The Electromagnetic Properties of the Light Pseudoscalar Mesons via the Primakoff Effect

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The PrimEx (Primakoff Experiment) Collaboration is preparing to perform a high precision (1.4%) measurement of the two photon decay width of the neutral pion, $\Gamma_{\pi^o \to \gamma\gamma}$. This measurement will provide a stringent test of the predictions of the U(1) axial anomaly in quantum chromodynamics. Photons from the Jefferson Lab Hall B photon tagging facility will be used to produce neutral pions in the Coulomb field of a nucleus. The two photons from the pion decay will be detected in a hybrid calorimeter (HYCAL) which will utilize lead tungstate ($PbWO_4$) scintillating crystals as well as lead glass Cherenkov shower counters.

The equipment being constructed for these measurements will be of general utility for experiments requiring the detection of multiphoton final states. As such, we are planning a related program to study the radiative widths of the η and η' mesons. In addition, the $\gamma\gamma^* P$ vertex will be examined, where P represents the π^o, η, or η' pseudoscalar mesons and γ^* is a virtual photon. Such measurements will enable one to study the transition regime from soft nonperturbative physics to the hard processes of perturbative QCD. We plan to measure the photon momentum dependence of the form factors $F_{\gamma\gamma^* P}(Q^2)$ and thereby map out an extension to the axial anomaly to provide a clean test of QCD predictions for exclusive processes. Measurements of the π^0, η and η' transition form factors at very low Q^2 are particularly important to allow a model independent extraction of the slope of the transition form factor, which measures the size of the meson's electromagnetic interaction radius.

A determination of the slope of these form factors at low Q^2 would allow one to uniquely fix a low energy constant $\mathcal{O}(p^6)$ in the effective chiral Lagrangian [1,2]. By limiting the range of extrapolation to the photon point, measurements of the π^0, η and η' transition form factors at very low Q^2 (~ 0.001–$0.5 GeV^2$) are particularly important to measure the size of the meson's electromagnetic interaction radius in a model independent manner. One important additional reason to better understand the transition from factors of π^0, η and η' is that pseudoscalar exchange is the major contribution to the hadronic light-by-light scattering part of the muon anomalous magnetic moment[3], and is thus clearly crucial for measurements of a_μ that search for "new physics" beyond the Standard model.

References:

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