Mesoscopic molecular ions in Bose–Einstein condensates

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Goals: to study transport properties in ultracold samples doped with charged impurities

Atom–ion collisions

Why ultracold atom–ion collisions?

• relevant to ultracold Rydberg and ultracold plasma experiments

• Binary collisions
  – as they approach
  – energy levels shift
  – radius propagates
  – after the collision
  – return to initial center of elastic process
  – jumps on other center of charge transfer

• Na + Na+(°)

Transport Properties

- Diffusion: For ion in its trap (separates ions)
  \( \eta = 1 + a^2 \frac{10^{12}}{a} \)

- Dispersion term

- After the collision

- Ion mobility

- Conductivity

- Elastic cross sections (in units of \( \sigma \))

- Hopping radius

MOT conditions

\( n_m = \frac{n_m}{m} = \frac{n_m}{m} \)

\( T = 1.5 \times 10^9 \text{ K} \)

− de Broglie wavelength

− Frozen gas: de Broglie amorphous system

− Mob. and ion can be neglected

− Hopping radius

\( \tau_m = \frac{n_m}{m} = \frac{n_m}{m} \)

\( T = 1.5 \times 10^9 \text{ K} \)

Hole Mobility

- Einstein relation

- Hopping is random

- Frequency (each E)

- Hole mobility

- Total mobility

\( n_m = 10^{22} \text{cm}^{-3} \)

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Process

- Elastic collisions

- Charge transfer

- Total elastic cross section

- Charge transfer cross section

- Partial elastic cross sections

- At large energies

- At medium energies

- At ultraviolet energies

- Rates out: small

- Physical regimes

- Energy levels

- Initial position

- Density in bound level

- Thermal equilibrium

- Level numbers

- \( n_m = \frac{n_m}{m} \)

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Conclusions & outlook

- Ultracold gas doped with ions may exhibit a sharp increase in conductivity

- System becomes conductive because of hole hopping

- Degenerate Bose gas may capture a large number of atoms: mesoscopic molecular ion

- Capture rate becomes constant

- NEMS/Wave spectroscopy

- Creating a transfer pulse of green momentum in the BEC

- Superfluidity

- Polarization of atoms affects superfluidity

- Mobility

- Pauli blocking

- Mesoscopic Fermi systems, excitations not allowed

Signature?

Mobility?

Ultrasound?

Use as microtraps?