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

Search for physics beyond the Standard Model via generation mixing of charged leptons using a high intensity muon source

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Purpose and Background of the Research

●Outline of the Research

The fundamental model of particles, the Standard Model (SM), was complete to a certain level after discovery of a Higgs particle giving mass to particles. Theoretical structure of the SM and phenomena not explained within the SM implies the existence of new physics beyond the SM and the most important subject is its exploration. With various approaches being placed importance on, this project focuses on the structure called generation of charged lepton, lepton with electric charge. The generation mixing, transition between particle types, was observed in quark and neutrino (neutral lepton) sectors. The mixing in charged lepton has not been observed even though many models predicts its existence. Particular attention has been paid in muon-electron transition, due to possibility to establish an experiment with high sensitivity utilizing advanced intense proton accelerator and detector. This project establishes such an experiment with the best ever sensitivity to search for muon-electron transition and leads to a next generation experiment with even higher sensitivity.

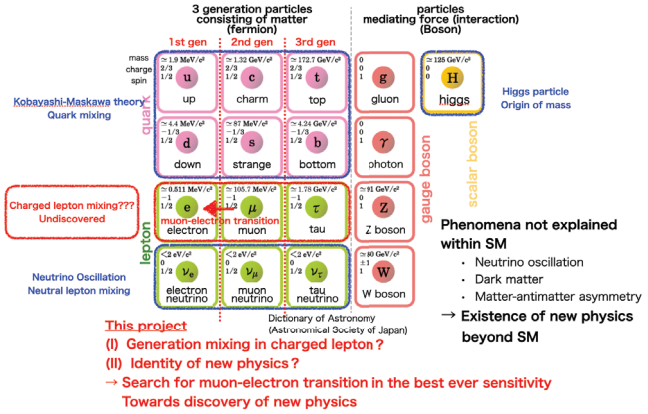

Figure 1. Outline of the research

●Outline of the Research

The COMET experiment to search for muon-electron transition with the best ever sensitivity is under preparation in the J-PARC accelerator, the world-leading intense and pulsed proton beam facility. The figure shows its entire plan and features. A huge number of secondary particles (pion, muon) produced with the proton beam are captured in a high field super-conducting solenoid. The curved solenoid selectively transports negative muons, which stop at a nuclear target and are utilized to search for the transition. Its signal is an electron with monotonic energy equivalent to muon mass. A various models predicts extremely tiny rate of 10^{-14}～10^{-17} , only accessible with highly pulsed muons and a high-sensitive detector.

The COMET experiment is planned in two steps (Phase-I and –II). In Phase-I, the transport solenoid up to the 1st 90 deg is used for the beam measurement and the search with 10^{-15} sensitivity. In Phase-II, the final layout is completed to carry out the search with 10^{-17} sensitivity in a high power. The purpose in this project is the beam measurement in Phase-I, detector and accelerator development towards Phase-II.

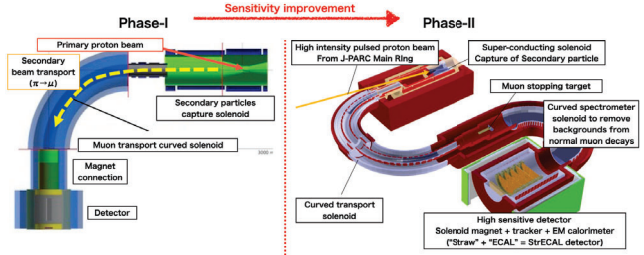

Figure 2. Plan of the COMET experiment

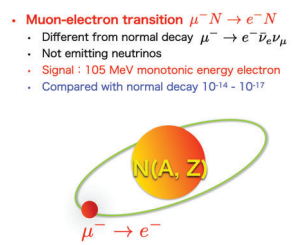

Figure 3. Muon-electron transition

Expected Research Achievements

●Beam measurement and search with 10^{-15} sensitivity in Phase-I

The beam measurement in Phase-I uses the StrECAL detector, consisting of solenoid magnet, tracker and electromagnetic (EM calorimeter. This high-sensitive detector has been developed for the search with 10^{-17} sensitivity in Phase-II. The tracker, consisting of proportional tubes using conductive thin straws, needs to be operational in vacuum and reconstructs charged tracks. The EM calorimeter (ECAL) consists of bright and fast LYSO inorganic crystals and silicon photo detectors operational under magnetic field and measures energy in high resolution.
The short transport solenoid in Phase-I causes backgrounds coming from pions in the beam. The search itself is carried out a cylindrical detector insensitive to the central part of the beam. The StrECAL detector measures the entire beam to understand the beam itself and to achieve 10^{-15} sensitivity. The development of the detector as a prototype for Phase-II is completed in the evaluation in the beam measurement.

●Accelerator development towards Phase-II, using the beam in Phase-I

In order to carry out the COMET experiment, it's essential to establish a high-quality pulsed proton beam and low-energy (8 GeV) acceleration. A number of particles in acceleration is called as a bunch. The pulse quality is evaluated with tiny leakage in between bunches. The accelerator is ready for Phase-I and this project focuses on the development for Phase-II. In particular, the fast pulse magnet to instantly modify the beam orbit is improved in the driving electronics, also to be utilized for even better quality for Phase-I. In high intensity operation in Phase-II, the magnet to slowly extract a part of the beam needs to have wider effective area and is planned to be developed with a new material. Those studies realizes the best performance in Phase-I and completes the preparation for Phase-I.

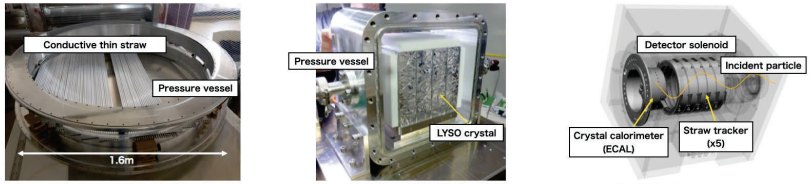

Figure 4. High-sensitive StrECAL detector

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