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DECAY MODES OF ISOSCALAR GIANT RESONANCES THROUGH ($\alpha,\alpha'\gamma$) COINCIDENCE STUDIES

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Using the 150 MeV alpha beam from IUCF the particle decay channels of isoscalar giant resonances in ^{62}Ni are being investigated by observing the discreet gamma transitions of residual nuclei in coincidence with scattered alpha particles. The particles were identified with a solid state silicon telescope at a laboratory angle of 15.8°, and gamma-rays were detected using three Ge(Li) detectors located at 40°, 94°, and 150° with respect to the beam. Isoscalar resonance-like structure at 65 $A^{-1/3}$ MeV is observed in alpha-gamma coincidence spectra and the gamma-producing decays proceed predominantly through one neutron emission.

In the statistical model of decay calculated by the computer code MB II[1] from an initial spin of 2ħ in ^{62}Ni at 16.4 MeV excitation, the particle decay distribution is predicted to be 92% neutron, 7% proton, and 1% alpha evaporation. Reasonable sharp cut-off initial distributions vary these predictions by less than one percent. The evaporation neutrons are distributed as approximately 16% s-wave, 40% p-wave, 34% d-wave, 8% f-wave, and 1% g-wave, and leave the residual ^{61}Ni-nucleus in a broad band with an upper limit around 6.5 MeV excitation and with a wide spin distribution centered around 2-3 ħ. Purely statistical dipole transitions directly to the low-lying states without regard to nuclear structure yields the intensity patterns in spin as indicated in the fourth column of Table I. Also presented is continuum behavior for initial sharp cut-off distributions with maximum spins 3 and 7 ħ (the maximum spin transfer from semi-classical momentum transfer at radius R = 1.2 $A^{-1/3}$). We conclude that it would be difficult to extract the resonance admixture in the observed pattern. Also, angular correlations with the alpha particle are not strong. This may be due to the coupling of the average d-wave neutron and at least one p-wave gamma-ray to this initial orientation.

Figure 1 presents the side feeding strength with excitation in ^{61}Ni for spins 1/2, 3/2, 5/2, and 7/2 populations. Ignoring nuclear structure, the dipole transitions from 4 MeV excitation would go as $(4-E)^3$

Table I. Percentage sidefeeding strength in ^{61}Ni from decay of 11.2 to 23.8 MeV excitation of ^{62}Ni

	MBII CALCULATION			
Spin in ^{61}Ni	Sharp cut-off approx. J_{max}=7	J_{max}=3	Initial J=2	Measurement
1/2	1.5	5	7	12 (1)
3/2	5	17	22	21 (3)
5/2	9	25	31	26 (1)
7/2	14	23	25	24 (2)
9/2 & higher	71	21	16	17 (2)

Errors include only statistics and do not reflect the errors introduced from estimations of ground state, first excited state, or 9/2 and higher strengths from systematics of the data.

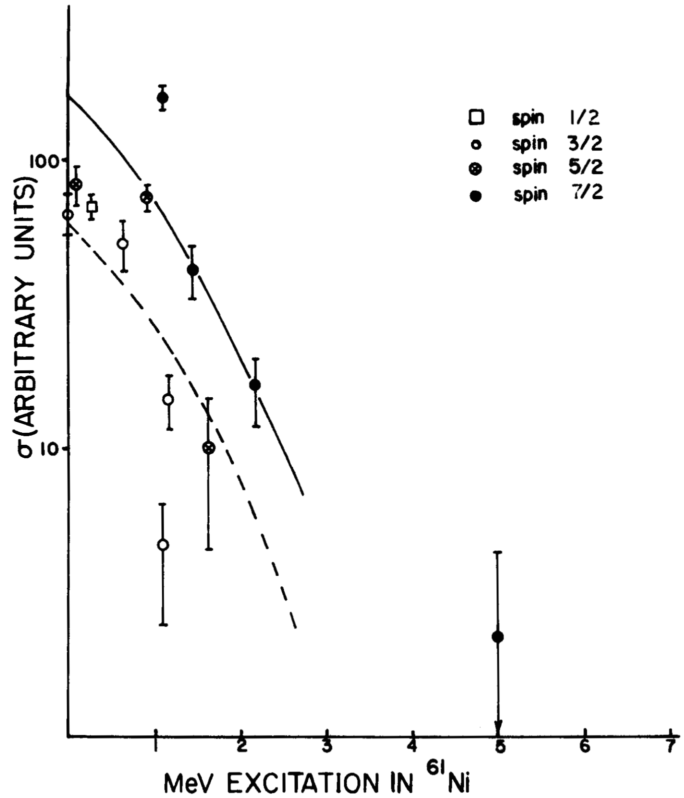

Figure 1. Sidefeeding strength of low lying ^{61}Ni states. Both lines indicate a $(4\text{-}E)^3$ energy dependence.

