A dual isotope rubidium co-magnetometer is being developed at CYRIC toward electron EDM search using laser cooled francium. This magnetometer can be used to measure not only the fluctuations of magnetic field and other shifts associated with trapping light. As a first step, Rb MOT has been realized with a single laser by creating sidebands with a fiber coupled electro optic modulator (ECM). The laser and RF system used in the present work for obtaining the MOT and the atom number variation as a function of RF frequency and RF power is discussed. This technique can be extended for trapping of $^{85}$Rb and $^{87}$Rb simultaneously.

**EDM search using cold francium atoms**

Francium ($Fr$)

Laser cooled and trapped Fr atoms could be used to achieve long interaction time. Trapped and localized atoms reduce systematic errors. 
- Slow velocity
- Localization
- Doppler effect
- M. Harada et al. (2016)

Fr has large enhancement factor of the electron EDM. Laser-cooled and trapped rubidium (Rb) atoms can be used as co-magnetometer.

Energy shifts:

$$\Delta E = -\mu \cdot B \pm d \cdot E_0$$

One of the errors of the EDM is restricted by the fluctuation of the magnetic field.

$$\sigma < 10^{-20} \text{ cm}$$

**Development of a dual isotope rubidium co-magnetoeter toward electron EDM search using laser cooled francium**

Aiko Uchijama$^1$, Ken-ichi Harada$^1$, Kosuke Sakamoto$^2$, Takeshi Inoue$^3$, Saki Ito$^4$, Masatoshi Itoh$^5$, Hirokazu Kawamura$^2$, Kazuo S Tanaka$^1$

$^1$Cyclotron and Radiisotope Center (CYRIC), Tohoku University, 6-3 Aramaki aza Aoba, Aoba-ku, Sendai, Miyagi 980-8578, Japan
$^2$Frontier Research Institute for Interdisciplinary Sciences (FRIS), Tohoku University, 6-3 Aramaki aza Aoba, Aoba-ku, Sendai, Miyagi 980-8578, Japan
$^3$Center for Nuclear Study (CHS), the University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-0033, Japan

**Motivation to search for the permanent electron EDM dipole moment**

Permanent electric dipole moment

Time reversal symmetry (T) violation

CPT invariance

Charge conjugation and parity symmetry (CP) violation

**Dual isotope rubidium co-magnetometer**

Laser cooled and trapped atoms measurement have many advantages on the EDM measurement. The fluctuation of the laser intensity of optical lattice cause the systematic errors. In addition to the measurement of magnetic field fluctuations this is also required.

Rubidium (Rb)

Two stable abundant isotopes $^{85}$Rb and $^{87}$Rb

Procedure for Fr and Rb simultaneous trap

1. Produce Fr using nuclear fusion reaction
2. Magneto-optical trap (MOT) Fr and Rb
3. Optical dipole force trap (ODT) Fr and Rb
4. Trap Fr and Rb in optical lattice together

**Development $^{87}$Rb MOT for simultaneous dual-isotope MOT**

Light source required for Rb MOT

RF system for 6.5 GHz

RF frequency was controlled by tuning WCO

6.5 GHz sideband

$^{87}$Rb MOT using the 6.5 GHz sideband

Magneto-optical trapping using single laser was achieved.

- Laser power: 20 mW for each axis

Next plan

- Dual isotope MOT with single laser
  - Development of RF system for $^{87}$Rb
  - Comparison of the combination of laser and RF frequency
- Dual isotope ODT
- Measurement of magnetic field and laser intensity simultaneously with Rb dual isotope