実験報告書様式（一般利用課題・成果公開利用）

MLF Experimental Report

提出日 Date of Report

課題番号 Project No.
2016B0146

実験課題名 Title of experiment
Measurement of neutron-nuclear spin correlation terms with a polarized xenon target

実験責任者名 Name of principal investigator
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所属 Affiliation
J-PARC Center

装置責任者 Name of responsible person
Kenichi OIKAWA

装置名 Name of Instrument/（BL No.）
NOBORU / BL10

実施日 Date of Experiment
2017.3.21 9:00 - 2017.3.23 9:00

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions.　Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

・ Enriched Xe gas (^{129}Xe >90%) contained in glass, 0.536g

・ Natural Xe gas contained in glass, 0.469g

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results.　If you failed to conduct experiment as planned, please describe reasons.

A xenon (Xe) is interesting to measure a correlation term $\boldsymbol{s}\cdot\boldsymbol{I}$ of a neutron spin $\boldsymbol{s}$ and a target nuclear spin $\boldsymbol{I}$ with a polarized Xe target for a verification of a neutron optical theorem (NOPT). It has been observed the large parity non-conserving (PNC) effect at the p-wave resonance in neutron-nuclear reactions, and it polarizes up to 10^{-2}–10^{-1} at pressures of 10^{-1}–10^{0} atm by using a spin exchange optical pumping (SEOP) method. We plan to measure the neutron polarizing ability, spin dependent cross section and neutron spin rotation with polarized Xe [1], which are predicted to depend on neutron energy E_n strongly around resonance peaks.

As the first step, we would measure the neutron polarizing ability at a 9.6 eV s-wave resonance peak of ^{129}Xe when unpolarized neutrons transmit through the polarized Xe cell. Fig. 1 shows the experimental apparatus in BL10 schematically. Pulsed neutron beams from a spallation neutron source transmit through collimators, the Xe cell, a metal foil, and are counted by a position sensitive neutron detector (PSND) placed at 14.5 m position apart from the source. For obtaining high count rates, the PSND consists of a Li glass scintillator and multi-anode photomultiplier tube (MAPMT) having 16×16 pixels with a 3×3 mm^2 pixel size.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

The metal foil is used to compensate time fluctuations of the detector by referring to a 5.2eV resonance peak of ^{109}Ag. A ratio R (=T/T_0) between neutron transmissions with the polarized and unpolarized Xe cell, denoted by T and T_0, is expressed as $R = \cosh(N\sigma l \rho P)$, where N, σ, l, P, and ρ denote a number density, neutron cross section, thickness, polarization and spin dependent parameter of Xe. The neutron polarization is described as $P_n = (1-R^{-2})^{1/2}$ with R. The Xe cell is polarized by utilizing an in-situ SEOP system. The values of P are monitored by nuclear magnetic resonance (NMR) signals with an adiabatic fast passage (AFP) method as shown in Fig. 2.

We tried to measure the neutron polarizing ability of a cell-I, which is a cylindrical glass cell in 2.5 mm diameter and 5 cm long, and contains in natural Xe gas of about 3 atm pressure. Fig. 3 (A) shows a two dimensional (2D) distribution of neutrons passing through the cell-I. Fig. 4 (A), (B) and (C) show the values of T, T_0 and R as a function of flight time t, where the 4×4 pixel area enclosed by solid lines in Fig. 3 (A) was used for data analysis. Fig. 4 (C) suggests that ΔR (=$R-1$) ≈ 0.02 was obtained at the 9.6 eV resonance peak of ^{129}Xe in contrast with $\Delta R \approx 0$ at the 5.2eV resonance peak of ^{109}Ag. If $\Delta R \approx 0.02$ is caused by ^{129}Xe polarization P, the values of P are estimated to be 0.56 or 0.19 by assuming total angular momentum J =1 or J =0. However, they are inconsistent with $P \approx 0.05$ estimated from the typical NMR signal in Fig. 2. This inconsistency should be made clear by checking influence of background and uncertainties of our NMR system carefully [2].

The cell containing in the enriched ^{129}Xe gas of a low pressure is predicted to obtain higher P because increment of Xe gas pressure causes increment of Rb spin destruction due to the effect of binary collisions between Rb and Xe. We prepared a cell-II which is a cylindrical glass cell in 3.5 mm diameter and 10 cm long, and contains in enriched ^{129}Xe gas of less than 1 atm pressure. We measured the neutron transmission of the cell-II for evaluating amount of ^{129}Xe and statistics accuracy. Fig. 3 (B) shows the 2D distribution of neutrons after passing through the cell-II. Fig. 5 shows the values of T_0, where the 6×6 pixel area enclosed by solid lines in Fig. 3 (B) was used for data analysis. Fig. 5 mentions that amount of ^{129}Xe of the cell-II is suitable for measuring the neutron polarizing ability.

