REPORT ON EXPERIMENT E349: QUASIFREE RADIATIVE CAPTURE IN THE DEUTERON

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The purpose of Experiment E349 is to investigate that portion of the phase space for the pd $\rightarrow$ pdγ process that is associated with the quasifree radiative capture of the incident proton by the target neutron within the deuteron.[1,2] This region of phase space is characterized by a very low kinetic energy (0–5 MeV) for the residual proton from the target deuteron. One expects many of the observables to be similar to those found in the case of free capture, p + n $\rightarrow$ d + γ. We have measured cross sections and analyzing powers for d($\vec{\text{p}}$,dγ)p at 200 MeV, and will compare them directly to precise results obtained at the same energy for the free process $\vec{\text{p}}$n $\rightarrow$ dγ.[3–8] It should be noted that the differential cross sections[3–6,8] and analyzing powers[4,7] for the free process, to which the quasifree results will be directly compared, are the most precise data in existence today for the free process.

The reaction pd $\rightarrow$ pdγ is one involving a three body–final state, which is kinematically described by nine parameters. However, conservation of energy and momentum provide four constraints. We therefore need to determine only five independent parameters to describe fully the three–body final state. In this experiment we choose to measure the angles of the gamma ray (θ_γ and ϕ_γ) and the deuteron (θ_d and ϕ_d), and the kinetic energy of the deuteron (T_d). We measure these parameters with sufficient precision to allow a determination of the kinetic energy of the residual proton to better than 180 keV, and it's angle to better than 20°.

The experiment is performed in the General Purpose Area of BL5. The beam exits the beam pipe through a thin Kapton foil about 1 m upstream from the target, and enters the beam pipe leading to the Faraday cup through a thin Kapton foil about 2.5 m downstream of the target. Most of the region through which the beam passes is filled with thin-walled helium bags. Solid CD_2 and C foils are used as targets. The recoiling deuterons pass through a helium bag and are detected at small angles (2.5° - 20°) in a large detector stack consisting of special wire chambers and a highly segmented array of plastic scintillators. This determines the deuteron's angles to ±0.5°, and it's energy with 3% resolution (FWHM).[1] This array is mounted on one of the large movable arms of the General Purpose Area. The associated photons are detected in an array of plastic scintillators, converter plate, wire chambers, and lead glass mounted on the other movable arm of the General Purpose Area. This detector assembly permits the determination of the photon angle to ±0.5°, with an efficiency of ~ 25%.[1] Photons are cleanly identified using time-of-flight (TOF).

A 12-shift setup and development run was made July 15-19, 1994 using split beam at 200 MeV. In this time a halo-free and well aligned beam line tune was developed, and equipment, electronics, and data-acquisition software were set up and debugged. In addition, the response of the scintillators were mapped using pp and pd elastic scattering, and an absolute determination of detector angles made using the pd kinematic crossing in p-d elastic scattering at 51.1°. This work constituted the projects of two student participants of the IUCF REU program, E.E. Sigmund and N.R. Claussen.[9]

The 31-shift production run was made Aug. 23 - Sept. 5, 1995. All the goals of the experiment were attained. High statistics data were obtained at laboratory angles of 30°, 45°, 60°, 75°, 105°, and 140° for CD_2 and C targets. Data at 60° were also obtained for Ni and Ta targets. Quasifree d + γ events were clearly observed on-line from the deuterium target. We typically obtain a deuteron background from carbon of ~ 15%, and a randoms background of ~ 5%. One finds a well-defined peak in the energy spectrum of the deuterons that occurs at the energy expected for the free reaction kinematics. Its width is well reproduced by a Monte Carlo simulation of a simple quasifree model.[1] The differential cross sections obtained on-line are the same as the free cross sections, with an estimated systematic uncertainty of ± 30%. This uncertainty is expected to drop to ~ ± 10% for the final analysis. This analysis will yield analyzing powers and cross sections as a function of detailed phase-space coordinates. These results will be used to determine the extent to which a quasifree model can be utilized in p-d collisions. The model will be tested on heavier nuclei using our results from C, Ni, and Ta.

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9. 1994 Summer Undergraduate Research Program In Nuclear Physics at the Indiana University Cyclotron Facility; Project Director: C. Olmer.

A MEASUREMENT OF STIMULATED EMISSION FROM ^{83m}Kr

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A device that produces stimulated gamma ray emission and generates coherent radiation in the keV photon range (a graser) should be possible utilizing recoilless emission in nuclear transitions. Extensive research in the field has produced many experimental approaches but no conclusive results. The graser isotope we are investigating allows the concentration of radioactivity into a specific volume, addressing one of the more pressing issues in graser development. The lasing transition of interest is the 32 keV gamma from ^{83m}Kr, a decay product of ^{83}Rb which has a half life of 86 days (Fig. 1).

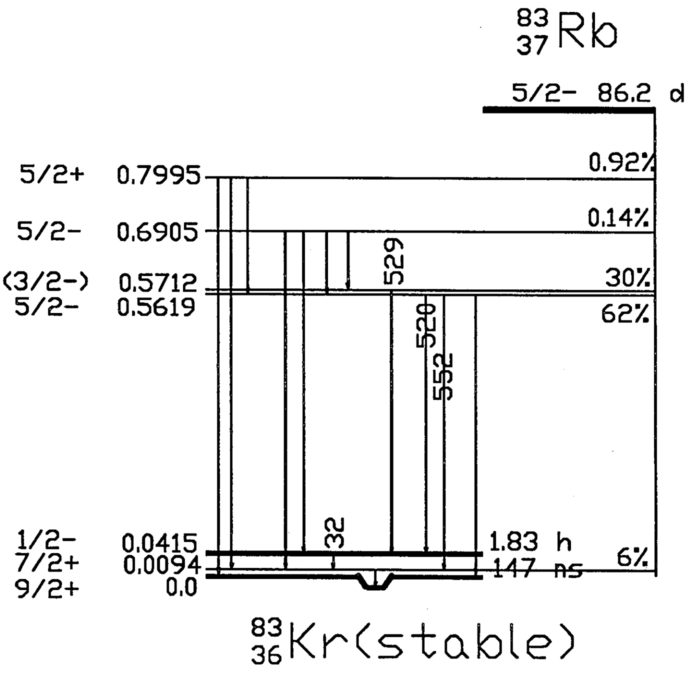

Figure 1. Decay scheme of ^{83}Rb. The transition of interest is the 32-keV gamma from ^{83m}Kr.