PAC14 Few-Body Workshop
Williamsburg Lodge, July 15, 1998

INTRODUCTION

This was the first of what are expected to be a series of workshops focusing on one of the five scientific topics that characterize the Jefferson Lab physics program. One of the motivations for these workshops is to review the existing program in the context of recent scientific developments. This is especially important since part of the program (beginning with PAC4) dates back nearly ten years. Another important motivation is to match the existing program with recent key questions in the subfield in order to assess possible opportunities for future experiments.

The workshop included an overview of the approved few-body program in each Hall presented by the Hall leaders. A summary of key theoretical questions and recent developments was presented by R. Schiavilla, followed by a summary of recent experimental developments both at Jefferson Lab and elsewhere by R. Ent. This was followed by an extensive round table discussion where key scientific questions were formulated and then matched to the approved program to identify possible future experimental opportunities for the Lab.

In order to develop a set of basic questions that define the physics motivation for exploring few-body systems at Jefferson Lab, each workshop participant was asked to formulate a specific issue to be addressed by such research. Following a discussion relating and comparing these issues, several key questions were developed. These questions are presented below followed by the relevant issues that were discussed for each topic.

KEY QUESITONS

1. Can few-body systems be understood in terms of a "*standard model*" for nuclear physics with only nucleon degrees-of-freedom? Key issues include:

   — Is a consistent and "exact" description of ^{2}H, ^{3}H, ^{3}He, ^{4}He possible within a standard model? (i.e. can a single interaction and current operator account for all nuclei?)

   — Precise and complete tests of the "*standard model*" need to be identified and carried out experimentally.

   — A complete "*standard model*" requires correct incorporation of relativistic effects, meson-exchange currents, and isobar currents.

   — Do we understand three-body forces and N-body currents? Can we find explicit experimental signatures for such many-body effects?

   — The basic Coulomb sum rule should be exploited as a test of the nucleon picture.

   — It is important to experimentally explore the small components of the few-body wave functions (e.g. D-state, S'-state, etc) and compare with predictions of the "*standard model*."

   — A reliable "*standard model*" can provide a setting for extracting fundamental quantities from few-body systems, e.g. neutron form factors from measurements with the deuteron and ^{3}He.

2. Are quark/gluon degrees-of-freedom required in understanding selected properties of few-body systems?

   — Is PQCD relevant in understanding the high-momentum transfer behavior few-body form factors?

   — Are the short-range structures in light nuclei manifestations of conventional correlations among nucleons or of the internal quark degrees-of-freedom?

   — To what degree are potential medium modifications of static and dynamic nucleon properties (e.g. mass, radius, form factors, structure functions) the manifestation of nucleon degrees-of-freedom? Is there sensitivity to novel QCD effects?

   — Can the mechanism for high-energy N-nucleon breakup of few-body systems be identified with underlying quark degrees-of-freedom?

   — Can "smoking gun" observables be identified as a direct signature of quark/gluon degrees-of-freedom?

3. Can we derive this "*standard model*" from QCD?

   — Can we determine the origin and structure of the nucleon-nucleon interaction directly from QCD?

   — Are there direct connections between the "*standard model*" and QCD-inspired calculations that use effective field theory and chiral perturbation theory?

EXPERIMENTAL OPPORTUNITIES FOR THE FUTURE

It was generally agreed that the approved few-body program at Jefferson Lab holds considerable promise in exploring many of the aforementioned important issues. However, it was also clear that a number of opportunities exist, beyond the approved program, to directly address some of those issues. Listed below are several possible future experiments that were discussed at the workshop, followed by the key issues that each addresses.

— Threshold deuteron electro-disintegration: Measurements of this reaction at Jefferson Lab could extend the exploration of the role of meson-exchange currents to higher-momentum transfer.

— T_20 for the deuteron to momentum transfers > 7 fm-1: These measurements are necessary in order to determine all of the elastic form factors of the deuteron to high-momentum transfer.

— ^2H, ^3H, $^4He(e,e'p)$ to high-momentum transfer at large E_m and P_m. By probing the high-energy/momentum part of the spectral function these measurements are important for establishing the extent and role of short-range correlations in the "*standard model*."

— Testing the Coulomb sum in $^{3,4}He$: These measurements are sensitive to the nucleon degrees-of-freedom and can provide information on short-range correlations.

— ^3He(gamma,pp)n for E_{gam} > 3 GeV: There are intriguing results from high-energy deuteron photo disintegration. These studies could be extended to the three-body system with measurements of high-energy, three-body breakup of ^3He.

— $^{2}H(e,e'N^*)$: These data can provide information on role of isobar currents in the nucleon-nucleon interaction and on the propagation of N*'s in nuclei.

— Elastic form factors for ^{3}H: There is only one conditionally approved experiment using a tritium target. As this nucleus is one of only four few-body nuclear systems, careful tests of the "*standard model*" would require information on ^{3}H.

— $^{4}He(e,e'd$^polarized): This experiment could provide new information on the structure of tensor correlations.

CONCLUSIONS

This was the first Jefferson Lab PAC workshop to provide a useful overview of the approved program in few-body nuclear physics. A number of key questions for this field were formulated and discussed within the context of the present program. Several opportunities were identified where additional experiments at Jefferson Lab could provide important constraints on our understanding of few-body physics.