EXPERIMENTAL SUMMARY AND OUTLOOK

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A brief experimental overview of the workshop is given, with emphasis on polarized targets from the experimental equipment perspective, and kinematic coverage, precision, and newly investigated channels from the experimental results perspective.

1. Introduction

Considerable progress has been made in the past two years regarding the GDH Sum Rule and its extensions. Recent progress in experimental equipment and techniques, photoproduction, and electroproduction are briefly summarized below, along with an outlook for future developments. References to the relevant talks are indicated as much as possible.

2. Polarized Targets

The common thread to most experiments addressed in this workshop is the need for polarized nucleon targets. Not much progress has been made for polarized proton targets. In the case of solid polarized targets, NH_3 remains a good choice, with typical polarizations of 70% or higher. No significant progress was reported for atomic sources, such as that used at HERMES.

On the other hand, significant progress has been made in achieving higher deuteron polarization. For experiments that aren't too sensitive to nuclear corrections, such as COMPASS, ^{6}LiD has proven to be a good choice, with polarization reaching 50%, and an effective dilution factor greater than 0.4, if ^{6}Li is treated as a polarized deuteron bound with an unpolarized alpha particle. One of the most exciting developments presented at this conference was the achievement of nearly 80% deuteron polarization in butanol doped with a trityl radical in a frozen spin target, in actual experimental running conditions (see talk by Gerhard Reicherz). High polarization using other radicals has also been demonstrated recently in the lab (see talk by Donald Crabb).

Improved polarization for the technically very challenging HD target was reported (see talk by Steve Whisnant). Proton polarization of 70% and deuteron polarization of 17% was seen in the lab, although not yet used for data taking.

There has been steady improvement in the polarization and dilution factor of high pressure ^{3}He gas targets, with average polarizations approaching 50% being acheived in recent experiments at JLab (see talk by Jaideep Singh). Future improvements may come from longer glass cells with thinner walls, improved cell designs, and the use of Potassium instead of Rubidium in the polarization transfer process.

In the future, we can expect slow but steady progress in polarized targets: higher polarization, higher radiation resistance, ability to run at higher beam intensities, and better dilution factors.

3. Photoproduction

The integrand of the GDH Sum Rule is the helicity difference of the total photoproduction cross section as a function of photon energy ν. New data from ELSA have now extended this measurement for a proton target to 3 GeV, showing for the first time convincing evidence that the integrand changes sign (as predicted by Regge models), and also showing evidence of a 4th resonance region near $k = 1.4$ GeV, possibly corresponding to F_{35} and F_{37} resonances (see talk by Klaus Helbing). These data illustrate the power of high statistics measurements with polarized beam and target to learn above elusive high mass resonances. The GDH integral up to 2.9 GeV is found to be 226 ± 5 mub. For the sum rule to be satisfied, the integral above 2.9 GeV must be -21 μb, which is consistent with Regge model fits to electroproduction data, and preliminary data from CLAS up to 5 GeV presented by D. Sobe at the 2002 GDH Workshop. The E159 experiment planned at SLAC to measure the integral from about 4 to 40 GeV (P. Bosted, spokesperson), has unfortunately been put on indefinite hold, so it may be many years before experimental confirmation of the GDH integral for the proton can be firmly established or refuted.

Preliminary data for the deuteron were also shown. The GDH integrand has been measured up to 800 MeV at MAMI (see talk by O. Jahn), and up to 1.8 GeV at ELSA. Of particular interest is the isovector GDH Sum Rule (proton minus neutron), which can be formed by combining the proton and deuteron data. Indications at present are for a very close cancellation of the proton and neutron in the resonance region, with a large portion of the integral required to come from the high energy Regge region if the Sum Rule is to be satisfied. This could be measured up to 11 GeV when the planned JLab upgrade is completed.

