Spin-exchange polarized ^{3}He for electron scattering

Gordon D. Cates

University of Virginia, Charlottesville, VA 22903, U.S.A.

Polarized ^{3}He targets based on spin-exchange optical pumping (SEOP) have been successfully used to measure spin-dependent neutron observables in electron scattering for over two decades. Examples of the physics that has been studied include the spin structure of the neutron in deep inelastic scattering, the Q^2 dependence of the generalized Gerasimov-Drell-Hearn (GDH) integral, the electric form factor of the neutron, and single-spin asymmetries in semi-inclusive deep inelastic scattering (SIDIS). The expanding scope of the physics that has been studied with these targets has only been possible because of dramatic increases performance. The advances in the polarized ^{3}He target technology has been due to both an improved understanding of the underlying physics as well as technological advances.

In this talk, I will first summarize the work that has resulted in over an increase in the effective luminosity of these targets by well over an order of magnitude. This includes the use of alkali-hybrid SEOP and the use of high-power spectrally-narrowed lasers. Substantial gains have been made in the quantity of ^{3}He gas that can be polarized, the maximum polarizations achieved, and the rate at which the gas can be polarized. The rate at which polarization is achieved is particularly important for tolerating high electron-beam currents. I will also describe our measurements of the so-called X-factors, that characterize an as yet unidentified relaxation mechanism that limits the maximum polarizations that can be achieved.

Also discussed will be the development of next-generation polarized ^{3}He targets that will be used in upcoming experiments following the JLab energy upgrade. Among the new features incorporated into these targets is the use of convection to rapidly circulate the polarized ^{3}He gas between the chambers in which the SEOP takes place and the target chamber, through which the electron beam passes. We have shown that convection, unlike diffusion, results in a much smaller polarization gradient between the two chambers without significant loss of polarization. It appears that significant increases in the performance of polarized ^{3}He targets can be expected to continue for many years.