PQB

Photocathode Analyzing Power Study

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GaAs Analyzing Power

- The GaAs crystal has preferred axis for absorption of linearly polarized light, Linear Dichroism (LD): difference in absorption of light polarized parallel and perpendicular to an orientation axis (Phys. Lett. A 212, 231 (1996))

- Circular Dichroism (CD): difference in absorption of left- and right-handed circularly polarized light. CD is zero for GaAs.

- Measure the super-lattice photo-cathode analyzing power (QE anisotropy), turn off Pockels Cell (PC) and do a Rotatable Half Wave Plate angle (θ) scan:

\[
QE = QE_0 \left( 1 + Ay \sin(4\theta + \phi) \right)
\]

\[
Ay = 3.7\%
\]
Not Perfect Circular Polarization?

- Residual linear polarization causes charge asymmetry when coupled to photocathode analyzing power.

- Measure the charge asymmetry (turn on Pockels Cell and do a RHWP scan).

\[
A_q = 621.07 + (-1244.23 \sin(20 + 39.86) + 405.41 \sin(40 + 125.23))
\]
RHWP Scans

\[ A_q = A_y \left[ c_0 + c_1 \sin(2\theta + \phi_1) + c_2 \sin(4\theta + \phi_2) \right] \]

<table>
<thead>
<tr>
<th>Term</th>
<th>Caused by</th>
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<tbody>
<tr>
<td>( c_0 )</td>
<td>Vacuum Window Phase Shift</td>
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<tr>
<td>( c_1 )</td>
<td>RHWP Phase Shift</td>
</tr>
<tr>
<td>( c_2 )</td>
<td>Pockels Cell Residual Phase Shift &amp; Imperfect Initial Linear Polarization</td>
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- Did RHWP Scans with:
  1. Insertable Half-Wave Plate: IHWP IN or IHWP OUT
  2. Insertable Linear Polarizer: ILP IN or ILP OUT
     1. ILP OUT: Spot 900/900
     2. ILP IN: Spot 850/800, to run from same spot as OUT; ILP moved the beam by about 2 mm
  3. Pockels Cell HV set for maximum circular polarization (PITA = 0 V) or set for elliptical polarization (PITA = -120 V)
Run 689, PITA = 0, IHWP OUT, ILP OUT, QWK_1102

\[ A_q = -952.43 + 1252.02 \sin (\theta + 65.86) + -841.07 \sin (\theta + 66.39) \]

\[ \Delta x = -0.39 + 0.52 \sin (\theta + 64.99) + -0.40 \sin (\theta + 89.46) \]

\[ \Delta y = 0.88 + 0.30 \sin (\theta + 52.80) + -0.22 \sin (\theta + 125.73) \]
Run 690, PITA = -120, IHWP OUT, ILP OUT, QWK_1I02

\[ A_q = -938.92 + 1160.79 \sin (\theta + 38.98) + 2740.88 \sin (\theta + 12.66) \]

\[ \Delta x = -0.30 + 0.50 \sin (\theta + 33.64) - 1.50 \sin (\theta + 177.87) \]

\[ \Delta y = 0.90 + 0.30 \sin (\theta + 21.32) + 0.98 \sin (\theta + 3.05) \]
Run 691, PITA = 0, IHWP IN, ILP OUT, QWK_1I02

\[ A_q = 799.62 + -1220.48 \sin(\theta + 63.16) + 595.06 \sin(\theta + 97.69) \]

\[ \Delta x = 0.48 + -0.45 \sin(\theta + 57.87) + 0.41 \sin(\theta + 114.58) \]

\[ \Delta y = 1.36 + -0.26 \sin(\theta + 46.04) + 0.25 \sin(\theta + 152.48) \]
Run 692, PITA = -120, IHWP IN, ILP OUT, QWK_1I02

\[ A_q = 776.38 + -1145.43 \sin (2\theta + 36.03) + -3131.25 \sin (4\theta + 13.94) \]

\[ \Delta x = 0.38 + -0.51 \sin (2\theta + 29.90) + -1.71 \sin (4\theta + 2.77) \]

\[ \Delta y = 1.36 + -0.30 \sin (2\theta + 19.77) + -1.13 \sin (4\theta + 9.48) \]
Run 693, PITA = 0, IHWP IN, ILP IN, QWK_1I02

\[ A_q = 716.63 + (-1135.11 \sin(2\theta + 57.07)) + 771.17 \sin(4\theta + 156.63) \]

\[ \Delta x = 0.48 + (-0.46 \sin(2\theta + 62.91)) + 0.41 \sin(4\theta + 139.95) \]

\[ \Delta y = 1.22 + (-0.18 \sin(2\theta + 40.38)) + (-0.37 \sin(4\theta + 3.60)) \]
Run 694, PITA = -120, IHWP IN, ILP IN, QWK_1102

\[ A_q = 685.19 + \ -1101.51 \sin(2\theta + 28.65) + \ -3632.83 \sin(4\theta + 15.45) \]

\[ \Delta x = 0.45 + \ -0.49 \sin(2\theta + 25.19) + \ -1.77 \sin(4\theta + 3.38) \]

\[ \Delta y = 1.22 + \ 0.25 \sin(2\theta + 179.31) + \ -1.00 \sin(4\theta + 10.56) \]
Run 695, PITA = 0, IHWP OUT, ILP IN, QWK_1102

\[ A_q = -902.07 + 1159.96 \sin(2\theta + 60.47) - 552.36 \sin(4\theta + 125.06) \]

\[ \Delta x = -0.18 + 0.48 \sin(2\theta + 61.78) - 0.38 \sin(4\theta + 117.80) \]

\[ \Delta y = 0.91 + 0.19 \sin(2\theta + 41.58) - 0.37 \sin(4\theta + 167.70) \]
Run 696, PITA = -120, IHWP OUT, ILP IN, QWK_1I02

\[ A_\theta = -881.34 + 1104.97 \sin(2\theta + 32.29) + 3267.84 \sin(4\theta + 14.76) \]

\[ \Delta x = -0.11 + 0.49 \sin(2\theta + 32.79) + 1.61 \sin(4\theta + 0.68) \]

\[ \Delta y = 0.95 - 0.20 \sin(2\theta + 177.41) + 0.83 \sin(4\theta + 3.75) \]
Summary of RHWP Scans

- IHHWP IN $\rightarrow$ IHWP OUT: $A_q \rightarrow -A_q$
  - IHWP does not cancel helicity correlated effects caused by residual linear polarization

- ILP has small effect
  - The initial polarization is highly linear
  - Because of the way the three laser beams are combined, ILP can only be used during beam studies

- How to zero charge asymmetry?
  - Use $c_2$ to compensate for offset term or
  - Zero offset term by rotating photocathode
Photocathode Rotation

- Measure Offset term \( (c_0) \) as a function of photocathode angle \( (\theta_c) \)
- Choose angle where Offset is zero

Offset = 693.7 \cos(2\theta_c + 21.0)
Why use IHWP?

IHWP cancels helicity-correlated changes due to:

1. Position differences caused by Pockels Cell steering
   - PC alternately pulsed to +HV and -HV to change from right to left circularly polarized light and vice-versa
   - PC behaves alternately as converging and diverging lens
   - If beam is off-center, it can be steered
   - Induces helicity-correlated position differences

2. Electronic cross talk