Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 832–833

3.15 Radiative Capture of Polarized Neutrons by Protons at Medium Energies.*

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Theoretical studies of the deuteron photo-disintegration or its inverse, the neutron-proton radiative capture reaction, done in the 70's, revealed that the electro-magnetic interaction of nucleons alone could not account for the total reaction yield at all energies. The coupling of photons to virtual pions was found to play an important role in different energy domains: the inclusion of meson exchange currents (MEC) was necessary to explain the thermal neutron capture cross section (1), and at high energies major contributions could be ascribed to isobar configurations (IC), such as intermediate Δ's and N*'s (2). A more recent analysis shows that certain polarization observables, e.g. the neutron analyzing power of the $\vec{n}p \rightarrow d\gamma$ reaction, are relatively insensitive to different nucleon-nucleon potential parameterizations (3). One concludes, therefore, that these quantities may be sensitive to meson exchange and other reaction mechanism effects which only recently have been included in the calculations.

An experimental program is presently in progress at TRIUMF to provide sensitive tests for the various theoretical models now in use. The results of an investigation of the $np \rightarrow d\gamma$ radiative capture processes at 180 and 270 MeV have been published elsewhere (4), and further experiments above the pion threshold are currently underway.

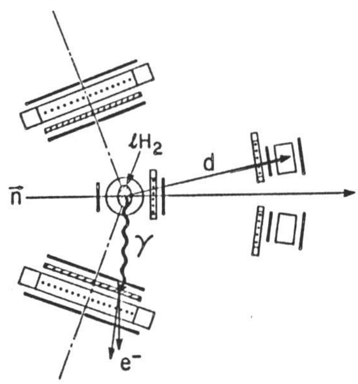

Fig. 1 Schematic layout of the $\vec{n}p \rightarrow d\gamma$ exp. apparatus.

The procedure for the experiments in progress is the following: starting from a polarized proton beam at 350, 425 and 497 MeV, the TRIUMF neutron beam facility with its liquid deuterium production target, provides polarized neutrons at 334, 407 and 479 (±5) MeV (5). The transverse spin transfer coefficient r_t for the $D(\vec{p},\vec{n})pp$ reaction in this energy range is between -.75 and -.85 at 9 degrees (6), so that neutron polarizations of 50% or more can be obtained with a proper setting of the proton spin rotation solenoid and the two neutron spin precession magnets. The active volume inside the cryogenic target flask contains about one litre of liquid hydrogen.

The photons from the $\vec{n}p \rightarrow d\gamma$ reaction are detected in coincidence with the recoil deuterons. Each photon counter consists of a 13 mm thick lead converter mounted 81 cm from the target location, followed by a 40 x 90 cm^2 delay line chamber to measure the position of the emerging electron shower, and a pair of plastic scintillators used as photon triggers. The stack is preceded by another pair of plastic counters in anticoincidence to ensure charged particle suppression. The deuterons are detected in an array of two thin (1.5 mm and 3.0 mm) plastic scintillators, which provide energy loss information and allow a time-of-flight measurement over a distance of one meter. Both counters are preceded by 30 x 30 cm^2 delay line chambers used for charged particle track reconstruction. Finally the deuterons are stopped in a segmented 24 x 24 x 15 cm^3 NaI crystal (preceded by a copper degrader when necessary), and their energy is measured. A plastic veto counter in front of the liquid hydrogen target discriminates against charged particle contaminants in the neutron beam. The set-up is symmetric about the beam axis, and a complete coverage of a 28 to 135 degrees angular interval (lab) for the photon emission is possible with two detector settings. The deuterons of interest are well separated from the appreciable proton background in the particle identification spectrum, and the photons are unambiguously identified by their flight time to the photon detector. Well above the pion threshold, the spectra are dominated by $np \rightarrow d\pi^\circ$ reaction products. Only a complete kinematical reconstruction of all events, making use of deuteron energy vs. deuteron angle and photon angle vs. deuteron angle correlations, can uniquely differentiate between the $d\gamma$ and $d\pi^\circ$ final states. Protons from elastic n-p scattering are measured simultaneously at small angles which will be used for an absolute cross section normalization.

Test runs at 479, 407 and 334 MeV, carried out at first with a polyethylene target and later with the liquid hydrogen target, have already demonstrated the feasibility of the experimental technique and the final production runs with polarized beam are scheduled to begin in June 1985.

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* Work supported in part by a grant from the Natural Sciences and Engineering Research Council of Canada.