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A new Research Proposal to PAC44 for Review by the CLAS collaboration

Search for Hybrid Baryons with CLAS12 at 6.6 GeV and 8.8 GeV

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I. ABSTRACT

This proposal is aimed to launch an experimental program to study the s-channel excitation of baryons with dominant gluonic admixtures (hybrid baryons) at masses M $\geq$ 1.8 GeV with CLAS12 in Hall B [1, 2]. The experiment will measure the exclusive $K^+\Lambda$, $K^+\Sigma^0$, and $\pi^+\pi^-p$ electroproduction channels off the proton at electron beam energies E_{beam} = 6.6 GeV and E_{beam} = 8.8 GeV. The electron beam will impinge upon a liquid hydrogen target in the CLAS12 center. Scattered electrons will be detected in an angle range of 2.5° to 4.5° in the Forward Tagger and for angles greater than 6° in the CLAS12 Forward Detector. The experiment will cover a mass range up to 3.0 GeV over a range of photon virtualities Q^2 from 0.05 GeV^2 to 2.0 GeV, which is still almost unexplored.

This proposal substantially enhances our capabilities to:

- search for new baryon states with the glue as a constituent component, the so-called hybrid baryons, by extending the measurements toward small photon virtualities, where the expected magnitudes of the hybrid-baryon electroexcitation amplitudes are maximal;
- study the structure of prominent nucleon resonances in the mass range up to 3 GeV, in the regime of large meson-baryon cloud contributions and explore the N^* longitudinal electroexcitation approaching the photon point;
- search for three-quark "missing" resonances at low photon virtualities, in the electroproduction of different final hadron states, with the highest fluxes of virtual photons ever achieved in exclusive meson electroproduction experiments.

The KY final states will be measured in topologies where the scattered electron and K^+ are detected. The four-momentum of the hyperon will be reconstructed employing energy-momentum conservation and data may be complemented by events in which protons from the hyperon decay will be detected.

For the $\pi^+\pi^-p$ channel the observables will be obtained from the combination of all possible event topologies, where the scattered electron and all final hadrons are detected, as well as when only two of three final state hadrons are detected, with the four-momentum of the third hadron reconstructed from energy-momentum conservation.

The unpolarized differential cross sections will be obtained for the aforementioned exclusive channels and complemented by measurements of the differential transverse-transverse and transverse-longitudinal interference cross sections. In the KY channels, the angular dependencies of the differential cross sections will be augmented by data on the induced and transferred polarizations for the recoiling hyperons, while for $\pi^+\pi^-p$ exclusive electroproduction, nine independent one-fold differential cross sections will extracted in each bin of W and Q^2.

$\gamma_v pN^*$ electrocouplings will be determined from the new data using all available approaches, that will be extended to reproduce the data down to the low $Q^2 < 2.0 GeV^2$ range: the well-known unitary isobar models and dispersion relation approaches [3], which are very effective for two-body final states, such as as KY, and the meson-baryon reaction model for $p\pi^+\pi^-$ exclusive electroproduction [4, 5].

The hybrid baryons will be identified as additional states in the N^*-spectrum beyond the regular three-quark states, as was predicted in recent LQCD studies of the baryon spectrum [6] that demonstrated the emergence of hybrid baryons from the QCD-Lagrangian.

Unfortunately spin and parities of hybrid baryons are expected to be the same as those for regular three-quark states. However the presence of explicit gluonic degrees of freedom in the hybrid baryon wave function implies different color-multiplet assignments for the quark-core: color octet for the hybrid states versus color singlet for the regular ones. This results in distinctively different Q^2-evolution of the hybrid-baryon electrocouplings, expecially at Q^2 values lower than 2.0 GeV^2.

Since lowest hybriyd baryons with spin-parity assignments of $J^p = \frac{1}{2}^+$ and $J^p = \frac{3}{2}^+$ are predicetd to cover the mass range of 2.2 - 2-3 GeV, and they are exptected to decay in final states with significan $s\bar{s}$ content, such as K^+Y and $N\pi\pi$, the new information on the $\gamma_v pN^*$ electrocoupling evolution with Q^2 in the proposed kinematics will substantially enhance our capability of discovering new baryon states.

Consistent results on resonance masses, $\gamma_v pN^*$ electrocouplings for all exclusive decay channels under study, and Q^2-independent partial hadronic decay widths, over the full covered Q^2-range, will offer convincing evidence for the existence of new states.

As a byproduct, the proposed kinematic range also correponds to the biggest contributions from the meson-baryon cloud in the baryon structure, allowing us to considerably improve our knowledge on this component, which is relevant for the structure of all N^* states studied so far [5]. Finally it will be possible to explore the longitudinal N^* electroexcitations as the photon virtuality goes to zero, using data on π^+n, π^0p, ηp exclusive electroproduction off protons, which could be studied as an extension of the measurements included in this proposal.

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