論文の内容の要旨

論文題目：　New detector system for the precise neutron lifetime measurement using pulsed cold neutron beams

パルス化された冷中性子ビームを用いた
中性子寿命精密測定のための新しい検出器システムの開発

氏名　：　音野　瑛俊

The neutron lifetime τ_n and the baryon density of the universe η are key parameters for Big Bang nucleosynthesis. Recently, the measurement of the cosmic microwave background radiation at the Wilkinson Microwave Anisotropy Probe has become increasingly sensitive to η, which motivates a neutron lifetime measurement with improved accuracy.

Since the first observation of the neutron decay in 1948, various methods for the measurement of the neutron lifetime using nuclear reactors have been developed, resulting in the world average 881.5±1.5 s given by the Particle Data Group. The proposed method in this manuscript employs an accelerator for the first time in all neutron lifetime measurements, making use of the world's most intensive pulsed neutron source at the J-PARC accelerator complex in Tokai, Ibaraki, Japan. In this method, pulsed monochromatic bunch passes through a time projection chamber (TPC), which detects the electron from the neutron decay. The neutron flux can also be measured via

the ^{3}He(n,p)^{3}H reaction by mixing a small amount of ^{3}He in the same detector.

A measurement accuracy of a level 0.1% is needed to be competitive with the world average. To achieve this, backgrounds to the neutron decay and the ^{3}He(n,p)^{3}H reaction have to be physically reduced and statistically subtracted. In this work, a low background TPC has been developed, making use of polyether ether ketone (PEEK) as its main component, which contains no radioactive sources; ^{6}Li plates are installed in the inner wall of the TPC to capture scattered neutrons; the TPC is surrounded by 4π shielding to reduce environmental radiation. Consequently, the achievable signal-to-background ratio is estimated to be 1, corresponding to a statistical uncertainty of 0.8% for 150 days of beam time, assuming the current beam power of 220 kW. In parallel, an analysis algorithm has been developed, which subtracts the remaining backgrounds using a data-driven approach while retaining more than 99.9% detection efficiency for the neutron decay and the ^{3}He(n,p) ^{3}H reaction. As a result, all the systematic uncertainties arising from the particle detection are reduced to a level of 0.1%.