CONF-720309--1

SYSTEMATICS OF L = 0 TRANSITIONS OBSERVED IN THE

(p,t) REACTION ON NUCLEI NEAR N = 50⁺

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1. INTRODUCTION

It has been shown that ⁸⁸Sr can be regarded as a reasonably inert core for the low-lying levels of nuclei in the mass 90 region. The ground states of the heavier N = 50 isotopes will in such a model contain protons distributed in the 2p_{1/2} and 8g_{7/2} orbitals and be of the form

$$a(\pi p_{1/2})^2_0(\pi 8g_{7/2})^{n-2}_0 + b(\pi 8g_{7/2})^n_0.$$

The orthogonal configuration will result in a low-lying 0⁺ excited state. If the linear combination is unchanged as neutrons are added to the N = 50 core, such 0⁺ states cannot be populated by the (p,t) reaction. However, if configuration changes occur due to the added neutrons, population of the 0⁺ states through the (p,t) reaction supplies a sensitive probe to determine the extent of these changes.

Another class of 0⁺ states in nuclei at and above closed shells are the so-called pairing vibrations. They are states consisting of pairs of particles excited from the core into the valence shell. They occur at

*Research sponsored by the U. S. Atomic Energy Commission under contract with Union Carbide Corporation.

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higher energies and are generally of considerable strength. They are excited in the (p,t) reaction by removal of a neutron pair from the closed core.

In this paper we show results from some of our recent (p,t) studies on nuclei near $N = 50$. For this report, we will discuss only the $L = 0$ transitions observed in reactions leading to or from nuclei with $N = 50$.

2. EXPERIMENTAL METHOD

Energy spectra were taken at 5° intervals over an angular range from 5 to 45 degrees. The tritons were detected with nuclear emulsions in the ORIC broad-range spectrograph facility. Incident proton energies used were varied from 31 to 40 MeV depending upon the specific experimental requirements and overall experimental resolution was about 20 keV.

3. RESULTS AND DISCUSSION

The $L = 0$ transitions observed in the $^{90}\text{Zr}(p,t)$ and $^{92}\text{Zr}(p,t)$ reactions are summarized in Fig. 1. The intensities indicated for each transition are obtained by matching the angular distributions at the first maximum. These numbers thus reflect only the relative cross sections measured and are uncorrected for effects of reaction dynamics and configuration changes. Only the ground state transition is shown for the $^{90}\text{Zr}(p,t)$ reaction since this represents the bulk of the $L = 0$ transition strength for pickup from the $N = 50$ core.

The level at 1.76 MeV in ^{90}Zr is generally attributed to the proton excitation discussed in the Introduction. This type of state has been observed with the (p,t) reaction on all of the zirconium isotopes and the observed strengths shown to be consistent with such an interpretation.¹

The transition strength to the three higher levels is attributed to removal of neutron pairs from the $N = 50$ core. These levels thus represent

the "pairing-vibration" strength observed in this nucleus. There are several interesting points to note about these levels: 1) The total intensity sums to only about 2/3 of that for the $^{90}\text{Zr}(p,t)$ ground state transition. 2) Although the most intense level is found at the same reaction Q-value as the $^{90}\text{Zr}(p,t)$ ground state transition, the center-of-gravity of the transition strength is of less negative Q-value with appreciable intensity to the 4.13 MeV level. 3) There is a distinct separation between the low-lying "valence" 0^+ levels and the levels carrying the pairing-vibration strength.

These zirconium data are from some of our earliest work in this region and the principal result was to show that, for these nuclei, major deviations are found from the predictions of the simple harmonic form of the pairing-vibration model.² Recently, Sørensen has shown that by including the effects of particle-hole correlations the observed energy shifts, loss of intensity, and fractionation of pairing strength in ^{90}Zr can be well accounted for within the framework of the pairing-vibrational model.³

We have extended the (p,t) studies to include Mo and Ru isotopes. The $L = 0$ transitions observed in the $^{92}\text{Mo}(p,t)$ and $^{94}\text{Mo}(p,t)$ reactions are summarized in Fig. 2. Part of the motivation for this work was to locate the level corresponding to the excited 0^+ expected from the proton configuration. The level observed at 2.52 MeV is our candidate for such a description since it agrees well with the excitation energy predicted by simple shell-model calculations for the $N = 50$ nuclei.

The pattern of the pairing vibration strength in ^{92}Mo is changed significantly from ^{90}Zr . Although there is a 0^+ level observed near the energy expected for the pairing vibration (in the harmonic form of the model), it carries almost none of the expected strength. Instead, the major

transition intensity is observed to a level over 1 MeV less bound. In addition, the observed 0^+ levels are rather evenly spaced with the orthogonal proton state being somewhat closer to the pairing vibration than to the ground state. The pattern observed here closely resembles that observed previously for the neodymium isotopes at $N = 82$.⁴

The $L = 0$ transitions observed in the $^{96}\text{Ru}(p,t)$ reaction are shown in Fig. 3. In this case the (p,t) reaction on $N = 50$ cannot be studied since ^{94}Ru is not stable. Of the levels observed in ^{94}Ru , the best candidate for the excited proton 0^+ appears to be the level at 2.99 MeV.

Since the mass of ^{92}Ru is unknown, we cannot determine the energy shift of the pairing vibration strength. We do observe, however, that the excited 0^+ levels have now become rather tightly grouped.

The intensities shown in the figures have been normalized in each case to the respective $N = 52$ to 50 ground state transitions since the zirconium data was not originally obtained at 31 MeV. These reactions have been restudied at 31 MeV to allow a clearer intercomparison between the three series. These results are not yet complete, but it seems clear that we observe a definite trend of decreasing strength from removal of neutron pairs from the $N = 50$ core as the Z of the isotopes is increased. A final analysis made by extracting enhancement factors from comparison with DWBA calculations is in progress.

REFERENCES

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FIGURE CAPTIONS

Fig. 1. Relative intensities for 0^+ states populated by (p,t) reactions on $^{90,92}\text{Zr}$ targets. The data shown is for an incident proton energy of 38 MeV.

Fig. 2. Relative intensities for 0^+ states populated by (p,t) reactions on $^{92,94}\text{Mo}$ targets. The data shown is for an incident proton energy of 31 MeV.

Fig. 3. Relative intensities for 0^+ states populated by the (p,t) reaction on ^{96}Ru . The data shown is for an incident proton energy of 31 MeV.

Zr(p,±)

Mo (p.t.)

Ru(p,t)