Design of Rb Cell for Polarized ^{3}He Ion Source Based on Electron Pumping

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Abstract

A new principle to produce a polarized ^{3}He ion, called "electron pumping" is recently proposed by Tanaka et al. We have newly constructed this type of polarized ^{3}He ion source at RCNP to prove the validity of this principle and to establish a practical ion source based on this method. In this paper we present design and performance of a Rb cell, which plays a critical role in this ion source. A thick Rb vapor more than 10^{15}atoms/cm^2 is successfully available with this Rb cell.

1 Introduction

A polarized ^{3}He beam is a promising probe in a research on nuclear physics. However, there is no practical polarized ion source, so far, because there is no practical method to polarize a ^{3}He particle. Recently, Tanaka et al. have proposed a new method to polarize a ^{3}He particle called "electron pumping". [1] It has been expected that typical nuclear polarization of $^3He^+$ ion is ~80 % at the vapor thickness of the Rb of 10^{15} atoms/cm^2 and 100 % of an atomic polarization. In order to experimentally prove the validity of the principle of "electron pumping" and to establish a method for a practical polarized ^{3}He ion source of this type, we have constructed a new polarized ion source based on the "electron pumping" at RCNP, Osaka University [2]. Since this method is based on multiple-electron capture and stripping collisions between an incident ^{3}He ion and polarized Rb atoms under a strong magnetic field, we paid special attention for designing the size and figure of the Rb cell since it must produce thicker and higher atomic polarized Rb vapor than that used in the ordinary optical pumping polarized ion source.

2 The Set Up of an Electron Pumping Polarized ^{3}He Ion Source and Rb cell

The whole set up of the polarized ^{3}He ion source based on electron pumping is depicted in Figure-1 [3]. The Rb cell is located at the center of a superconducting solenoidal magnet. A cross sectional view of the Rb cell is shown in Figure-2. The Rb cell consists of three coaxial sleeves, i.e. an inner sleeve, an outer sleeve and a cooling sleeve. Inside the outer sleeve, a solid Rb metal is vaporized. The vapor diffuse into the inner sleeve through four axial slits, so that the Rb vapor distributes uniformly in the inner sleeve. The inner sleeve has an entrance and an exit aperture of 10 mm and its length is 296 mm. These two sleeves are located inside the cooling sleeve. A temperature of a wall of the inner sleeve is monitored by a thermocouple. This output is used as a feedback signal of a heater to stabilize the cell temperature.

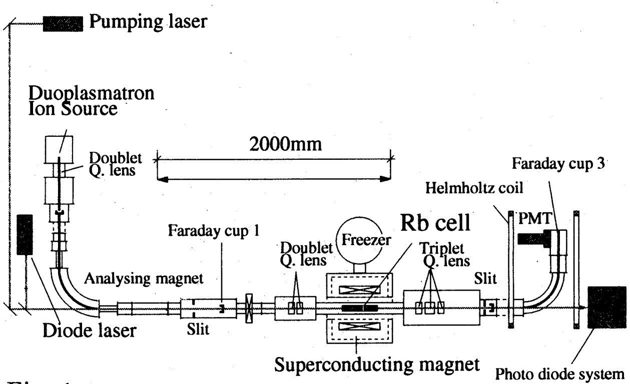

Fig. 1 The whole set up of the polarized ^{3}He ion source based on electron pumping.

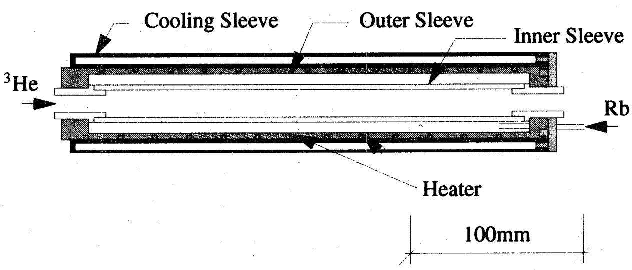

Fig. 2 A cross sectional view of the Rb cell. A length of the cell is 296mm and a full aperture is 29 mm

3 Experimental Result and Conclusion

We measured the thickness of the Rb vapor by means of the Faraday rotation effect [4]. We can measure the Faraday rotation angle in accuracy of ±0.05 °. The measured Rb thickness as a function of the cell temperature is plotted in Figure-3 in comparison with those calculated by using a saturated Rb vapor pressure. Since a time constant of a cell temperature is small due to the present cell structure, a good stability of the Rb cell temperature of ±0.1 °C at 100 °C was obtained.

It is clear from the Figure-3 that the present Rb cell can produce the vapor thicker than 10^{15} atoms/cm^2 at 160°C. The stability of the Rb cell temperature is ±0.1 °C at 100 °C.

This stability corresponds to a change of $\pm 4.0\times 10^{11}$ atoms/cm^2 in the Rb thickness. Since the accuracy of the measurement of the Faraday rotation angle (± 0.05 °) corresponds to $\pm 1.91\times 10^{12}$ atoms/cm^2, the precision of the measurement of the Rb thickness is determined by the accuracy of the Faraday rotation angles.

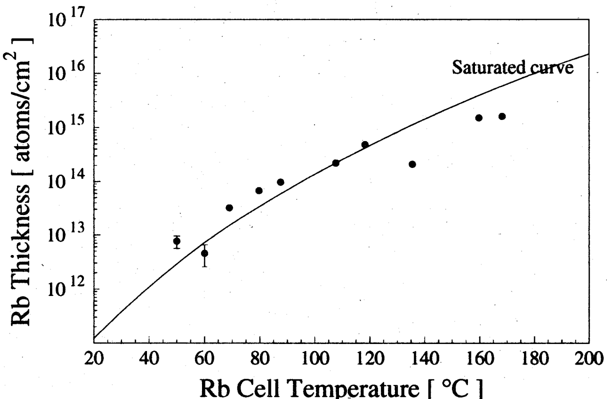

Fig. 3 The measured Rb vapor thickness by the Faraday rotation method. The solid curve shows that calculated from a saturated Rb vapor pressure.

Acknowledgement

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