The plan for measurement of angular distribution in (n,γ) reaction with polarized neutron beam

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Motivation

The current universe cannot be understood by CP violation in standard theory.

We aim to search for CP violation in compound nuclei.

When neutrons are incident on target nuclei, the scattering amplitude can be described by Eq(1).

D≠0 suggests CP violation via CPT theorem.

$$f = A + B\sigma\cdot\hat{I} + C\sigma\cdot\hat{k} + D\sigma\cdot(\hat{I}\times\hat{k}) \quad (1)$$

σ Neutron spin
$\hat{k}$ Neutron momentum
$\hat{I}$ Nucleus spin

To measure P violation, polarized neutron and non-polarized target are needed, and CP violation needs to polarize each other. (Fig.1)

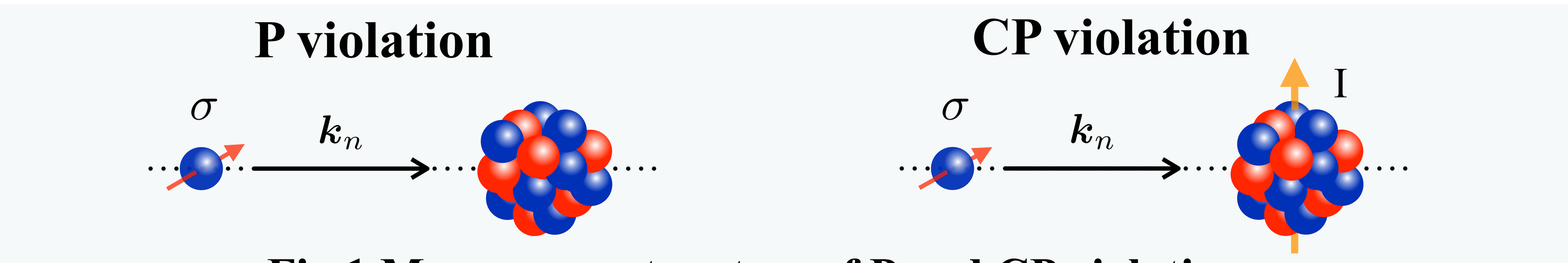

Fig.1 Measurement system of P and CP violation

The P violation enhanced by 10^6 times have been observed in compound nucleus reactions.

If enhancement of P violation occurs in the nucleus, the CP violation is also enhanced. It is given by the Eq(2).

$$\Delta\sigma_{\mathrm{CP}} = \kappa(J)\frac{W_{\mathrm{T}}}{W}\Delta\sigma_{\mathrm{P}} \quad (2)$$

$\kappa(J)$ Spin factor
W_{T}/W gcp/gp
$\Delta\sigma_{\mathrm{P}}$ P violation in nuclei

It is necessary to precisely measure P violation as a pre-measurement step for CP violation.

Outline of experiment

▫ P violation measurement

We will measure the P violation in nuclei with the highest precision by using high intensity neutron beam of J-PARC at BL04.

^{139}La with low neutron resonance energy and large asymmetry(Fig.2) is used for the target nucleus. Highly polarized neutron and optimum thickness target are required.

