Micro-Kelvin Molecules Production

LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories
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Problem

To create samples of atoms and molecules at micro-Kelvin temperatures

Molecules and atoms at such low temperatures behave as waves as well as particles. In addition, they contain such low kinetic energy that they can be "trapped" by external electric, magnetic, or optical fields.

Cold Polar molecules can be used to:

- Store information for quantum computing
- Study phase transitions in materials
- Perform ultrahigh-resolution spectroscopic measurements in order to test basic physics
- Create new quantum materials

Approach

The approach we use is a variation of kinematic cooling

A single collision between a hot atom or molecule and a cold atom of similar mass has a small probability of transferring enough energy to slow the hot atom or molecule sufficiently for it to be trapped.

Our project was to build an apparatus that produced a sample of ultracold, 100-microKelvin, ^{87}Rb atoms trapped within a magneto-optical trap (MOT). A beam of hot ^{85}Rb atoms was formed to intersect with the ultracold sample. If the appropriate cooling collision occurs then ^{85}Rb would be detected in the MOT.

This exemplifies the conceptual physics of the cooling in the MOT experiment. All the momentum is transferred in a single collision.

Results

Results From LDRD: First Experiment is to Collide ^{85}Rb from cold, trapped ^{87}Rb to cool ^{85}Rb

1) Produced a MOT of a cold ^{87}Rb
2) Scatter ^{85}Rb cold ^{87}Rb
3) Observe ^{85}Rb by fluorescence in MOT

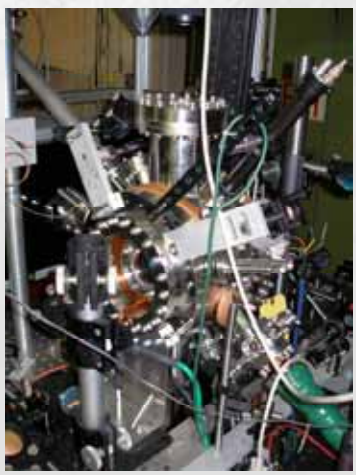
- UHV chamber, pressure > 10^{-10} torr
- CW laser system stabilized to 1 part in 10^{8}.
- 9 individual laser frequencies generated using AO and EO technologies.

Observation: We observed a significant increase in the ^{85}Rb fluorescence signal, over the background fluorescence signal!

Currently: We cannot unambiguously attribute the signal to the desired result.

Non-resonant fluorescence of ^{87}Rb atoms may be nearly equivalent to the expected signal. Further experiments underway to resolve this issue.

We have built a new, higher-flux source for ^{85}Rb in order to generate larger signals.



Significance

There are no techniques presently developed for the cooling of molecules from room temperature to microKelvin temperature. The ability to do this will open several areas of scientific discovery including Bose-Einstein condensation of molecules, molecular interferometery, low-energy scattering and ultrahigh-resolution spectroscopy.

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