Development of the Polarized ^{3}He Target

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Polarized nucleon-polarized nuclei scattering is a unique probe to investigate the spin structure of nuclei since target-related observables are extremely sensitive to small spin-dependent components of the target wave function. It is this sensitivity that makes these spin observables such a severe test of theoretical models. In addition, one can obtain information about reaction mechanisms, spin dependent nucleon-nucleon interactions in the nuclear medium, and off-shell behaviors of the N-N amplitudes. The ^{3}He and ^{4}He nuclei are the most attractive in this aspect as well as for searches of 3N force effects because these nuclei are the most dense. We have proposed to measure the differential cross section and spin-spin correlation parameter C_{yy} of the p^3He elastic backward scattering at E_p = 200 - 400 MeV. For this purpose, we need to develop a thick and highly polarized ^{3}He target.

There are two methods to polarize ^{3}He nucleus. One uses the direct optical pumping of the metastable 2^3S_1 state of ^{3}He atom [1]. In the other method, ^{3}He is polarized by a two step process. At first, Rb vapor is polarized by optical pumping with a circularly polarized light. Next, the Rb electron polarization is transferred to the ^{3}He nucleus by the spin-exchange scattering [2]. We use the second method, which can be more easily applied for thick targets.

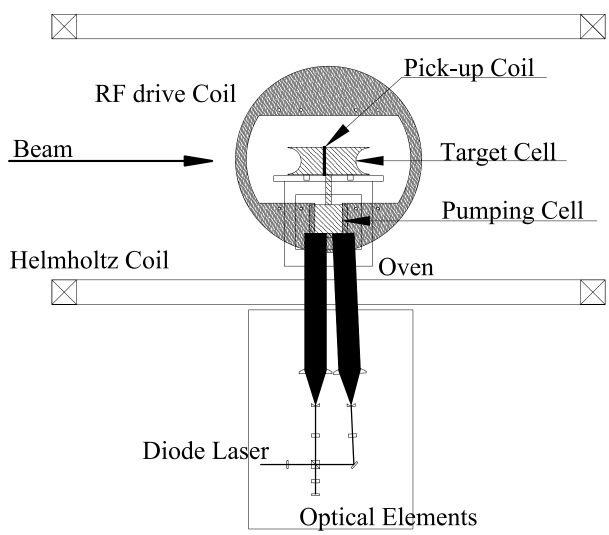

Figure 1: The schematic setup of the ^{3}He target

The system consists of several coils, cells, an oven, and a laser system. The schematic setup is shown in Fig. 1. The Helmholtz coils produce a holding field vertical to the beam direction. The RF drive coils are used to generate an oscillating field perpendicular to the holding field. The pick-up coil is orthogonal to both the Helmholtz coils and RF coils. The cell which is made of borosilicate glass (Corning7056) consists of two parts, a target cell and a pumping cell, connected by a transfer tube. During operation the pumping cell is heated to about 190 °C to get sufficient Rb density for optical pumping and spin exchange scatterings. Polarized ^{3}He atoms are transferred to the target cell by diffusion. By using two cells we can avoid problems of large backgrounds from the oven and of depolarizing effects. A high power diode laser which is a Fiber Array Packaged Laser, COHERENT FAP-79-30C-800LB, and optical elements are introduced to polarize the Rb atoms in the pumping cell. The ^{3}He polraization is measured by the Adiabatic Fast Passage (AFP) NMR method.

Figure 2 shows the current dependence of the output power of the diode laser. We usually operate the laser at 35 A. The wavelength of the light emitted from the diode laser is adjusted by changing the current to a peltier element on which the diode is mounted. The temperature is measuerd with a sensor (LM335) attached to the diode. Temperature dependence of the wavelength is shown in Fig. 3. In order to adjust the wavelength to the Rb D1 line (794.7 nm), the diode is cooled down to about 25 °C by adjusting the current to the poltier element.

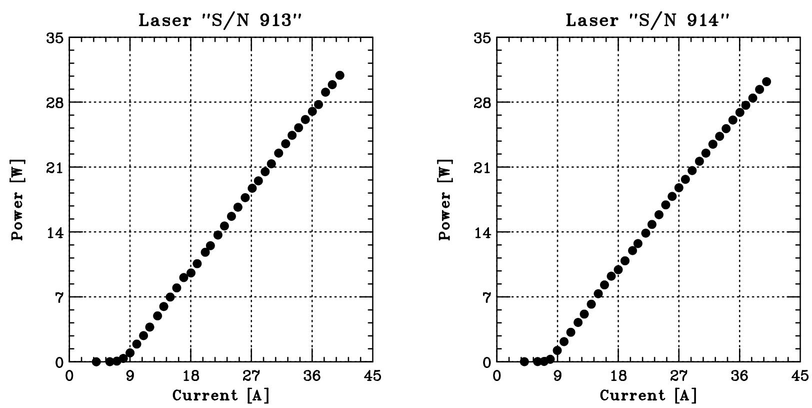

Figure 2: Current dependence of the output power of the diode laser.

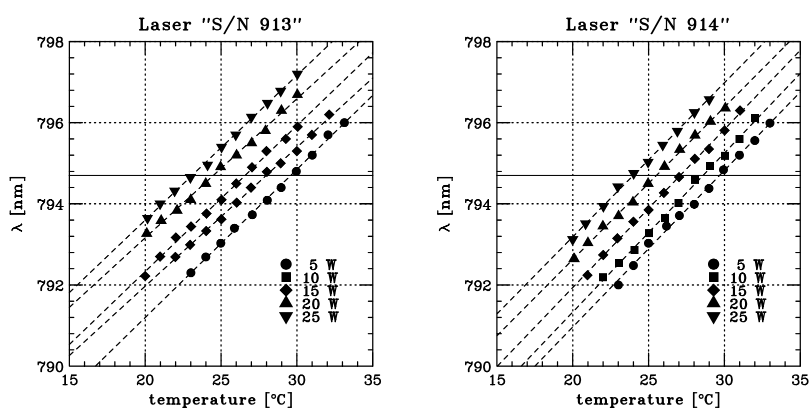

Figure 3: Temperature dependence of the wavelength of the diode laser.

References

[1] F.D. Colgerove, L.D. Scheafer, and G.K. Walters, Phys. Rev. **132**, 2561 (1963).

[2] T.E. Chupp, M.E. Wagshul, K.P.Coulter, A.B. McDonald, and W. Happer, Phys. Rev. C **36**, 2244 (1987).