Spin Observables For Polarizing Antiprotons

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We analyze the electromagnetic helicity amplitudes and spin observables for elastic antiproton-electron and antiproton-proton scattering, with one photon exchange. This is of interest to the PAX collaboration at GSI Darmstadt, which plans to polarize an antiproton beam by repeated interaction with a polarized Hydrogen target in a storage ring.

A generic equation is used to obtain expressions for polarization phenomena to first order in QED for these elastic processes, i.e. polarization transfer, depolarization and asymmetries. Using a direct computation in *Mathematica*, all the helicity amplitudes and spin observables for these processes are calculated. Form factors and masses are kept as parameters so these relations can easily be applied to other processes.

For example, the polarization transfer observable for polarization normal to the scattering plane $K_{N\,N}$ for the elastic process $\vec{A} + B \to A + \vec{B}$ with masses m_A and m_B in the Centre-of-Mass frame is

$$\frac{d\sigma}{d\Omega} K_{N\,N} = \frac{2\,\alpha^2\, m_A\, m_B}{s\,t}\, G_E^A\, G_M^A\, G_E^B\, G_M^B$$

where we have used the Sachs electric and magnetic form factors G_E and G_M, the fine structure constant α and the Mandelstam variables s and t. Similarly expressions for all other spin observables are presented.

A method to polarize an antiproton beam by pure electromagnetic interaction with an electron target is discussed. The differential equations that determine the possible rate of buildup of polarization require numerical estimates of the spin observables. We present analytic expressions and numerical results for the spin observables at the energies of interest to PAX. An estimate of the polarization buildup rate is determined.