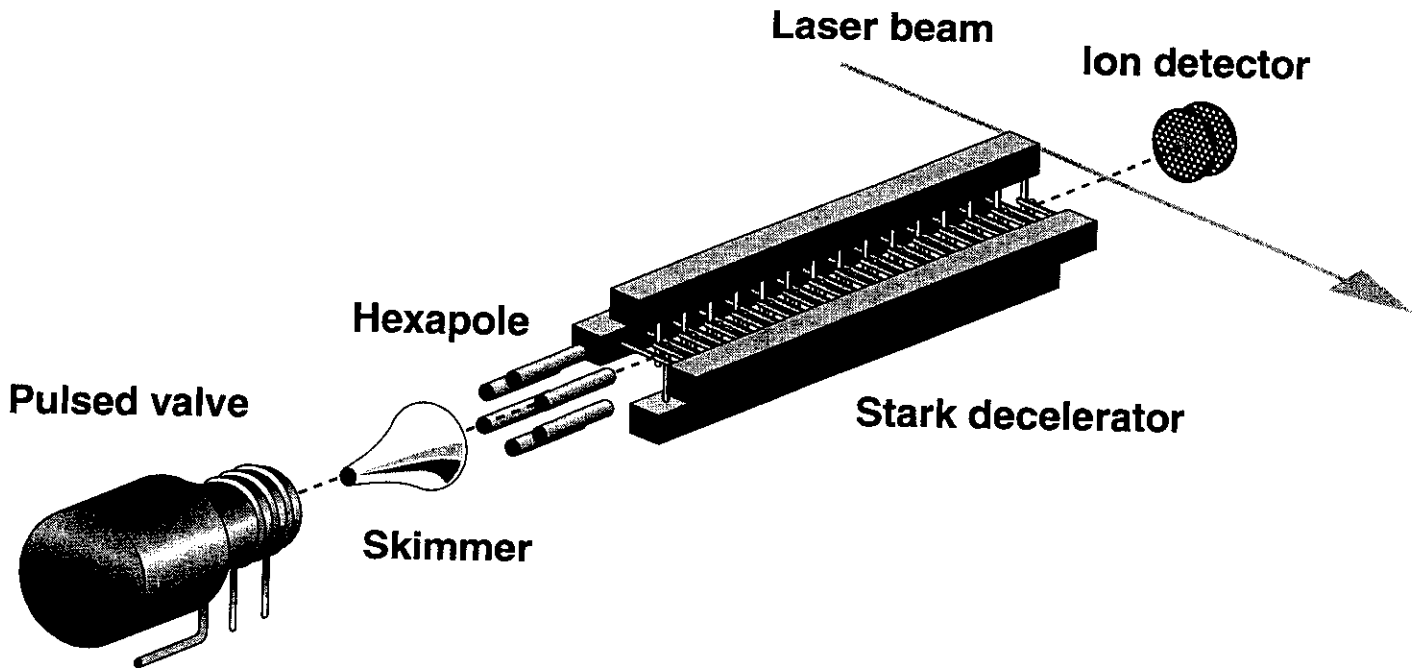
- Velocity spread



- Divergence

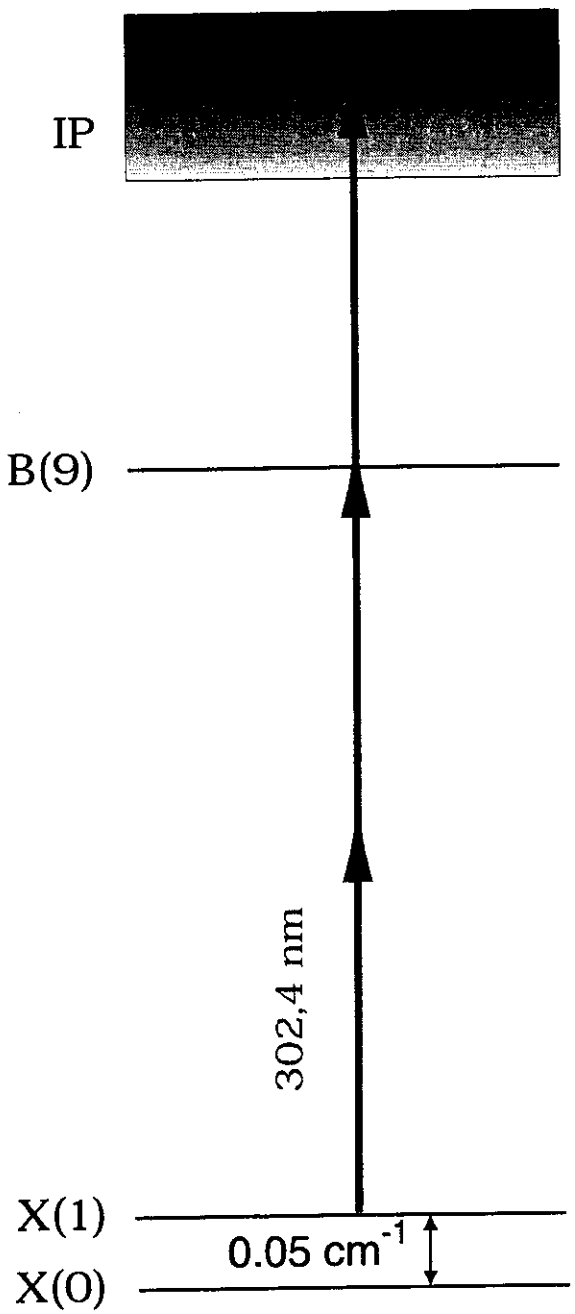


Experimental Setup

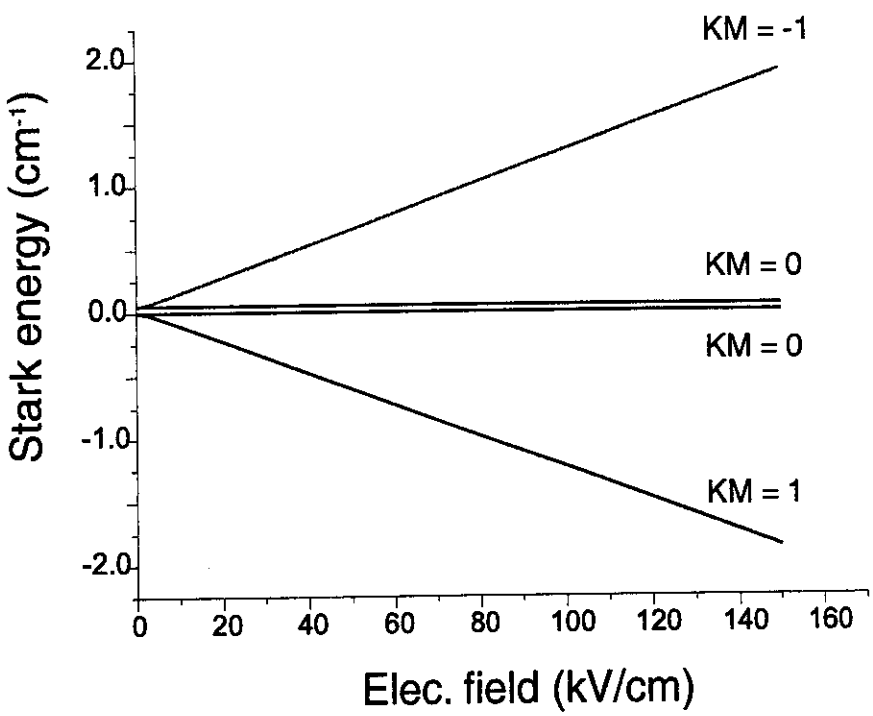


Detection and Stark shift of ND_3