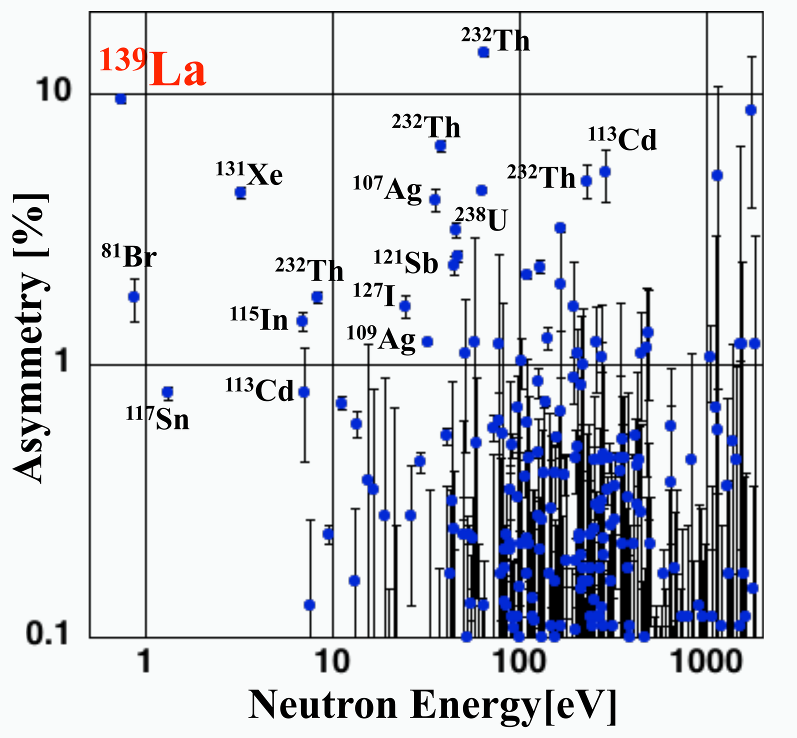

Fig.2 Relationship between neutron resonance energy and asymmetry

▫ Final state dependence of P violation

By further increasing the statistics, it becomes possible to measure the final state dependence of P violation.

In order to measure this, it is necessary to detect γ rays emitted by (n,γ) reaction.

Estimation

▫ Optimum thickness

When we try to measure P violation, the optimum thickness of the target is determined by the cross-section and the polarization ratio of the neutron. Fig.4 shows the relationship between the thickness of lanthanum and measurement time when P violation is measured with an accuracy of 10%.

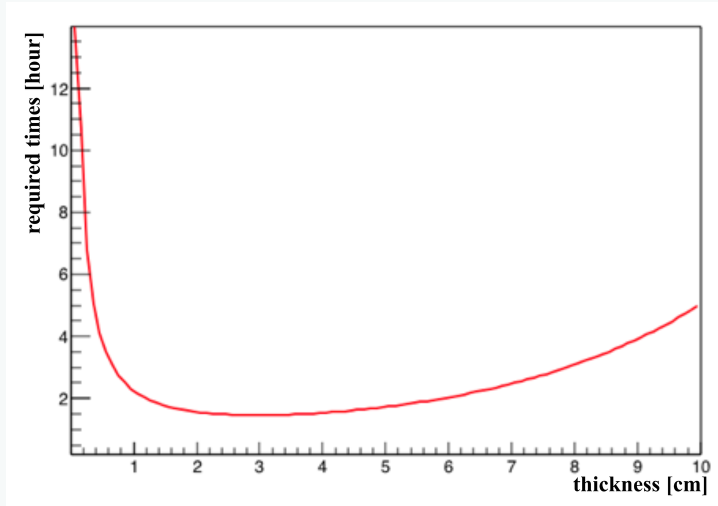

Fig.4 Relationship between ^{139}La thickness and required times

Table.1 shows experimental condition. **The optimum thickness of lanthanum is 3.0 cm when P violation measured with an accuracy of 10%.** However, when we use a thick lanthanum like this values, we measure the blurred angular distribution due to scattered neutron in the target. Therefore, it is considered good to use as thin as possible.

Neutron intensity	2613 n/s
Polarization of ^{3}He	45%
Neutron polarization	20%
Neutron transmission	65%
Effective thickness	17 atm・cm

Table.1 Parameters in the experiment

Experiment setup

As shown in Fig.6, first, unpolarized neutrons are polarized with ^{3}He spin filter from the beam line upstream. After that, polarized neutrons are irradiated the target. At that time, gamma rays emitted by (n, γ) reaction are measured with germanium detectors(Fig.5), and The neutron transmitted through the target is measured with a transmission detector.

