Development of polarized ^{3}He ion source

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From the last year on, we have developed a bench-test device which checks the validity of principle of the SEPIS (Spin Exchange Polarized Ion Source) polarized ^{3}He$^+$ ion source. The basic principle of polarization is based on an expected enhancement of the spin-exchange cross section for a ^{3}He$^+$ ion incident on a Rb atom at a low incident energy of ^{3}He$^+$ [1]. This year, we preliminarily measured an energy dependence of the polarization transfer coefficients, P_T for the ^{3}He$^+$ + Rb system because P_T is directly connected to the spin-exchange cross section. Here, P_T is defined as

$$P_T = 2 \times \frac{P_{^3He^+}}{P_{Rb}}, \tag{1}$$

where $P_{^3He^+}$ is a nuclear polarization produced by the spin-exchange collisions and P_{Rb} is a Rb atomic polarization. Here, a factor 2 is due to the fact that the conversion rate of an atomic polarization to a nuclear one by the hyperfine interaction is 0.5 in the weak field limit. A somewhat detailed description of the measurement is presented in the latest paper [2]. The ^{3}He$^+$ nuclear polarization was observed by a polarimeter using the beam foil spectroscopy, and the Rb atomic polarization was observed by the Faraday rotation angles with a probe laser.

An energy dependence of P_T was measured in an incident ^{3}He$^+$ energy ranging from 20 keV down to 4 keV. To prove the validity of SEPIS principle a further measurement at incident energies lower than 4 keV is of crucial importance. However, such an extremely low energy measurement was not so easy because of the low counting statistics due to the low beam emittance and low detection efficiency of the polarimeter. To overcome this difficulty a further improvement of the bench-test device is needed.

In this report, we present preliminary experimental results of the energy dependence down to 4 keV. In Fig. 1, the experimental results on P_T plotted as a function of the incident ^{3}He$^+$ energy are shown, where the thickness and polarization of Rb are kept constant. The error bars indicated are due to the counting statistics plus systematic errors. The solid curve in Fig. 1 is the result obtained by using theoretical spin-exchange cross sections calculated on the basis of the close coupling method [3]. As theoretically predicted, the characteristic behavior that P_T rises promptly according as decreasing the incident ^{3}He$^+$ energy is realized in the experiment. From this result the validity of SEPIS was qualitatively proven.

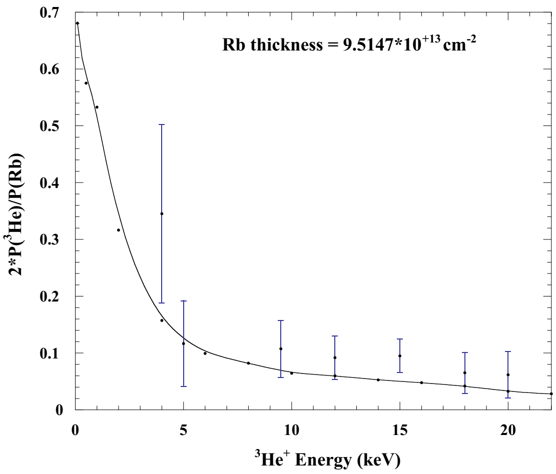

Fig. 1. Observed results of P_T plotted as a function of the incident ^{3}He$^+$ energy. The solid curve is the result of the theoretical calculation based on the close coupling method.

References

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