# Bose-Einstein condensate of potassium- 41 atoms

S. Inouye[1,2], T. Kishimoto[1], J. Kobayashi[2], K. Noda[1], and M. Ueda[2,3]

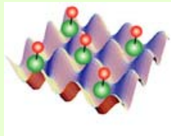
[1] Institute of Engineering Innovation, The University of Tokyo, Bunkyo-ku, Tokyo 113-8656, Japan

[2] ERATO, JST, Kawaguchi, Saitama 332-0012, Japan

[3] Department of Physics, Tokyo Institute of Technology, Meguro, Tokyo 152-8851, Japan

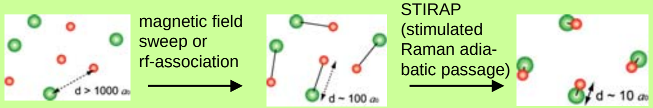
## Motivation

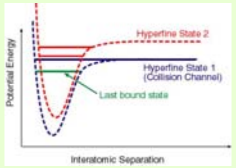
**Our goal** is to produce **ultracold polar molecular gas**. This will be **a new "playground"** for physicists, since molecules interact with **dipole-dipole interaction**, which is **long range** and **unisotropic**. Applications include "a toolbox" for lattice-spin models[1], quantum computation[2], and ultracold chemistry.



(polar molecules in a lattice)

"**Feshbach molecules**" is an important intermediate step for efficient production of ultracold polar molecules from ultracold atoms

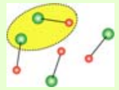



Feshbach resonance

Our plan is to prepare fermionic mixture made of $^6$**Li** and $^{40}$**K**

- **minimized three-body loss** at the resonance
- alkali-alkali mixture ensures spin-exchange interaction needed for F.R.



suppressed three-body loss for fermionic mixture

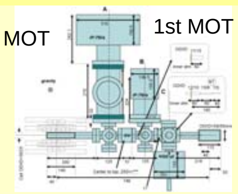
We plan **sympathetic cooling** of $^6$Li and $^{40}$K using bosonic potassium isotope (**$^{41}$K**) **as a coolant**. This simplifies the laser and vacuum setup. (LENS group has Bose condensed $^{41}$K via sympathetic cooling with $^{87}$Rb. See G. Modugno et al., Science 294, 1320 (2001))

*[1] A. Micheli et al., Nature Physics, 2 341 (2006)*

*[2] D. DeMille, PRL 88, 067901 (2002)*

## Experimental Setup

### Double-MOT system




### Four tapered amps

- **Enough laser power**

heat sinking

alignment jig

gluing aligned lenses

### Ioffe-Pritchard magnetic trap

- Clover-leaf configuration
- Square tubing

Radial: 325Hz @ 200A

Axial: 15.5Hz @ 150A

($\omega_i/2\pi$, for $^{41}$K)

### Homemade dispensers

mixing

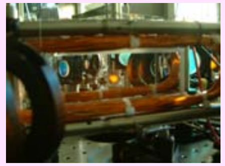
after installation

## Results

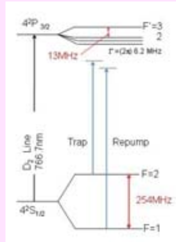
We are currently focused on **cooling $^{41}$K**

It is easy to make $^{41}$K MOT with large number of atoms, but temperature is high and density is low. One can utilize CMOT and Doppler cooling to optimize the phase space density without losing too many atoms.

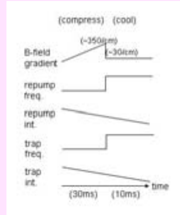
We performed rf-induced evaporative cooling of $^{41}$K atoms confined in an Ioffe-Pritchard trap. By driving |2,2> to |1,1> transition, we reached the phase transition for BEC.



41K MOT in the 1st cell




level diagram of 41K

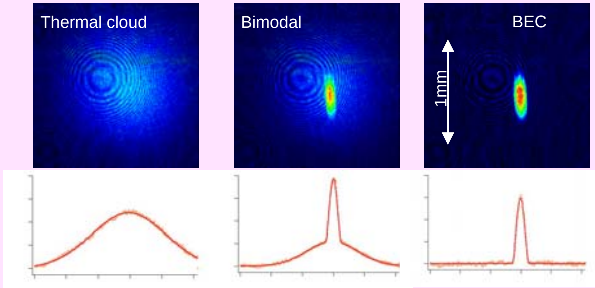



typical time sequence

| | Temp. (μK) | Density ($10^{10}$cm$^{-3}$) | Number ($10^9$) | PSD ($10^{-7}$) |
|---|---|---|---|---|
| Raman-MOT* | 2500 | 0.33 | 1.4 | 0.005 |
| MOT | 5000 | 1.6 | 1.6 | 0.009 |
| after CMOT | 100 | 5.1 | 1.0 | 10.1 |

*: "Raman MOT" refers to a condition where cooling and repump frequencies satisfy Raman condition. Simple optimization using fluorescence often leads to this frequency combination.

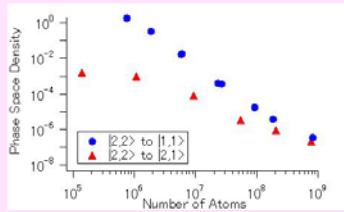
### Absorption images of 41K atoms after 40ms TOF




N = 2.4 × $10^6$
T = 750 nK

N = 1.1 × $10^6$
T = 520 nK

$N_{BEC}$ = 3.4 × $10^5$




typical evaporation trajectories

Optical density


## Conclusions

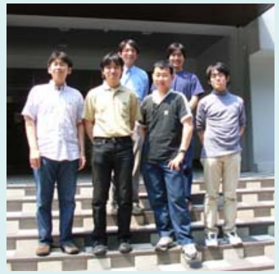
**We have produced BEC of 41K atoms by direct evaporation.**

- Largest number of atoms for 41K BEC
- Promising as a new coolant.

## Outlook

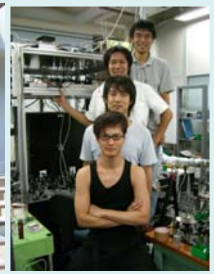
**Study the basic properties of 41K BEC**

**New chamber is being setup to investigate the proper optical transition for transferring Feshbach molecules to absolute ground state**



We made BEC!

Back from the left: S.I. , Tetsuo Kishimoto
Front: Jun Kobayashi, Kiyotaka Aikawa, Takuto Arae, Kai Noda



We study molecules!

From the top: Daisuke Akamatsu, Masahiro Hayashi Yousuke Fujikake, Yusuke Tano'oka