The power of exclusive reactions to improve the determination of resonance multipole strengths was nicely illustrated by the recent exclusive double polarization measurements on protons at MAMI (see talk by P. Pedroni). Reactions studied included π^-, π^0, π^+, η, and several combinations of two-pion final states. The later have been found to dominate the helicity difference cross section. Improved fits using both MAID and SAID unitary isobar models yielded modest improvements in the $\Delta(1232)$ parameters, but surprisingly large changes to the D_{13} resonance. When the full statistics of this impressive experiment are analyzed, even better determinations will be made. Measurements at higher energies are planned at JLab (see talk by C. Keith) and LEPS (talk by Y. Ohashi).

4. Electroproduction

The largest body of new data for inclusive scattering of longitudinally polarized electrons on longitudinally polarized nucleons comes from recent experiments at JLab. The largest experiment, EG1, collected close to 23 billion triggers with beam energies of 1.7, 2.4, 4.2, and 5.7 GeV, on both NH3 and ND3 targets, using the CLAS detector in Hall B. Preliminary results from the 1.7 GeV and 5.7 GeV data were shown in several presentations: the talk by Y. Prok focused on the proton results; G. Dodge focused g1 and its moments; and T. Forest looked at both targets from the point of view of duality. The high statistical accuracy of these data permit the detailed study of the extended GDH Sum Rule from low Q^2 (of order 0.1 GeV^2), where the $\Delta(1232)$ resonance dominates, to relatively high Q^2 (or order 5 GeV^2), where the pQCD in terms of polarized PDF's becomes applicable. The resonance region was also studied with high statistical precision, but a limited Q^2 range centered around 1 GeV^2, in the RSS experiment in Hall C at JLab (see talk by M Jones). In contrast to EG1 which could only measure $A_{\parallel}$, RSS also measured $A_{\perp}$, which (when the analysis is complete) will allow both g_1 and g_2 to be determined without recourse to a model of A_2. In Hall A, new data using a polarized ^3He target have allowed improved studies of both g_1 and g_2 for the neutron in the resonance region (see talks of S. Choi and X. Zheng). Combining the proton and neutron data together has allowed for greatly improved studies of the Bjorken Sum Rule at low Q^2 (see talk by A. Deur).

Considerable improvement has also been made in the study of the individual channels that go into the sum rules. The EG1 experiment has allowed much more precise measurements of double-spin and target single spin asymmetries in exclusive pion, eta, and ρ electroproduction (see talk by A. Biselli). First data on the target-polarized DVCS process from CLAS show promise for understanding GPDs (see talk by Shifeng Chen). A large body of two-pion data was recorded, but has not yet been analyzed.

New data on semi-inclusive electroproduction show promise for a better understanding of the flavor decomposition of the polarized quark distributions, understanding the roles of the Collins and Sivers mechanisms, and eventually accessing the contribution of orbital angular momentum to the spin sum rule (see talks by N. Makins and Jiansen Lu for results from HERMES, and by Harut Avakian for CLAS).

5. Outlook

From the experimental point of view, this 3rd GDH Workshop was perhaps the most impressive in terms of the sheer volume of new, precise data coming in. Much of the data is in a preliminary form of analysis, and a substantial fraction amount of raw data on tape remains to be analyzed. These data will help to fill in the moderate energy and Q^2 region for both the real and extended GDH Sum rules. Planned experiments will fill in gaps in low energy data photoproduction data (for example on the deuteron). Other planned experiments will study the very low Q^2 in electroproduction, where chiral perturbation theory predictions can be tested. The most obvious thing missing from the future program to fully test the GDH sum rule are measurements at high photon energy (above 3 GeV). Measurements could be extended to 5 GeV at JLab in the near future, and up to 11 GeV after the upgrade project. Ideally, measurements should be made at even higher energies (for example to cross charm threshold). While measurements with virtual photons extend up to 40 GeV and beyond for $Q^2 > 1$ GeV^2, there is also a need for high energy measurements at low Q^2.

The future is very bright for future measurements of exclusive and semi-inclusive channels. A major photoproduction program focusing on the resonance region is planned in CLAS with a frozen spin target, in particular. Experiments at Bonn, Mainz, Graal, Spin-8, LEGS, LEPS, DESY, CERN, and other facilities will also continue to make significant contributions. The JLab upgrade to 12 GeV will allow a rich expansion of the high precision frontier in the world spin program.