Polarisation Observables in Proton Antiproton to Lepton Antilepton Reactions

Elise Jennings
School of Mathematics, Trinity College, Dublin, Ireland

-

The electromagnetic form factors of hadrons as measured both in the space like and time like domains provide fundamental information on the nucleon structure and internal dynamics. The time like form factors are accessible through annihilation reactions such as $e^- e^+ \to p \bar{p}$.

Measurements of the polarisation transfer from electron to proton in elastic $e^- p \to e^- p$ scattering at Jefferson Laboratory show that the ratio $G_E(q^2)/G_M(q^2)$ of space like Sachs form factors is monotonically decreasing with increasing q^2 in contradiction with the G_E/G_M suggested by Rosenbluth scaling methods.

It is as a result of these experiments that a precise separation of time like form factors and polarisation measurements are planned at the future antiproton facility at GSI. The Polarised Antiproton eXperiments (PAX) collaboration plans to measure the form factors and their relative phases via single spin asymmetry in the annihilation reaction $\bar{p} p \to e^- e^+$ on a transversely polarised target. The spin averaged differential cross section for this reaction is

$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2}{s^3} \frac{1}{\sqrt{s - 4\,m^2}\,\sqrt{s - 4\,M^2}} \left\{ \frac{s^2}{2} \left(s - 4\,M^2 \right) |G_M|^2 - 4\,s\,m^2\,M^2 \left(|G_M|^2 - |G_E|^2 \right) \right.$$

$$\left. + \left[\left(t - m^2 - M^2 \right)^2 + s\,t \right] \left(s\,|G_M|^2 - 4\,M^2\,|G_E|^2 \right) \right\}$$

where m is the lepton mass and M is the mass of the proton. For studies of $\bar{p} p \to l^- l^+$, where l is μ or τ, the lepton mass, m, will be significant. We shall also give general expressions, including the lepton mass, for the single spin asymmetry, A_y and all double spin asymmetries. It is shown that the formulae reduce to previously known results in the case of zero lepton mass.