Nuclear Physics with Polarized γ rays Between 2 and 160 MeV

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The *High Intensity γ-ray Source* (HIγS) utilizes intra-cavity back-scattering of UV-FEL light in order to produce a γ-flux enhancement of approximately 10^3 over existing sources. At present, gamma-ray beams with energies ranging from 2-to-100 MeV are available with total intensities in excess of 10^8 γ/s, energy spreads of 3% or better, and 100% linear or circular polarization. The beam energy will be extended to 160 MeV by 2012. TUNL researchers, in collaboration with outside theoretical and experimental colleagues, have developed a broad-based research program in nuclear physics which is designed to exploit the unique flux, energy resolution and polarization of the HIγS beams.[1] The program includes low-energy studies of nuclear reactions of importance in nuclear astrophysics as well as studies of nuclear structure using the technique of nuclear resonance fluorescence. In this talk I will begin by giving an example of a recent study of photodisintegration of the deuteron which illustrates how new physics can be accessed with beams of the quality of HIγS beams. The precision data made it possible to determine the splittings of the three E1 p-wave amplitudes for the first time. The results are in agreement with theory when relativistic spin-orbit currents are included. Double polarization experiments under development include a study of the Gerasimov-Drell-Hearn Sum Rule for the deuteron and ^{3}He and an extensive Compton scattering program designed to probe the internal structure of the proton and the neutron. A commissioning experiment took advantage of the 100% linearly polarized beam in order to determine a unique signature of the Isovector Giant Quadrupole Resonance (IVGQR) of ^{209}Bi. A study of the *spin polarizabilities* of the nucleons is being developed and will be discussed. Studies at pion-threshold designed to provide accurate tests of the predictions of Chiral Perturbation Theory and to search for isospin breaking effects due to the up-down quark mass difference will also be described.[2] Finally, studies of photofission at beam energies below the (γ,n) threshold are being investigated as a means of identifying special nuclear materials. Preliminary data on the yields of neutrons parallel and perpendicular to the plane of polarization indicate a substantial difference between enriched and depleted Uranium.

1. *Research opportunities at the upgraded HIγS facility*, Progress in Particle and Nuclear Physics 62 (2009) 257-303.
2. *Chiral Dynamics in Photopion Physics: Theory, Experiment, and Future Studies at the HIγS Facility, Annu. Rev. Nucl. Part. Sci. 2009, 59:115-44.*