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

Broad Section B

Title of Project： Study of nucleon spin structure in quark level with a large polarized target

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【Purpose and Background of the Research】

How is matter built? Matter, namely atoms, are made of electrons and nucleons (proton and neutron). The electron is an elementary particle having spin 1/2 and its property is well known. In contrast, structure of the nucleon, also having spin 1/2, is not well understood. The nucleon is a composite particle composed of three quarks with orbital angular momentum (OAM)L=0. It is notable that quarks also have spin 1/2. And spin of the nucleon is created by the sum of the quark spins(in quark model).

However, it was found that the role of the quark spin is not significant. What makes the nucleon spin is not known now. This is called a mystery of the origin of the nucleon spin.

First, people considered gluon spin. Gluons having spin 1 mediating the force between the quarks can contribute to the nucleon spin. However, as related measurements are difficult, the studies have not reached a decisive conclusion. And this contribution seems not significant compared with the conventional expectations.

On the other hand, quark OAM which is never realistic in the quark model recently attracts interests. Because new experimental data are suggesting its existence.

【Research Methods】

The effect of the quark OAM is expected to appear in the left-right asymmetry of produced particles in muon induced reactions. This is called Sivers asymmetry (Fig.1). If non-zero values are observed for the asymmetry, it is considered as an evidence of the OAM.

A muon beam from SPS at CERN impinging on the COMPASS polarized target (Fig.2), and the produced

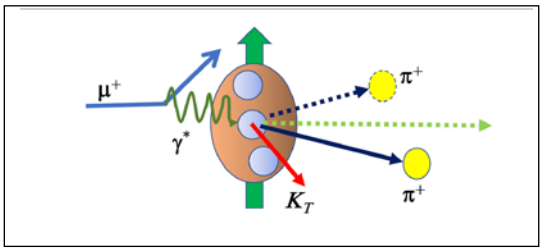

Figure 1 Sivers Asymmetry

particles are detected. Analyzing the data, the asymmetry is obtained.

Another important quantity, tensor charge (TC) of the nucleon, is also obtained. Appearance of electric dipole moment of nucleons which is expected to appear in the theories beyond standard model is affected by the TC.

【Expected Research Achievements and Scientific Significance】

Usually, OAM of constituents in a system in a lowest state do not appear in the case of the systems with atoms and nuclei. If one finds OAM of quarks in the nucleon which is the lowest state of quark system, a new paradigm is created.

The nucleon is a composite system with quarks binding strongly each other. To understand its structure, one has to rely on QCD(Quantum Choromo-Dynamics). Lattice QCD which deals with field theory in divided space-time is the unique way of calculation base on QCD. It has been partially successful in reproducing experimental results. However, they should be strictly checked with new experimental results.

Our study will provide with important quantities which

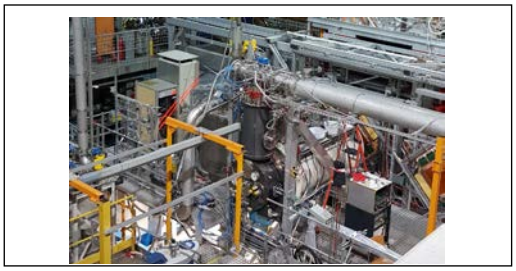

Figure 2 COMPASS apparatus

are necessary when predictions are given based on the theories beyond standard model. This leads to acceleration in searching new physics.

【Publications Relevant to the Project】

· **Collins and Sivers asymmetries in muonproduction of pions and kaons off transversely polarised proton.,** COMPASS, C.Adolph et al., ***Phys.Lett. B744 (2015) 250-259***

Measurement of the Collins and Sivers asymmetries on transversely polarised protons. COMPASS, M. Alekseev, et al., ***Phys.Lett. B692:240-246,2010***

【Term of Project】 FY2020- 2023

【Budget Allocation】 155,200 Thousand Yen

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