Fundamental Physics with Cold Neutrons

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NPDGamma experiment

Construction of most of the infrastructure for the testing and installation of the liquid hydrogen target for the NPDGamma experiment was completed in September 2005. This included a ~50 meter vent tube in the LANSCE experimental hall and a shorter vent stack in an external building where the liquid hydrogen target will first be tested. The cryogenic operation of the target was tested in October 2005 using liquid neon. Preparations are underway for a liquid hydrogen safety review to be held in November 2005 at Los Alamos.

In parallel the NPDGamma apparatus is being used to search for parity violating gamma asymmetries in a series of nuclei in the A~50 region. The scientific motivation is to test the statistical theory of parity violation in a mass regime that is well-separated from the previous measurements of the TRIPLE collaboration on epithermal resonances in heavy nuclei in mass regions of A~100 and A~240. We have developed a theory which predicts the expected root mean square of the parity violating gamma asymmetry upon polarized neutron capture for the energy-weighted gamma cascade that is measured in our current-mode gamma detector array. The preliminary results for the parity-odd gamma asymmetries, along with the theoretical predictions for the expected root mean square parity-violating asymmetry using the weak matrix elements measured by TRIPLE (which varies for different nuclei due to different level densities), are as follows:

nucleus	Theory RMS PV asymmetry	Experiment RMS PV asymmetry	Error on RMS PV asymmetry
^{45}Sc	1.6×10^{-7}	-7×10^{-7}	3×10^{-7}
^{48}Ti	2.3×10^{-7}	$+7 \times 10^{-7}$	4×10^{-7}
^{55}Mn	1.3×10^{-7}	$+5 \times 10^{-7}$	8×10^{-7}
^{59}Co	1.6×10^{-7}	$+6 \times 10^{-7}$	3×10^{-7}
^{51}V	1.3×10^{-7}	Under analysis	

At this point we can say only that the data is not inconsistent with theoretical expectations. We plan to continue these measurements until the liquid hydrogen target is ready for installation.

NPDGamma also performed a detailed characterization of the polarized neutron beam, including the properties of the polarized 3he neutron polarizer, the RF neutron spin flipper, and a polarized 3He neutron polarization analyzer. This work is being written for publication. We are also writing up the results of parity violation measurements in Al, In, and Cu.

M. Snow and H. Nann manned several shifts over the summer at LANSCE devoted mainly to the parity violation measurements. IUCF graduate student Jiawei Mei moved to Los Alamos in

June 2005 to participate in the parity violation measurements and in the hydrogen target testing and installation.

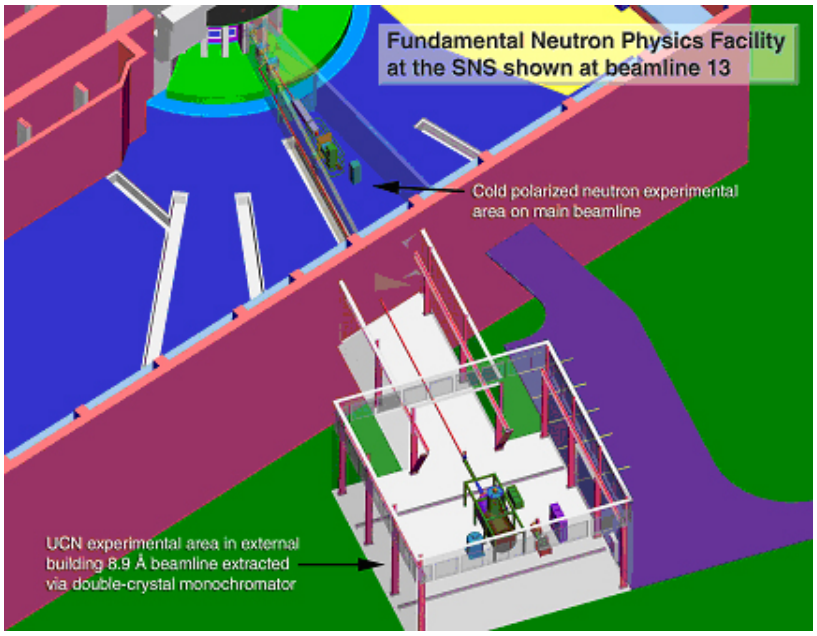
n-^{4}He spin rotation experiment

We are preparing an apparatus to search for the parity-odd rotation of a transversely-polarized neutron passing through a meter of liquid helium. A number of parts of the apparatus: the neutron spin flipper, the float-glass neutron guides, the ion chamber neutron detector, the neutron polarization analyzer mount, the liquid helium target chamber, and the data acquisition system were constructed over the summer of 2005. The cryogenic target is now being tested. The plan is to move the apparatus to NIST in early 2006 for an approximately year-long run.

