STUDY OF NUCLEAR STRUCTURE IN THE $\pi(f_{7/2})$ SHELL USING INTERMEDIATE-ENERGY COULOMB EXCITATION

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Recent experimental studies [1,2] of the low-lying excited states in neutron-rich nuclei have uncovered a general weakness of the N=20 shell gap. Such studies have provided a greater understanding of the interaction between the single particle and collective behavior of nuclei in this region. We performed an experiment (NSCL-98007) to continue the spirit of such studies, but focusing on heavier nuclei, above Z=20 in the „$(f_{7/2})$ shell, near the N=32 subshell. The aim of the experiment was to gain insight into nuclear structure by using intermediate energy Coulomb excitation [3] to measure the first excitation energies and transition matrix elements, B(E2↑), for several nuclei in this mass region. Since these two quantities are well described by microscopic models, the values are a direct measure of the evolution of nuclear shell structure.

Experiment 98007 was performed in April of 1999 at the NSCL. A mixed particle beam of neutron rich nuclei was obtained by accelerating a beam of ^{64}Ni in the K1200 to 60 MeV/A and fragmenting it with a 155 mg/cm^2 Be target. Using a single rigidity setting, the secondary beam was optimized for our desired nuclides and separated in the A1200 Fragment Separator. Fragments with an energy of approximately 42 MeV/A were delivered to the S800 spectrometer to perform the intermediate-energy Coulomb excitation (Coulex).

A gold foil (93 mg/cm^2) at the target position of the S800 induced the Coulomb excitation. A position sensitive NaI(Tl) array [4] detected the de-excitation gamma rays in coincidence with each identified particle. This experiment represented the first use of the S800 as a particle detector for a Coulomb excitation experiment. The thick plastic scintillation detector at the S800 focal plane (E1) provided the start signal for timing and measured total energy, the ion chamber provided ΔE information for particle identification, and the CRDCs provided the particle s vector at the focal plane.

The experiment began with a 60 MeV/A ^{40}Ar beam. This stable nuclide has a well-known first excitation (2^+) energy and B(E2↑) and has been used as a reference for previous, similar work. The on-line results from the test beam verified that our experimental set-up was working. The next part of the experiment saw the study of ^{64}Ni fragments. A single rigidity setting was used during the course of approximately 80 hours of data taking, in which fragments with Z=22—26 and N=30—36 were observed. At the end of the experiment, Coulomb excitation of the ^{64}Ni primary beam was measured to again verify the set-up.

The data analysis followed the usual approach for intermediate-energy Coulomb excitation experiments. The large velocities (~0.3c) of the projectiles necessitated Doppler corrections that were made on an event-by-event basis using the position sensitivity of the NaI detectors. Detector position and energy calibrations were performed with standard radioactive sources. Next, the Doppler correction was added to the analysis code and the ^{40}Ar data served to confirm the calculations. Then, with knowledge of the number of gamma rays counted, detector efficiencies, the number of beam particles counted and the target thickness, a cross section could be determined for certain fragments and, in turn, a value for B(E2↑) could be realized.
A summary of the experimental values of the preliminary cross sections which can be converted into B(E2↑) values from the present analysis of the data is given in Table 1, below. Completion of the data analysis for these and other nuclides observed in the experiment should elicit trends in nuclear structure in the „$(f_{7/2})$ shell.

Nuclide	^{56}Cr	^{62}Fe	^{59}Mn
Transition energy (keV)	1007	876.8	1239
Number of particles observed	2.96×10^7	2.05×10^8	6.79×10^7
Average particles per second	106	734	244
Cross Section (fm^2)	14.9 ± 2.0	23.7 ± 2.2	3.11 ± 0.58

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