Measurement of the Parity-Violating Gamma Asymmetry in the Capture of Polarized Cold Neutrons by Para-Hydrogen

*S.J. Freedman, B.K. Fujikawa, and the NPDG Collaboration***

The weak interaction between nucleons is mediated through the exchange of $W^{\pm}$ and Z^0 bosons between quarks. The range of the weak force is short when compared to the nucleon-nucleon separation in the nucleus and the weak nucleon-nucleon interaction may be represented by a meson exchange potential. In particular, the parity violating nucleon-nucleon observables can be described in terms of the weak meson-nucleon-nucleon coupling constants: H_π^1, H_ρ^0, H_ρ^1, H_ρ^2, $H_\rho'^1$, H_ω^0, and H_ω^1, which corresponds to the exchange of π, ρ, and ω mesons†. An important parity violating observable is the gamma ray asymmetry, A_γ, with respect to the neutron spin in capture of cold polarized neutrons on para-hydrogen: $\vec{n} + p \rightarrow d + \gamma$. The asymmetry, A_γ, is directly related to the weak meson-nucleon-nucleon couplings by:

$$A_\gamma = -0.045 H_\pi^1 + 0.001 H_\rho^1 - 0.001 H_\omega^1 - 0.002 H_\rho'^1$$

where the coefficients are well-known. Note that the asymmetry is dominated by H_π^1 and a measurement of A_γ is essentially a measurement of H_π^1. Best theoretical values for the weak meson-nucleon-nucleon coupling constants predict that the value for the asymmetry is approximately of the order: $A_\gamma \sim 5 \times 10^{-8}$‡. Previous measurements of H_π^1 in ^{18}F and other systems have resulted in very different values†§ and a possible source of this discrepancy is the uncertainty in the nuclear corrections. A precise detemination of H_π^1 from the asymmetry A_γ will resolve this issue.

The goal of the NPDG experiment* is to measure the asymmetry, A_γ, to better than 0.5×10^{-8}. Systematic errors must be kept well below the 10^{-9} level and more than 4×10^{16} neutron captures must be observed in order to achieve this goal. This experiment is being planned for the Los Alamos Neutron Scattering Center (LANSCE). Neutrons from the LANSCE spallation target are thermalized with a liquid hydrogen moderator and guided to the experimental apparatus which is shown in Fig. 1. The experimental apparatus consists of a ^3He neutron spin filter, a RF neutron spin flipper, a liquid hydrogen target (catalyzed by paramagnetic material), and a CsI detector array is used to detect the 2.2 MeV gamma ray from neutron capture.

This experiment was favorably reviewed by the LANSCE program advisory committee in October, 1997. A proposal to the US Department of Energy will be submitted in March, 1998. An engineering run to test the CsI detectors, the RF spin flippers, and the data acquisition is planned for the July-November 1998 LANSCE cycle.

Footnotes and References

*The NPDG collaboration institutions are: Los Alamos National Laboratory, Petersburg Nuclear Physics Institute, Indiana University, University of Michigan, University of California and the Lawrence Berkeley National Laboratory, National Institute of Standards and Technology, University of New Hampshire, Kyoto University, KEK National Laboratory, and the Joint Institute for Nuclear Research.

†E. Adelberger, *et al*., Ann. Rev. Nucl. Part. Sci., **35**, 501 (1985).

‡B. Despanques, *et al*., Ann. Phys. **124**, 449 (1980).

§C. Wood, *et al*., Science **275**, 1759 (1997).

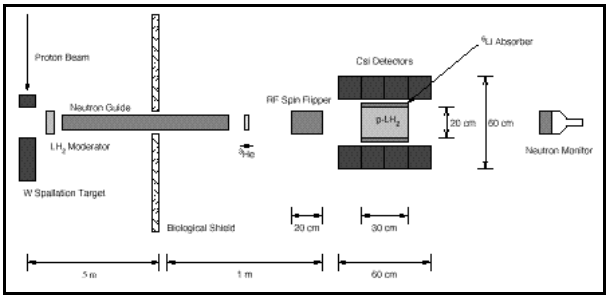

Fig. 1. Conceptual design of the proposed NPDG experiment.