The goal of the experiment is to reach a sensitivity of 3 x 10^{-7} rad/m with a systematic error below 1 x 10^{-7} rad/m. This sensitivity will be sufficient to place interesting constraints on the weak NN interaction. The experiment will form the Ph.D. thesis projects for graduate students Chris Bass and Da Luo and has also involved first-year graduate students Tiffany Findley and Jonathan Horton. Postdoc Anna Micherdzinska also works on the experiment.

Preparations for SNS experiments

After a NSAC review of the fundamental neutron physics field, the DOE approved the start of a project to construct a nuclear/particle physics beamline at the Spallation Neutron Source at Oak Ridge. We have participated in the simulations for the design of this beamline and in the development of the scientific program for the facility. The construction of the cold neutron beamline is approximately one year ahead of schedule and the first neutron beam is anticipated in 2007.



The fundamental neutron physics beamline at the Spallation Neutron Source held its first call for letters of intent. Letters were submitted for the NPDGamma experiment, a follow-on experiment to search for parity violation in polarized neutron capture on deuterium (NDTGamma) and for a future run of the n-^{4}He neutron spin rotation experiment. All three letters of intent were approved by the committee, which means that it is the intention of SNS to welcome the experiment at some time in the future.

One of the processes which limit the accuracy with which parity violation measurements with cold neutrons can be performed is neutron depolarization. Last March 2005 PSI approved a proposal by M. Snow to measure the depolarization of cold neutrons in liquid deuterium. This experiment is scheduled for Nov. 3-9, 2005 at the FUNSPIN beamline at PSI. If the cold neutrons polarization survives in a sufficiently thick target of liquid deuterium then it may be possible to conduct a future parity violation experiment in liquid deuterium at SNS. M. Snow has collaborated with theorist J. Dawson of New Hampshire to develop a model for the polarization dependence of the double differential cross section of cold neutrons in liquid hydrogen and deuterium which will be tested by this measurement.

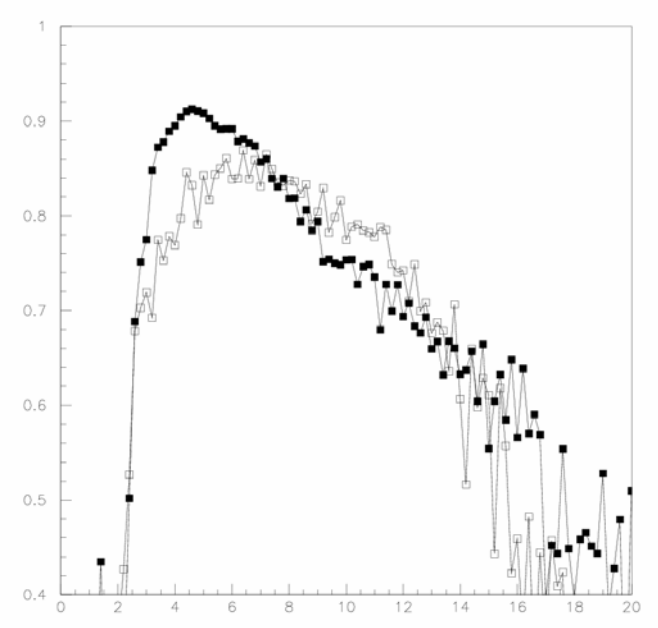


Figure 1. Transmitted neutron polarization versus wavelength for an 4-cm cell that is empty (solid dots) or filled with 98% orthodeuterium at 20 K.

For such an experiment to be possible it is essential that cold neutorns do not depolarize significantly under transmission through the target. Figure 1 shows the transmitted neutron polarization on the vertical axis and the neutron wavelength on the horizontal axis for two cases: (1) an empty cell (solid dots), (2) a 4 cm thick cell full of liquid orthodeuterium (98% ortho) at 20K. The neutron depolarization is small enough that a future spin rotation experiment in orthodeuterium is possible. This work was done at the FUNSPIN beamline at the SINQ neutron source at PSI by an Indiana/DePauw/PSI/Jagiellonian collaboration

aCORN neutron decay experiment

In the first part of 2005 the aCORN collaboration completed the preliminary design report for the spectrometer it will build to measure the "little a" asymmetry in neutron beta decay. An executive committee was appointed and a project management plan was established. The formal construction phase of the project started on Oct 15, 2005 with the expectation that the completed components of the spectrometer will be delivered to IUCF in the early summer of 2006 where it will be assembled and tested at the LENS facility.