Magnetic Moment of the $S_{11}(1535)$ Resonance

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Static properties of baryons such as magnetic moments contain important information about the structure of baryons. In particular, they provide a good test for QCD-inspired models in the non-perturbative region. The magnetic moments of ground-state octet baryons (N, Λ, Σ, Ξ) are measured through spin precession measurements. However, such techniques cannot apply to nucleon resonances because their lifetimes are too short ($\sim 10^{-23}$ sec). It has been proposed to extract the magnetic moment of $\Delta(1232)$ from the $\pi^+ p \to \gamma \pi^+ p$ and $\gamma p \to \gamma \pi^0 p$ reactions [1]. Similar procedure can also be used to determine magnetic moment of $S_{11}(1535)$ nucleon resonance, $\mu_{S_{11}(1535)}$, from the $\gamma p \to \gamma \eta p$. The determination of the $\mu_{S_{11}(1535)}$ is particularly interesting and important because it may clarify the ambiguity for the $S_{11}(1535)$ resonance descriptions.

There are suggestions [2] that the $S_{11}(1535)$ resonance is not a traditional three-quark state predicted from quark models; instead, it is a quasi-bound $K\Sigma$ state which can be dynamically generated from meson-baryon scattering. Although these two descriptions for the $S_{11}(1535)$ resonance are very different, they both show similar and indistinguishable resonance behaviors in scattering cross sections. On the other hand, the determination of the $\mu_{S_{11}(1535)}$ will present a very good test for these two descriptions since they are totally different mechanisms. In fact, we have obtained very different $\mu_{S_{11}(1535)}$ values for these two mechanisms in our preliminary calculations.

In addition, it is well known that the excited-state baryons are generally mixing states of SU(6) super-multiplets. Although different mixing schemes in various quark models can often explain the baryon spectroscopy well, we found that the values of resonance magnetic moments are very sensitive to the mixing schemes. The measurement of the $\mu_{S_{11}(1535)}$ will be the first for an orbitally excited baryon (all octet and decuplet baryons have the same ground-state spatial wavefunctions as the nucleons). Therefore, the determination of the $\mu_{S_{11}(1535)}$ should provide a unique test for various theoretical models for baryons.

The $\gamma p \to \gamma \eta p$ reaction in the $S_{11}(1535)$ resonance region is investigated as a method to access the $\mu_{S_{11}(1535)}$. The calculations of the $\gamma p \to \gamma \eta p$ reaction are performed within the context of an effective Lagrangian approach containing both the $S_{11}(1535)$ resonant mechanism and a non-resonant background. Predictions are shown for forthcoming $\gamma p \to \gamma \eta p$ experiments, which will be performed in the near future by using the Crystal Ball detector at MAMI [3]. In particular, the sensitivity of unpolarized cross sections and photon asymmetries to the $\mu_{S_{11}(1535)}$ is displayed for those forthcoming data.

References

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