[1] K. Sakai et al, J. Phys.: Conf. Ser. **340,** 012037 (2012)

[2] K. Sakai et al. JPS Conf. Proc. , 036015 (2015)

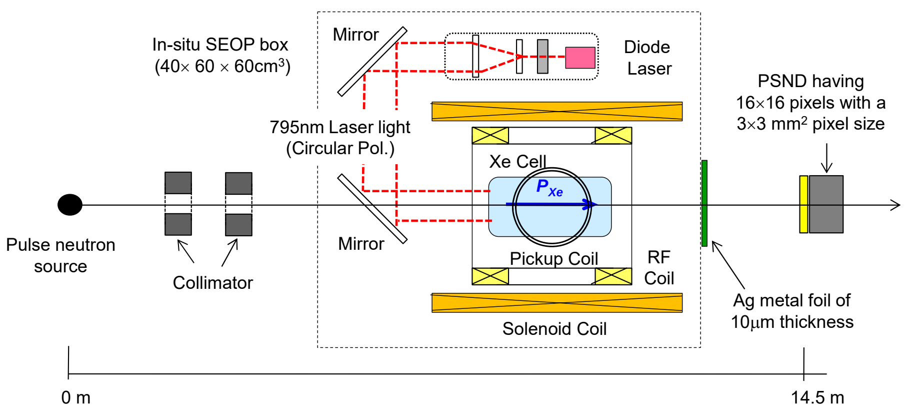

Fig. 1. Experimental apparatus for detecting neutron polarizing ability of Xe at BL10

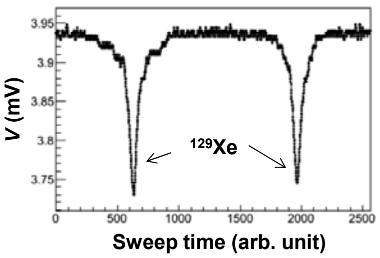

Fig. 2. NMR signal of ^{129}Xe of cell-I

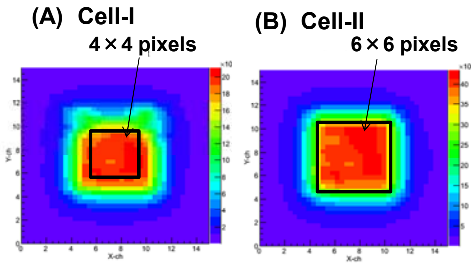

Fig. 3. 2D distributions of neutrons by the PSND with (A) cell-I and (B) cell-II

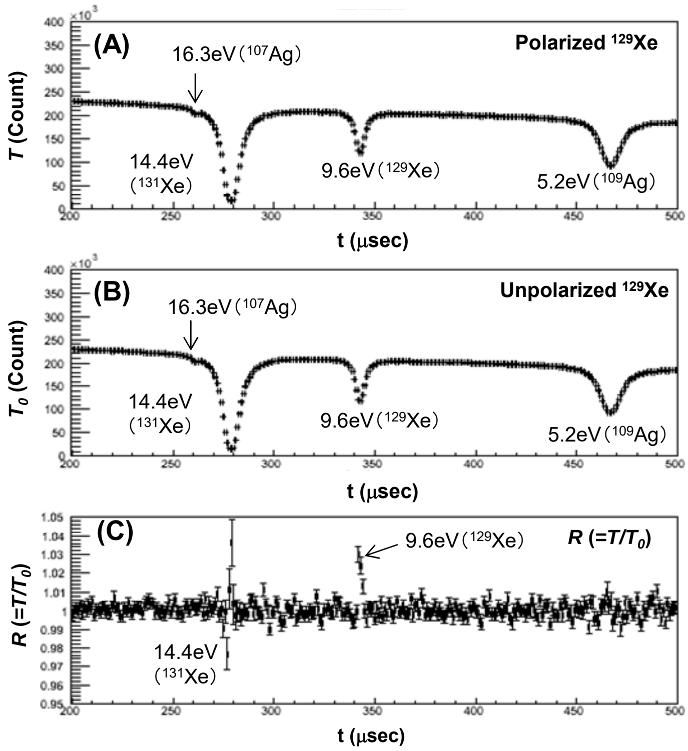

Fig. 4. (A) Neutron transmission T by measuring for 5.5 hours with polarized Xe of cell-I, (B) T_0 for 5.5 hours with unpolarized Xe, and (C) ratio R between T and T_0 as a function of flight time.

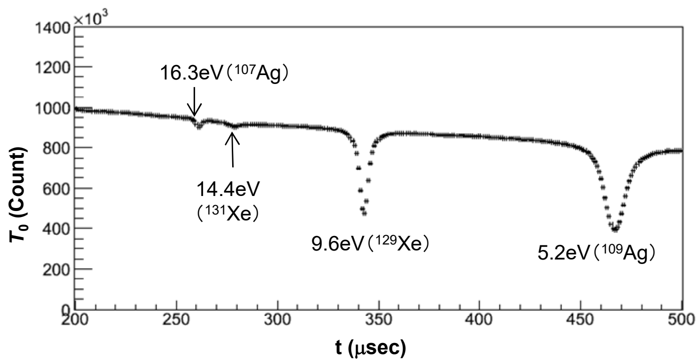

Fig. 5. Neutron transmission T_0 of enriched Xe cell (cell-II) by measuring for 8 hours