

Search for New Forms of Hadronic Matter in Photoproduction

P. Eugenio (*FSU*)*[†], C. Salgado (*NSU/JLab*)*, D. P. Weygand (*JLab*)*,
A. Afanasev (*JLab*), V. D. Burkert (*JLab*), S. Capstick (*FSU*),
P. L. Cole (*JLab*), P. Coltharp (*FSU*), D. Ireland (*Glasgow*),
L. Guo (*JLab*), J. Kellie (*Glasgow*), M. Khandaker (*NSU/JLab*),
K. Livingston (*Glasgow*), C. A. Meyer (*CMU*), M. Nozar (*JLab*),
A. Ostrovidov (*FSU*), E. S. Smith (*JLab*), B. Stokes (*FSU*),
M. Wood (*USC*),
and the CLAS Collaboration

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Abstract

We propose to search for new forms of hadronic matter utilizing a photon beam at CLAS in Hall B. Motivated by recent experimental results for gluonic hybrid meson candidates and from recent theoretical Lattice QCD and Flux-tube model calculations, photoproduction should provide an ideal hunting ground for gluonic matter. Jefferson Lab offers an excellent opportunity to undertake the study of meson spectroscopy at intermediate energies. Current studies are underway at CLAS which show the feasibility of using CLAS as a meson spectrometer for few-body final states. We propose to perform meson spectroscopy using CLAS, in Hall B. We will study reactions having multiple charged particles in the final state, of the form $\gamma p \rightarrow: p\pi^+\pi^-\pi^0, n\pi^+\pi^+\pi^-, pK^+K^-\eta, nK^+K^+\pi^-, \Delta^{++}\eta\pi^-, pp\bar{p}$.

Discoveries of new phenomena in nuclear and particle physics have provided insight into the fundamental constituents of matter. In the past few decades we have seen a new picture emerge in which quarks form the building blocks of nearly all matter. Yet the gluon, which carries the force which binds quarks, can interact with other gluons to form a bound state, or interact as a fundamental constituent of matter along with the quarks. Thus new forms of gluonic or hybrid matter should exist.

*Spokesperson

[†]Contactperson

The search for hybrids in recent years has resulted in considerable excitement. Theoretical predictions from both gluonic flux-tube models and recent lattice gauge theory results predict the lightest hybrid at a mass of 1.9 GeV for the exotic $J^{PC} = 1^{-+} q\bar{q}g$ -hybrid(see references . Exotic meson states are those with quantum numbers not accessible to conventional $q\bar{q}$ bound states. Recent experimental results find two very promising 1^{-+} exotic candidates. The $\pi_1(1400)$ seen decaying to $\eta\pi^-$ at Brookhaven has a mass somewhat too low for the theory prediction for a gluonic hybrid. A higher mass observed state, the $\pi_1(1600)$ is tantalizing as a gluonic hybrid, but its decay to $\rho\pi$ was unexpected. Even though the existence of both states appears very clear, these states have had a history of controversy, particular those produced via pion beams.

It has been pointed out by Close and Page that in the case of photoproduction, where the photon can be effectively replaced by a ρ interacting with an exchange π , ρ , or ω , the production strength for producing gluonic hybrids could be considerable. Furthermore, Szczepaniak and Swat concluded that in the case of photoproduction, the π_1 exotic and the well known a_2 should be produced on an equal footing, whereas in pion production the exotic is suppressed by a factor of 10.

One of Jefferson Lab most important missions is the study of QCD at intermediate energies. Meson spectroscopy is one of the leading ways to study QCD at the confinement scale. Exotics, Hybrids, and Strangeonia are poorly known, and they represent the next frontier in hadronic physics. The spectroscopy of mesons in the 1 to 2 GeV/c^2 mass range will provide insight into these new forms of hadronic matter, and thus aid in the study of QCD at the realm of confinement. Jefferson Lab offers an unique opportunity to undertake the study of meson spectroscopy at intermediate energies. And current studies at CLAS are showing the feasibility of using CLAS as a meson spectrometer for few-body final states. Motivated by these and recent experimental results for gluonic hybrid meson candidates and from recent theoretical Lattice QCD and Flux-tube model calculations, We will search for gluonic hybrid mesons utilizing a high energy photon beam at CLAS. Given the current limited acceptance of CLAS, this experiment will concentrate on important final states but with the focus on channels with a limited number of three to four charged particles in the final state.