DECAY MODES OF THE NUCLEAR CONTINUUM EXCITED IN PROTON-NUCLEUS INTERACTIONS

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Some preliminary results of the in-plane particle-gamma ray coincidence measurements for the 81.5 MeV p + ^{62}Ni interaction were presented in last year's annual report.[1)] Data have since been analyzed more systematically and results have led to the major portion of a Ph.D. thesis.[2)]

Charged particles were detected and identified with a three-element telescope subtending a circular solid angle of about 5 msr at laboratory scattering angles of 25.5°, 34.8°, and 45.5°. Three coplanar Ge(Li) detectors were located at +135°, -75°, and -135° from the incident beam direction to detect the gamma rays resulting from transitions between low-lying excitations of the residual nuclei. A similar experiment was performed this year at IUCF for the 199.8 MeV p + ^{62}Ni interaction using two-element particle telescopes consisting of a 0.25-inch plastic scintillator followed by a 4 in. x 5 in. NaI(Tl) detector. Serious difficulties in determining the particle detection efficiency (by scattering from hydrogen and ^{12}C) as well as large gain drifts in these NaI detectors allow us to make only general observations from the 199.8 MeV proton bombardment.

Because the characteristic gamma-ray transitions are possible only after particle emission has ceased, the p-γ coincidence technique can provide an experimental link between the scattered proton energy and final isotope production. The technique has allowed us to assign a new decay branch from the 3_1^- state of ^{62}Ni at 3.757 MeV excitation. Unidentified structures above 5 MeV excitation in ^{62}Ni are observed to decay through the 2_1^+ state of ^{62}Ni. Our data indicate that a similar study employing a high-resolution magnetic spectrograph may help to identify the structures observed in the proton spectra corresponding to 5-10 MeV excitation of ^{62}Ni.

Last year's preliminary analysis indicated a dearth of gamma rays associated with the decay of the giant-resonance structure centered around 17.5 MeV excitation resulting from 81.5 MeV p + ^{62}Ni. The observation persists through more careful analysis. From systematics of the observed gamma-ray intensities, about 85% of the continuum excitation may be seen at the three angles near the peak excitation of the resonance. Observed gamma-ray strengths scale with the observed singles continuum cross section both in bins across the resonance as well as between the three scattering angles, but not with the total singles (continuum plus resonance) cross sections within these particle gates. Deduced gamma-ray multiplicities from the Ge(Li) detectors are 0.29 (.04) for the giant resonance and about 2.4(.1) for the 45° continuum in the resonance excitation region. We have some evidence that 4.3(1.6)% of the resonance decays through the $1/2^-$, seniority ν=1, 283 keV excitation of ^{61}Ni. Well over 80% of the resonance decay is not accounted for in the gamma-ray transitions we observe. One should contrast this with the result of 150 MeV α + ^{62}Ni α-γ coincidence measurements where the resonance at 16.4 MeV excitation seems to be represented in the coincidence data.

To help clarify the resonance decay anomaly, we have requested beam time to measure singles proton angular distributions and analyzing powers to determine if the 80 MeV proton is strongly populating the giant quadrupole resonance as expected from the literature.[3] Particle-particle coincidence measurements may be necessary to determine if, in fact, the low gamma-ray coincidence yields are due to the resonance excitation.

For general continuum excitation, a comparison of our p-γ coincidence average nucleon removal with that of inclusive gamma-ray measurements yields an estimate of about 24% fusion contribution associated with the 81.5 MeV p + ^{62}Ni reaction. The data indicate that most reactions are associated with the emission of just one fast particle. The data are consistent with the two-step reaction mechanism first proposed by Serber[4] and a possible momentum-transfer dependence in the first step (deduced from the measured fast particle) is indicated by some details of the final isotope production as a function of angle. A momentum-transfer dependence of final-state populations would necessarily imply a localization of the initial interaction. Comparisons with exciton-model and nucleon-cascade evaporation-model calculations are consistent with the first step involving a nucleon-nucleon interaction, but the system very rapidly evolves to configurations involving many nucleons.

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2) J.D. Wiggins Jr., Particle-Gamma Ray Coincidence Studies on ^{62}Ni, Ph.D. Thesis, IUCF Internal Report 81-(1981).

3) D.C. Kocher et al., Phys. Rev. Lett. 31, 1070 (1973); ibid, Phys. Rev. C14, 1392 (1976).

4) R. Serber, Phys. Rev. 72, 1114 (1947).

THE DECAY OF HOT, HIGH-SPIN NUCLEI PRODUCED IN ^{6}Li-INDUCED FUSION

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Several aspects of our systematic investigation of fission and particle emission from "hot", high-spin fusion products in the Pb region have been brought to an encouraging conclusion: we have demonstrated that it is indeed possible to constrain statistical-model analyses of such decay processes sufficiently to test relevant features of the high-spin nuclear structure quantitatively. In order to do so, we have had to significantly expand the scope and improve the techniques of both the experiment and the statistical-model calculations, in comparison with previous work. Details concerning various features of the measurement and computational techniques have been reported previously,[1-3] and a complete description of the entire program, and of the nuclear theory questions addressed, has been presented recently.[4]

During the past year our efforts have been concentrated primarily on improving the statistical-