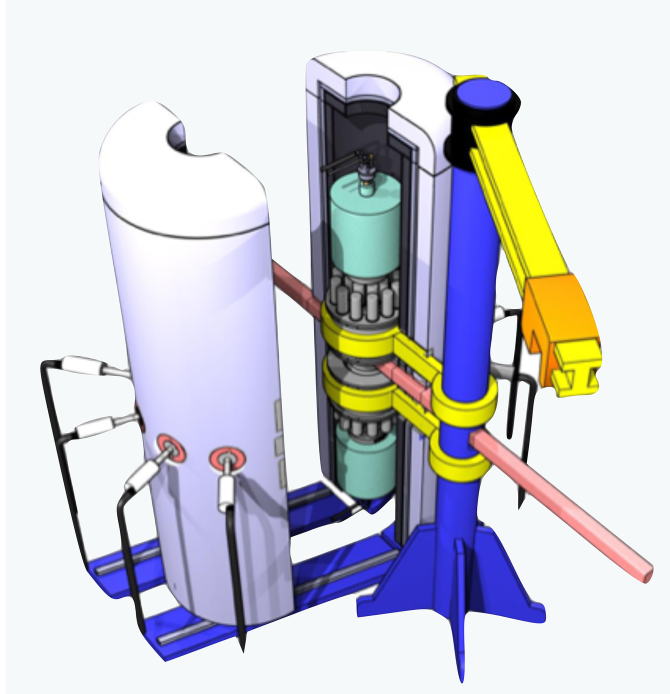

Fig.5 Germanium detectors

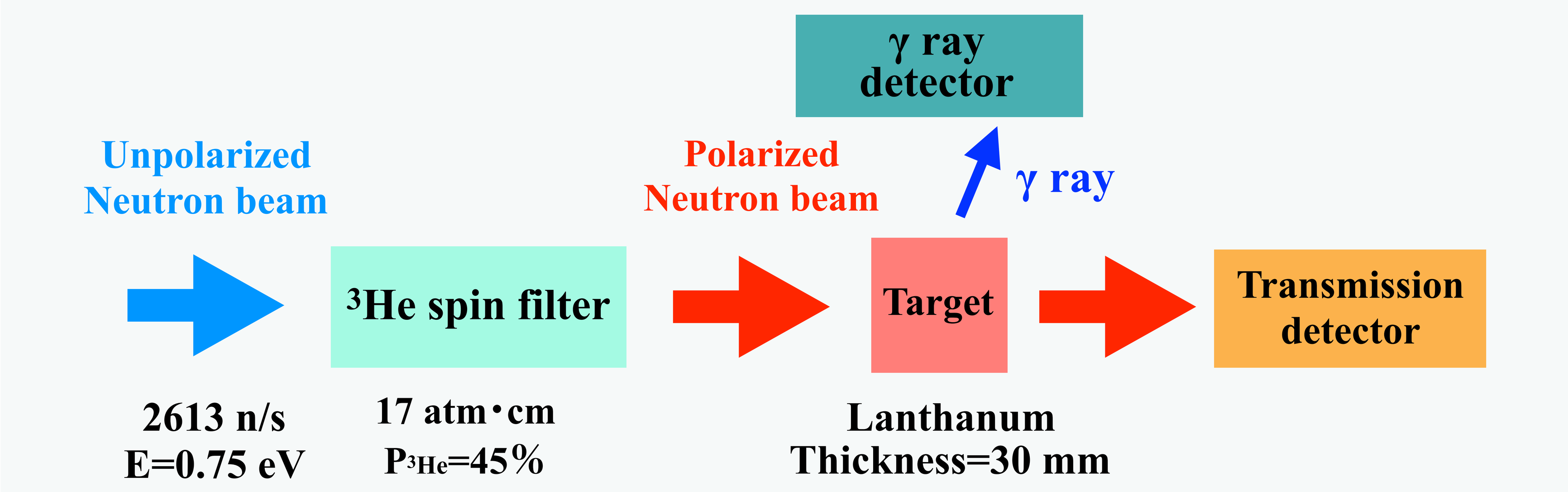

Fig.6 Experiment setup for P violation measurement

Conclusion

・Final state dependence of P violation has not been measured yet.

・In the case of La, it takes 1.5 hours beam time to measure the asymmetry with an accuracy of 10%.

・The optimum thickness is 3.0 cm. In addition, we need to consider the effect of scattering.

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