Deuteron Spin Dichroism: From Theory to First Experimental Results

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The microscopic process of coherent scattering of neutrons by nuclei in a medium can be described by a macroscopic index of refraction as introduced by Fermi [1] and later discussed in more detail by Lax [2]. The precession of the neutron spin (I=1/2) in a polarized target due to the nuclear pseudo-magnetic field ([Ref. [3] and references given there) is also a coherent effect in analogy to optical effects in anisotropic media. For deuterons (I=1) coherent scattering by an unpolarized target has been predicted [4] to result in bi-refringence (spin rotation and oscillation) and spin dichroism (appearance of tensor-polarization components in an initially unpolarized deuteron beam).

Our first experiments have aimed at observing the deuteron spin dichroism. Unpolarized deuterons accelerated by the HVEC tandem Van-de-Graaff accelerator at the Institut für Kernphysik of the Universität zu Köln passed unpolarized amorphous carbon targets of thicknesses 37.0±1.0, 57.8±1.0, 94.8±1.4, 132±2, 153±3, 169±3, and 188±4 mg/cm^2. The energy of the primary beam was changed in steps of 0.1 MeV to achieve average energies of the deuterons between about 6 and 8 MeV behind all targets. For the 169 mg/cm^2 target, e.g., the primary beam energies were 16.7 (17.5) MeV for 5.8 (7.5) MeV deuterons behind the target. Primary deuteron beams with energies in the range 6 to 8 MeV were used to perform empty target reference measurements. The possible tensor polarization components in the transmitted deuteron beam were measured with a polarimeter using the ^{3}He(d,p)^{4}He reaction [5]. There the spectra of the outgoing protons are measured using a forward (F) detector and four detectors positioned at polar angles of 24.5^o and azimuthal angles differing by 90^o (up(U), down(D), right (R), and left (L)). The differences of measurements with and without target, observed in the slopes of the proton-peak ratios (L+R+U+D)/F as a function of the energy of the transmitted deuterons, indicate a polarizing effect by the deuteron-target interaction. Details of the measurements, the analysis procedures, and preliminary results are presented.

References

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