A Measurement of the Neutron Spin-Polarization in Deuterium Photodisintegration

Tanner Polischuk[a,1], Rob Pywell[a], Blaine Norum[b], Thomas Krahulik[b,2], Matt Roberts[b], Haoyu Chen[b], Giovanni Jimenez[b]

[a] *University of Saskatchewan*
[b] *University of Virginia*

The force between nucleons, termed the nucleon-nucleon interaction or residual strong force, is wholly responsible for binding nucleons together to form atomic nuclei. Contemporary theories describing this interaction have been fitted to a wealth of nucleon-nucleon scattering cross sections with much success. This provides confidence to the various approaches when modelling this nuclear force, however, this is largely limited to unpolarized results. The polarization degrees of freedom within these interactions present an excellent opportunity to explore the richer dynamics of nuclear reactions.

Deuteron photodisintegration provides an excellent test case for investigating these quantities. The deuteron is the simplest and least energetic nuclear system, and the photon is well-understood through QED, allowing for the contributions of the nucleon interactions to be isolated. One such observable is the spin-polarization of the recoil neutron in deuterium photodisintegration. This quantity is of significant importance to nuclear physics, as there exists several discrepancies between historical measurements and theoretical calculations near the deuteron breakup threshold. Rectifying this inconsistency strengthens the understanding of the nuclear force.

Innovations in accelerator and detector technologies offer new capabilities to obtain precise results for deuteron photodisintegration. An experiment was conducted at the High-Intensity Gamma-Ray Source (HIGS) using a newly-developed detector array to measure the recoil neutron polarization by means of a spin-dependent scattering asymmetry. The experimental setup consists of a heavy-water target surrounded by polarization analyzers at several angles of interest, which themselves are surrounded by several liquid scintillation detectors. The photodisintegration neutrons undergo a spin-dependent scattering with Helium within the analyzers, and are then detected by the scintillators. The recoiling Helium nuclei are also detected, and a coincidence requirement is imposed between the signals. The measurement of a scattering asymmetry from these events directly correlates to the incident neutron polarization.

Included are the results from this investigation utilizing a circularly-polarized beam at energies of 8 and 16 MeV. This is a subset of a larger dataset that includes additional beam energies and polarizations.

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[1] Present address: University of Hawaii at Manoa
[2] Present address: George Washington University