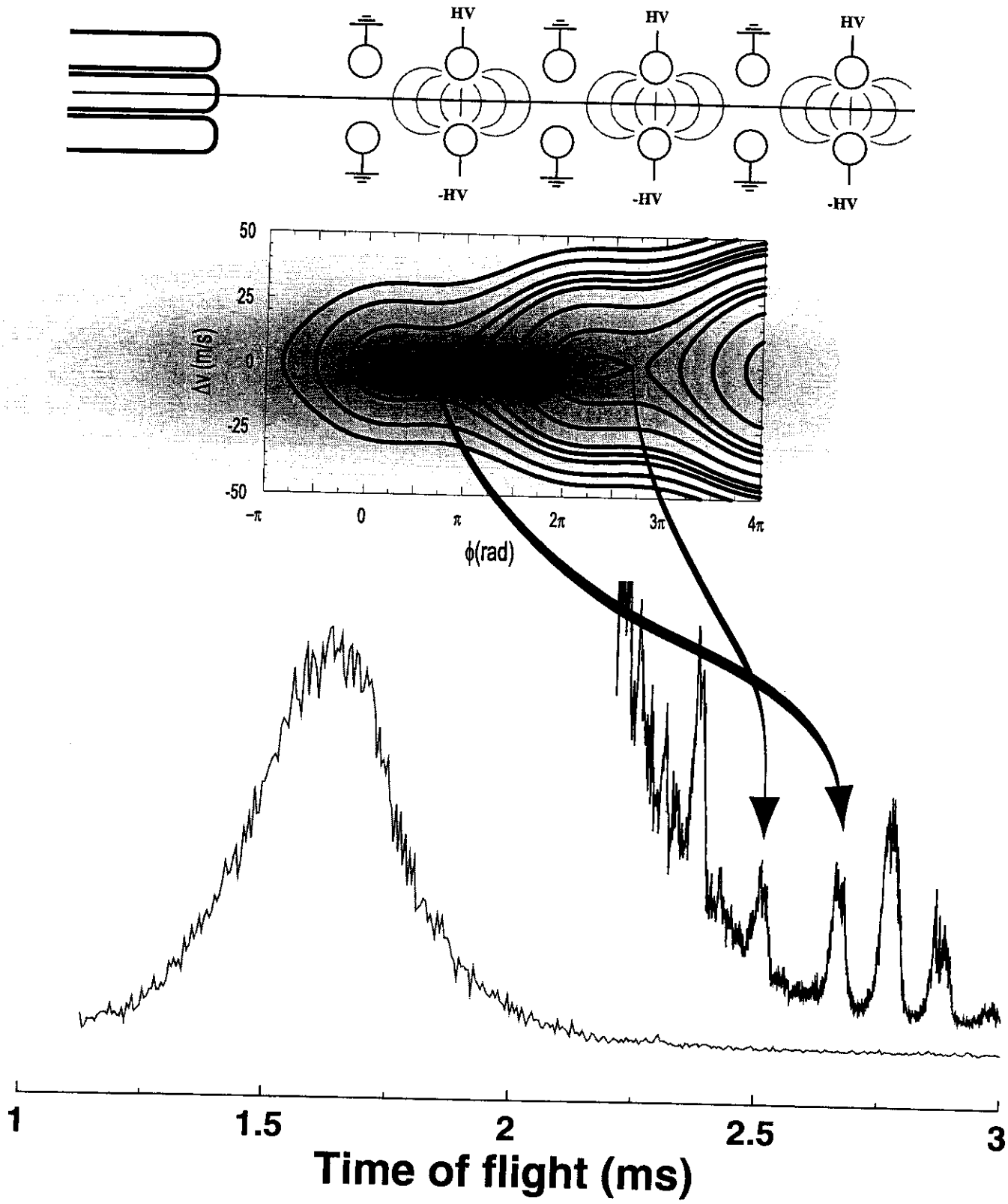
2+1 REMPI



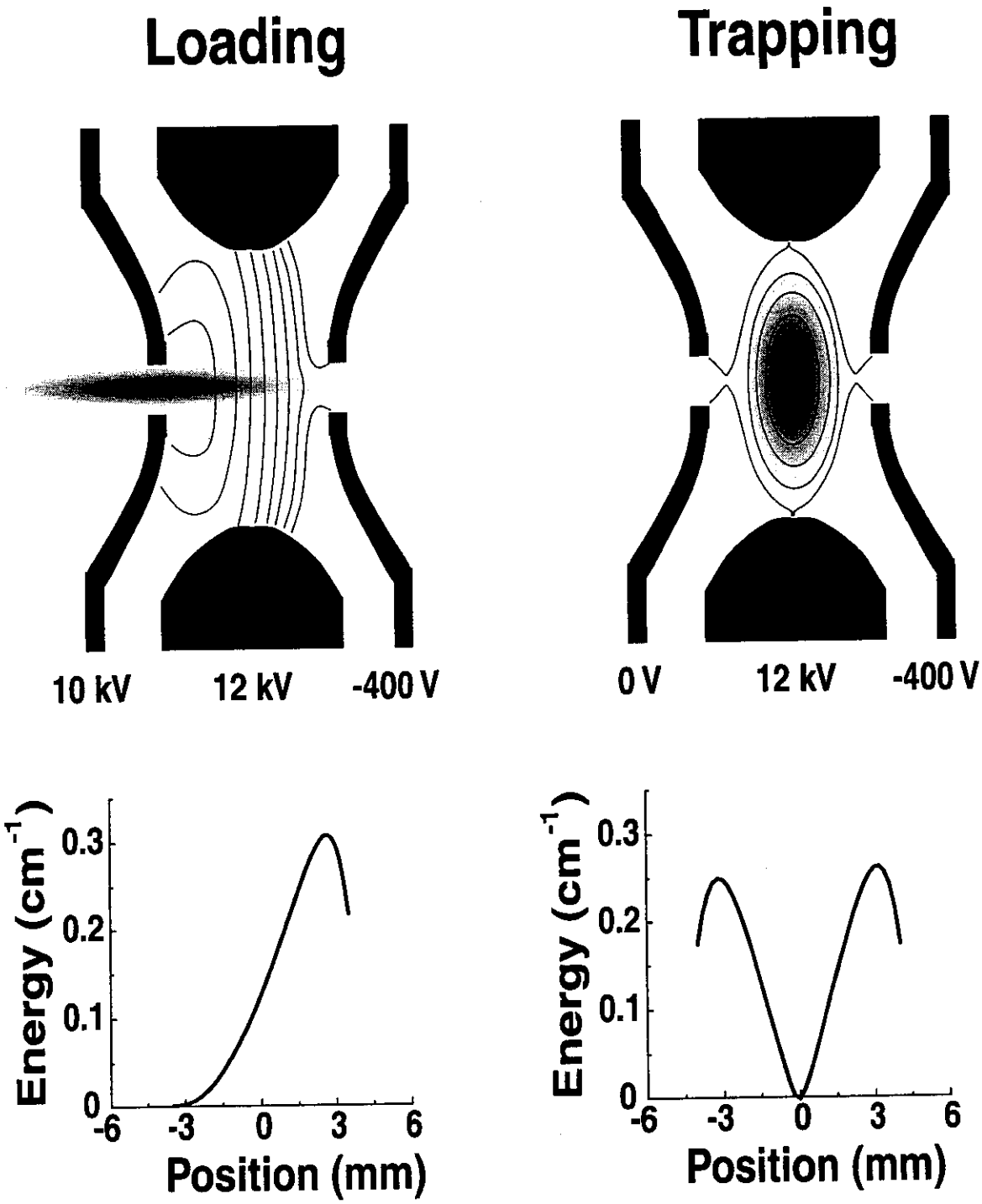
Stark splitting



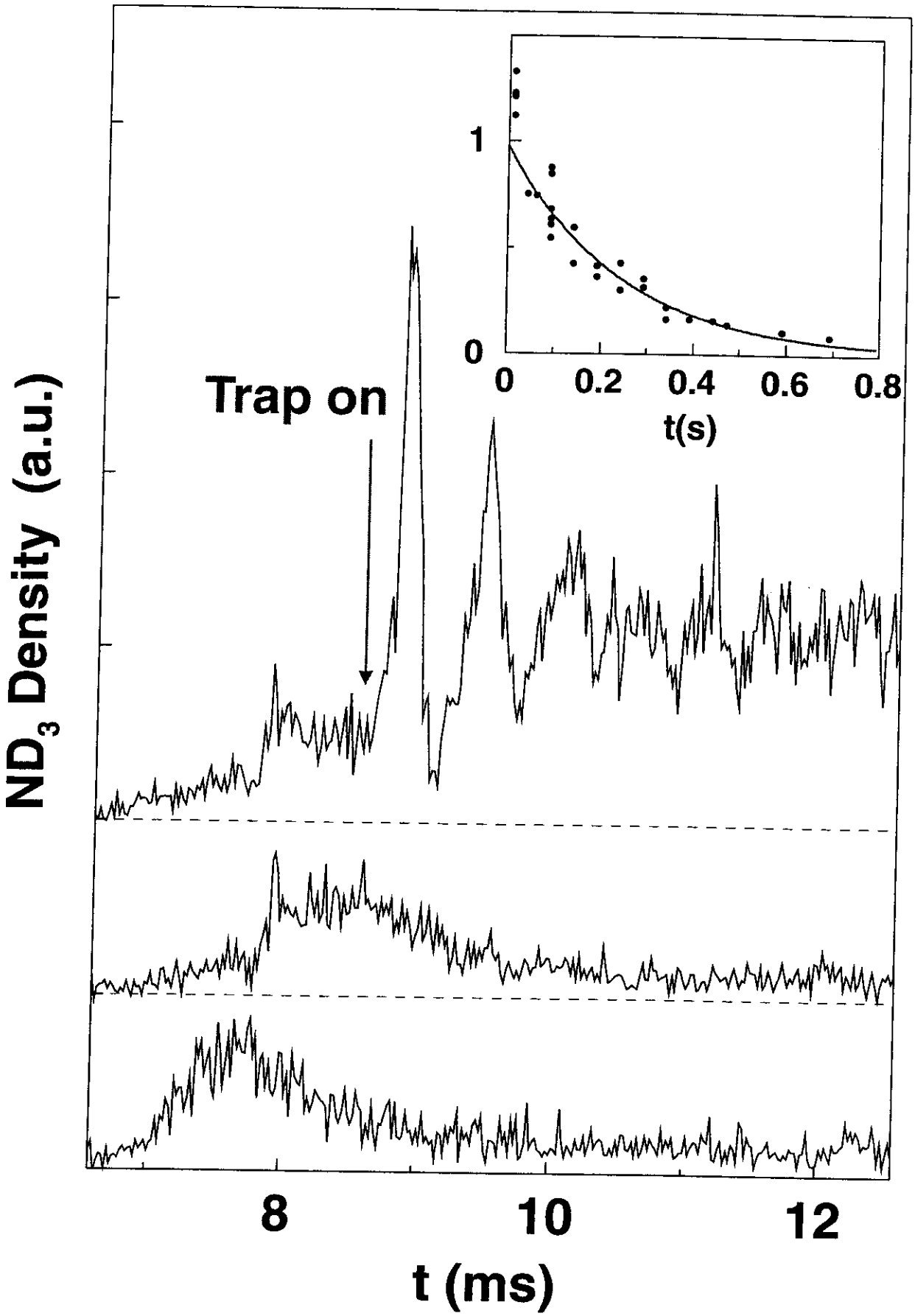
Deceleration of ammonia



Trap Loading



Trapping deuterated Ammonia



Conclusions & Future Prospects

- Time-varying electric fields can be used to decelerate and trap neutral dipolar molecules.
- This provides a method to translate the high phase-space density that can be obtained in a molecular beam from the moving frame to the lab-frame.
- Ammonia-d3 molecules have been trapped at a density of ~10^6/cm^3 and a temperature below 350 mK.
- Application to other dipolar molecules: Water, Hydroxyl-radical, Formaldehyde, etc.
- Experiments with cold molecules:
  trapping (collective quantum effects)
  storage ring
  scattering experiments etc.