Circular Beam Polarization in Double Polarization Experiments

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Outline

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Motivation

Double Polarization Observables in Two Meson Photoproduction

$$\frac{\partial\sigma}{\partial x_i} = \sigma_0\{(1 - \vec{\Lambda} \cdot \vec{P}) + \delta_\odot(I^\odot - \vec{\Lambda} \cdot \vec{P^\odot})$$

$$-\delta_l(\sin 2\phi(I^s - \vec{\Lambda} \cdot \vec{P^s}) + \cos 2\phi(\Sigma - \vec{\Lambda} \cdot \vec{P^c})\}$$

Where $\vec{\Lambda}$ is target Polarization, $\delta_\odot$ is degree of circular polarization

δ_l is degree of linear polarization

Must measure at least 8 of these observables to have a "complete" experiment.

No way to have a "complete" experiment without using circularly polarized photons.

Outline

1. Motivation
2. Creating Circular Polarization
3. Measuring Circular Polarization
4. Using Polarization in Analysis

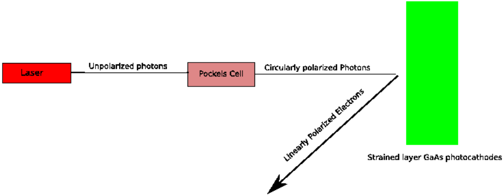
Overview

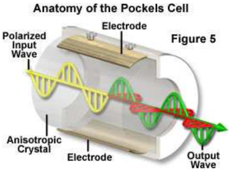
Creating Circularly Polarized Photons (Sequential overview)

1. Laser → Unpolarized Photons
2. Pockels Cell → Circularly Polarized Photons
3. Electron Gun → Low Energy Linearly Polarized Electrons
4. Accelerator → High Energy Linearly Polarized Electrons
5. Møller Detector → Measures Degree of Polarization of Beamline at Radiator
6. Radiator → Circularly Polarized Photons

Tech Note Polarized Source at JLab www.jlab.org/accel/inj_group/docs/2002/ori.pdf

Creating a Linearly Polarized Electron Beam





The Pockels Cell acts as a quick changing retarding crystal to create a photon beam that is constantly changing between the two needed polarization states.

The Electron Gun (Strained Layer GaAs crystal) uses photoelectric effect to turn circularly polarized photons into linearly polarized electrons. (conservation of angular momentum)

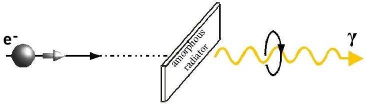
Hecht. *Optics* 3rd edition. 1998

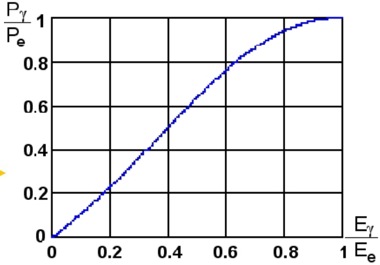
Creating a Circular Polarized Photon Beam

Bremsstrahlung Radiation is described by QED exactly

Helicity Transfer

$$P_{\odot} = P_{el} \frac{4z - z^2}{4 - 4z + 3z^2} \quad \text{Where } z = \frac{E_\gamma}{E_{el}}$$





Crede, Volker. $\pi^0\eta$ *Helicity Difference CB-ELSA Proposal to PAC*, 2005

Kammer, Susanne. *Strahlpolarimetrie am CBELSA/TAPS Experiment*, DPG Meeting 2008

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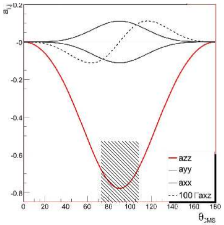
Møller Detector

Møller Scattering ($e^-e^- \rightarrow e^-e^-$)

Described Exactly by QED

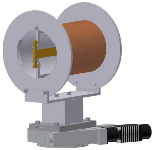
$$\frac{\partial\sigma}{\partial\Omega_{cm}} = \frac{\partial\sigma_0}{\partial\Omega_{cm}}(1 + a_{ij}(\theta_{cm})P_i^S P_j^T)$$

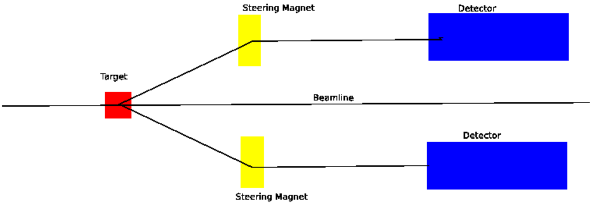
$$a_{zz}P_z^S P_z^T = \frac{N_{\uparrow\uparrow} - N_{\uparrow\downarrow}}{N_{\uparrow\uparrow} + N_{\uparrow\downarrow}} = A_{zz}$$



Electron Beam Polarization

$$P_z^S = \frac{A_{zz}}{P_z^T a_{zz}}$$





Kammer, Susanne. *Strahlpolarimetrie am CBELSA/TAPS Experiment*, DPG Meeting 2008

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Meson Photoproduction Polarimetry

$$\frac{\partial\sigma}{\partial\Omega_{cm}} = \frac{\partial\sigma_0}{\partial\Omega_{cm}}\{(1+\Lambda_z * P_z) + \delta_\odot(I^\odot + E * \Lambda_z)\}$$

$$\Uparrow$$

$\delta_\odot$ is the degree of polarization of the circularly polarized beam

Λ_z is the degree of polarization of the target in the z direction

Crede, Volker. $\pi^0\eta$ *Helicity Difference CB-ELSA Proposal to PAC*, 2005