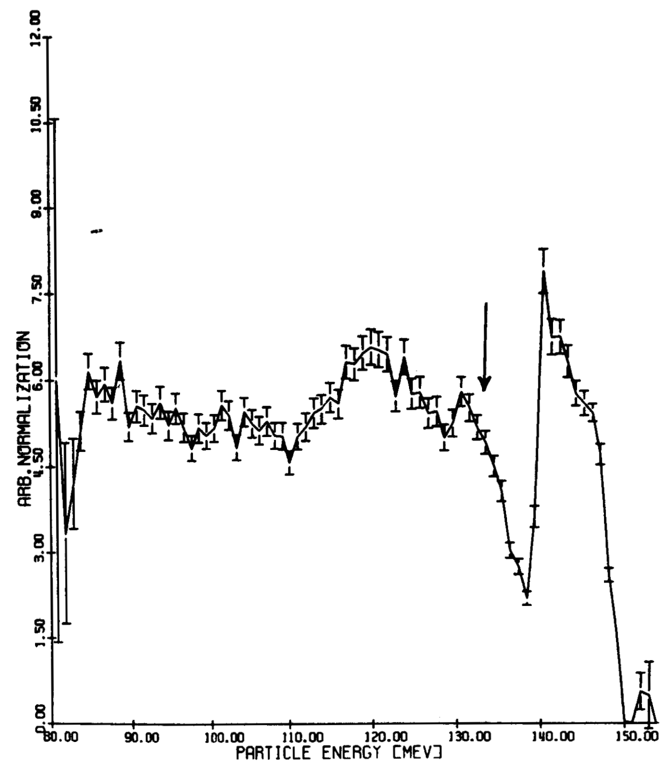

Figure 2. Gamma-ray multiplicity ratios (arbitrary normalization) with energy of alpha particles at 15.8° for coincidences in any of the three Ge(Li) gamma-ray detectors. The arrow indicates the position of the giant resonance around 16.5 MeV excitation.

for each spin and the relative normalizations of spins would reflect the initial populations and number of m-states available to each transition. It should be noted that the sparce data are not too inconsistent with this trend. The 9/2 and higher value in Table I was extracted from the observed 7/2 strength by fitting this dipole energy dependence to the second and third 7/2-states. This is tantamount to the assumption that the first 7/2-state at 1015 keV excitation is an yrast state through which all higher spin strength is funneled.

In Fig. 2 is a spectrum of the ratio of true coincidences to randoms for the three gamma detectors (summed). This quantity would be proportional to the gamma-ray multiplicity as a function of inelasticity of the reaction. The dip near 12 MeV excitation (E=138 MeV) can be understood from $(\alpha,\alpha' n)$ reactions leading to the ground state and first few excited states in ^{61}Ni. Since other decay channels are not yet important at this excitation, the effect dominates and lowers the measured multiplicity in this region. The absence of a pronounced dip at the two or three neutron thresholds could be understood from other decay modes "washing out" the effect.

In tracking across the resonance region in 3 MeV bins the pattern of gamma-ray strength is roughly constant except at the lowest excitations where direct population (from neutron evaporation) is important. The observations are consistent with two conclusions: 1) resonance and continuum decay similarly or 2) resonance decay has few gamma-rays of appreciable efficiency and therefore is not strongly represented in the coincidence spectra. The latter may occur from decays directly to ground states or to first excited states in odd-even nuclei below the experimental threshold. The resonance is measured to comprise about 29% of the singles strength in this region and, because the resonance region multiplicity is tending smoothly up from the dip to near the continuum value (at higher excitations) of around 5 units, it is tempting to conclude that the first possibility is more likely and that the isoscalar resonance does seem to decay in a manner similar to the continuum beneath it. Additional evidence is provided in that the shape of the 100-150 MeV multiplicity region is observed to overlap almost exactly with the ^{3}He spectrum displaced by about 22 MeV (the Q-value plus kinematic correction is 21.5 MeV).

It is interesting to note the gamma-ray enhancement around 119 ± 8 MeV corresponds predominately to ^{60}Ni gamma radiation. The same ratio for ^{3}He particles is presented in Fig. 3 and the enhancement around 120 MeV contains mostly ^{62}Ni gamma rays. The position is consistent with the $^{62}Ni(\alpha,{}^3He)^{63}Ni^* \to \tilde{n} + {}^{62}Ni^*$ reaction process. The detailed mechanisms of these phenomena and the remarkable similarity of the alpha and ^{3}He multiplicity spectra are still being investigated.

1) M. Beckerman and M. Blann, Univ. of Rochester Report UR-NSRL-135A (1977-unpublished).

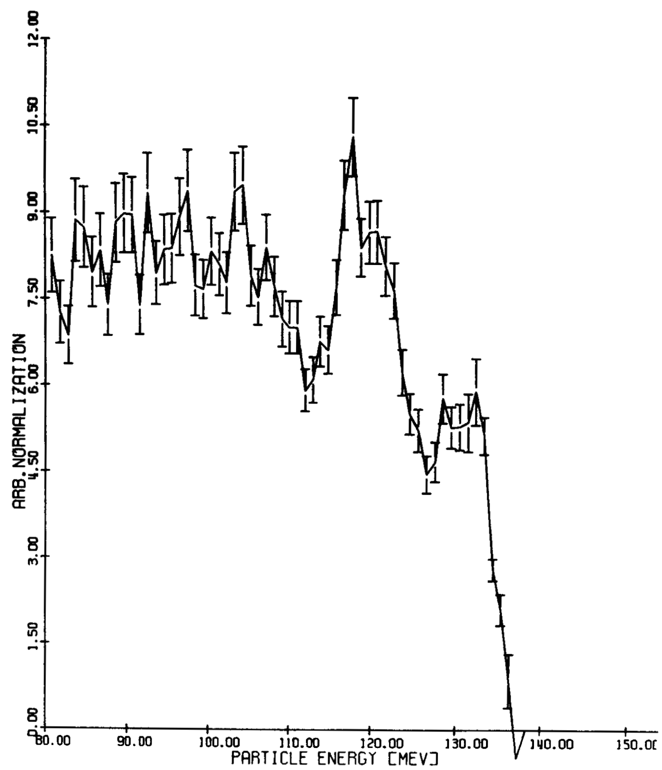

Figure 3. Gamma-ray multiplicity ratios (arbitrary normalization) with energy of ^{3}He particles at 15.8° for coincidences in any of the three Ge(Li) gamma-ray detectors.