【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Mathematical and Physical Sciences)

Title of Project : Search for the Electric Dipole Moment with Laser Cooled Radioactive Atoms in the Optical Lattice

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Research Project Number : 26220705 Researcher Number : 90251602
Research Area : Particle, Nuclear, Cosmic ray, Astro physics
Keyword : Experimental nuclear physics, Experimental particle physics, Electrid dipole moment, Laser cooling, Optical lattice, Fundamental symmetry

【Purpose and Background of the Research】

To explore the mechanism for the generation of observed matter-antimatter asymmetry in the Universe, the research on fundamental symmetry violations and various fundamental interactions using the laser cooled and trapped atoms is being promoted. One such phenomenon of our interest is the intrinsic electric dipole moment (EDM) of either elementary or composite systems. The non-zero observation of EDM provides the direct and conclusive signatures of the violation of time-reversal symmetry, and the CP violation under the CPT invariance. Using the extreme quantum states such as the cooled atoms in the optical lattice, we study the high-energy physics related to the phenomena which are thought to have happened in various epochs in the very early Universe.

【Research Methods】

The electron EDM in paramagnetic atoms is appeared and enhanced by the relativistic effects with the 3rd power of the nuclear charge. The heaviest alkali element such as the francium (Fr) has the largest enhancement factor, and the detailed calculation with the relativistic coupled cluster model shows the enhancement factor with ~895. The Fr atom has the function as a microscope to magnify the tiny electron EDM. We will apply the optical lattice technique to confine the Fr to achieve the accuracy with ~ 10^{-29} e・cm. In the optical lattice, the Fr atom is confined in each potential well generated with the lattice configuration, and the long interaction time can be achieved since the interaction or collision rates between atoms will be reduced. The EDM itself can be determined from the accurate measurement of the Larmor frequencies. The Fr is produced with the thermal ionizer with molten ^{197}Au target using the fusion reaction by ^{18}O beam from AVF cyclotron at CYRIC, Tohoku university.

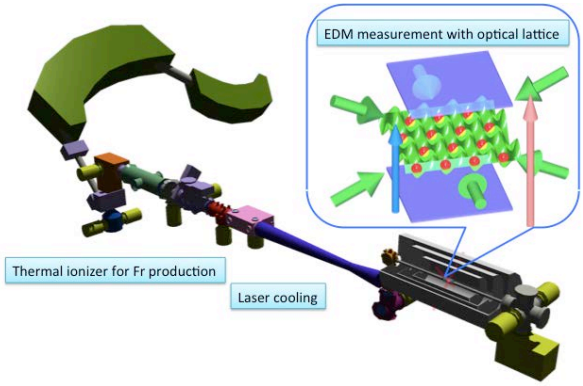

Figure 1 Overview of experimental apparatus of EDM measurement with optical lattice

【Expected Research Achievements and Scientific Significance】

The study of EDM paves a way for the continuing quest for the ultimate theory of the Universe and it has a great potential in uncovering many mysteries which have been puzzling the mankind for ages such as the very survival of ourselves amidst many cosmic catastrophes such as a complete annihilation of matter and antimatter. We will explore the mass hierarchy of the super symmetric particles with the mass range > 10 TeV, where it is difficult to access such a heavy mass region with collider experiments at present.

【Publications Relevant to the Project】

・Search for a permanent EDM using laser cooled radioactive atom
Y. Sakemi, K. Harada, H. Kawamura et al.. J.Phys.Conf.Ser. 302 (2011) 012051
・Laser-cooled radioactive francium factory at CYRIC
H. Kawamura, T. Inoue, Y.Sakemi et al.. Nucl.Instrum.Meth. B317 (2013) 582-585

【Term of Project】 FY2014-2018

【Budget Allocation】 149,700 Thousand Yen

【Homepage Address and Other Contact Information】

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