Accurate Electron Spin Optical Polarimetry (AESOP)

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Synopsis The next generation of high-energy parity violation experiments will require knowledge of the electron beam spin polarization to unprecedented accuracy. I propose to develop high-accuracy (< 0.4%) electron optical polarimetry, based on impact excitation of the noble gases to spin triplet Russell-Saunders states. Such measurements will allow us to calibrate, e.g., the 5 MeV Jefferson Lab injector Mott polarimeter to 0.5%.

The ultra-high accuracy parity-violation experiments being planned at Jefferson Lab (MØLLER, PVDIS) and the Mainzer Mikrotron (P2) will require that the electron polarization of the incident beam be known to < 0.5% to optimally interpret the physics asymmetries of order 10^{-9} that they will measure. Current electron polarimetry at these facilities is limited to accuracies ≥ 1% at both their experimental energies (of order 10 GeV) and at their injectors. Improvement at both the low- and high-energy ends of the experiment will be needed to achieve the 0.5% accuracy goal [1].

Mott polarimeters are used at the injectors of both MAMI and JLab, and operate at energies between 3 and 5 MeV. Mott polarimetry requires theoretical calculation of the analyzing power (the "Sherman function") which can currently be done with an accuracy of about 1% at 5 MeV. We thus propose to calibrate these Mott polarimeters to the requisite 0.5% by using electrons of polarization known to better than 0.4%. This would be accomplished by the use of optical electron polarimetry, which has currently been carried out to a *precision* of ~0.8% [2].

Optical electron polarimetry involves the exchange excitation of a well-*LS*-coupled state, and the measurement of the Stokes parameters of its subsequent fluorescence. This process has an analyzing power that can be determined analytically with no error, in the absence of contamination by cascades and strong scattering resonances. If these effects can be well characterized, the challenge becomes one of measurement accuracy alone. Figure 1 shows a design for a prototype polarimeter. It will use 5-cm-diameter optics, very high extinction polarizers, zeroth-order quartz retarders, and an *in vacuo* calibration light source. In order to eliminate the polarization effects of birefringent vacuum windows, we will operate the analysis optical polarimeter inside the vacuum as well.

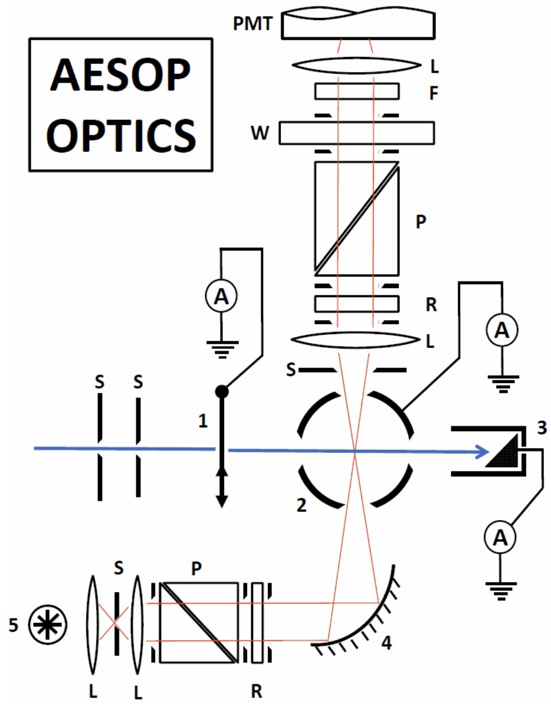

Figure 1. The AESOP setup showing electron or photon beam-defining slits (S), linear polarizers (P), retarders (R), a vacuum window (W), lenses (L), an interference filter (F), ammeters (A), and a photomultiplier detector (PMT). Also indicated are (1) a movable beam-current flag, (2) the effusive target gas containment cylinder, (3) the Faraday cup, (4) a mirror for the calibration source immediately to its left, and (5) a calibration light source. The light source in the vacuum system would use a noble-gas discharge lamp, whose fluorescence is focused at the electron-beam gas intersection point. Its polarization would be varied using the elements shown.

This work is supported by the US NSF (Award PHY – 1632778).

References

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