I. 3. Present Status of the Experimental Project for the Study on the Fundamental Symmetry Using Laser Cooled Radioactive Atoms

Sakemi Y.[1], Ando T.[1], Aoki T.[1], Aoki T.[2], Arikawa H.[1], Ezure S.[1], Harada K.[1], Hayamizu T.[1], Inoue T.[1,3], Ishikawa T.[1], Itoh M.[1], Kato K.[1], Kawamura H.[1,3], and Uchiyama A.[1]

[1]Cyclotron and Radioisotope Center, Tohoku University
[2]Graduate school of Arts and Sciences, University of Tokyo
[3]Frontier Research Institute for Interdisciplinary Sciences, Tohoku University

Matter-antimatter asymmetry (CP violation) is a subject that has relevance in many branches of physics. It has been observed in the decays of K and B mesons, and the results can be understood under the light of the work of Prof. Kobayashi and Maskawa in the context of the Standard Model (SM). However, the origin of CP violation is still not well understood. The observed matter-antimatter asymmetry in the Universe is linked to CP violation which is associated with unknown physics Beyond the Standard Model (BSM). In the contemporary era of the Large Hadron Collider (LHC) in which physicists in the world are waiting to find answers to many outstanding questions, attempts to look for new physics via non-accelerator probes are complementary and very significant. The experiments to search for the electric dipole moment (EDM) of elementary particles and CP violating interactions such as the electron-quark CP odd interactions certainly fall into the category of the highest precision low energy physics. They become important to know which energy should be explored for BSM with the next generation accelerator ILC.

The field of CP violation is vast and is growing rapidly and independently in different research areas. It needs the collaborations and coherent works between many areas of physics such as particle, nuclear, atomic and molecular physics and involves theoretical, mathematical, computational and experimental methods. In the case of the atomic EDM, the electron EDM is enhanced with 895 times for the heaviest alkali element francium (Fr). Also the observable of the parity non-conservation of nuclear system, so called anapole moment, is enhanced in Fr. At present, the development of the laser cooled Fr source at TR5 and TOF, CYRIC has been in progress to study the fundamental symmetry and interactions.

In this experimental project, the Fr is produced with the nuclear fusion reaction with ^{18}O beam supplied from AVF cyclotron and ^{197}Au target, and ionized by the high intensity thermal ionizer. The extracted Fr ion beam is transported to the neutralizer to get the neutral Fr atoms. In this year, we have installed the Wien filter in the beam line, which is the velocity filter to reject the residual atoms emitted from many sources with high temperature around the thermal ionizer, and to improve the purity of the Fr beam. The Fr atoms are loaded into the magneto-optical trap (MOT) to realize the cooled Fr source. The test experiments have been done already to observe the trapped Fr with MOT, and the detailed analysis is in progress.

The trapped Fr in the 1st MOT will be loaded to the 2nd MOT and transported to the EDM measurement cell with optical tweezers using optical dipole force. Then, the Fr atoms are trapped with optical dipole trap and optical lattice in the final stage in this project. The experimental overview is shown in Fig. 1. The double MOT system and optical dipole trap have been developed already and studied in more detail by stable element Rb. The optical dipole trap is treated, in principle, as the same technique of 1 dimensional optical lattice, so we have already accumulated the cooling and trapping techniques required for the EDM measurement. The EDM has to be measured in the magnetic field shield with co-magnetometer. The design of the shield system and the development of the prototype of the magnetometer have been done, and all the components will be studied further with online using the accelerator and offline experiment to check the performance to realize the EDM measurement accuracy with 10^{-29} ecm in next year.

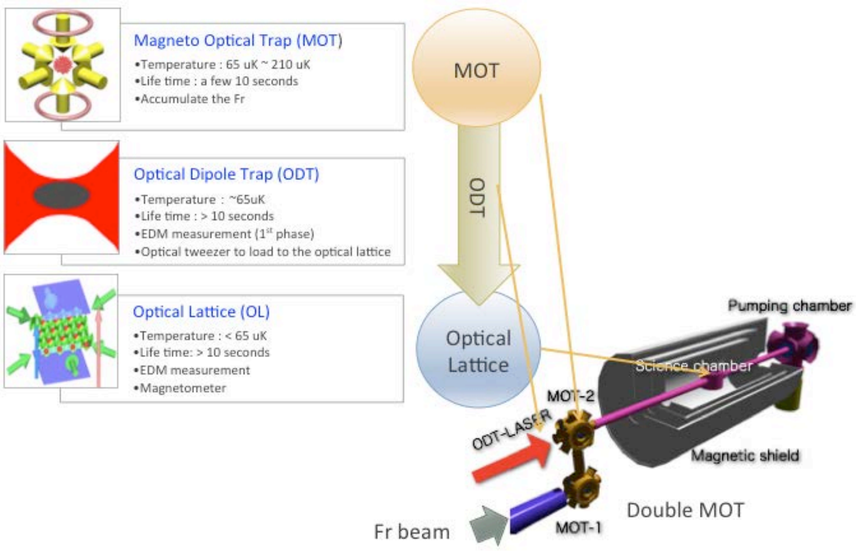

Figure 1. Overview of setup for the EDM measurement system.