When circularly-polarized light with near-bandgap energy illuminates a negative electron affinity (NEA) GaAs photocathode, spin-polarized electrons are emitted \([2, 3]\). The degree of polarization is defined to be

\[
P = \frac{N_\uparrow - N_\downarrow}{N_\uparrow + N_\downarrow},
\]

where \(N_\uparrow\) and \(N_\downarrow\) are the number of spin-up and spin-down electrons respectively.

For thick bulk GaAs illuminated with circularly-polarized light, the electron polarization is typically \(-35\%\) \([4]\). Using light with OAM, we explored the idea of imparting angular momentum to electrons in the conduction band of GaAs to create spin-polarized electron beams.

In our experiment, two linearly-polarized laser beams of comparable intensity were directed at diffraction gratings to produce two linearly-polarized Laguerre-Gaussian beams with varying amounts of OAM of opposite charge (see Fig. 2a). These beams were directed—one at a time—at a GaAs photocathode (Fig. 2b) to produce electron beams that were delivered to a compact retarding-field micro-Mott polarimeter \([5]\). The systematic error associated with beam misalignment, determined by displacing one linearly-polarized Gaussian beam relative to the other by a distance comparable to the spatial extent of the OAM beams, was \(-2\%\).

The polarization of electrons emitted from GaAs using OAM light was measured to be less than \(-2.5\%\) for all topological charges tested (Fig. 3). This is compared to \(-35\%\) polarization for circularly-polarized light. Given the systematic spatial displacement uncertainty, our measurements were consistent with zero, suggesting that OAM light does not couple to the extended (delocalized) electron states in a semiconductor, at least when the laser beam diameter is \(-100\ \mu m\) or larger.

References


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