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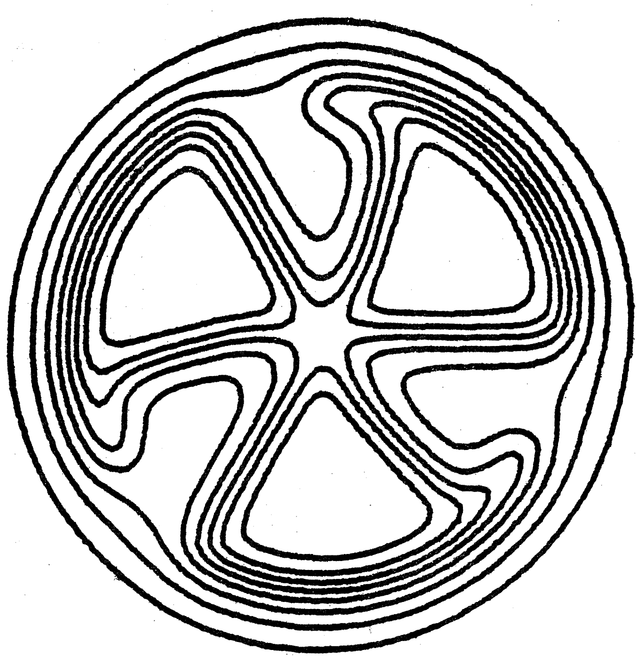

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Splitting of the Lowest T=2 State in ^{44}Ti, ^{48}Cr and ^{52}Fe*

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ABSTRACT

High resolution study of the ^{46}Ti, ^{50}Cr, ^{54}Fe(p,t)^{44}Ti, ^{48}Cr, ^{52}Fe reactions, provides evidence for the splitting of the lowest double analog state in ^{44}Ti and ^{48}Cr. The splitting is 20±2 keV in ^{44}Ti and 10±2 keV in ^{48}Cr. We could not identify splitting of the T=2 state in ^{52}Fe. But together with the previously observed splitting in ^{56}Ni the present results suggest that this is a common occurrence for self conjugate nuclei in the $f_{7/2}$ shell.

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The lowest excited double analog states[1] in light and medium weight nuclei were observed as final states in the isospin allowed direct processes such as (^{3}He,n) and (p,t) reactions,[1,2] and as compound nucleus resonances in isospin forbidden reactions initiated by protons and alphas.[3,4] These states were also found to decay by isospin forbidden proton and alpha emission,[5] and hence their properties are especially interesting from the point of view of isospin mixing.[6] In a recent study of the ^{58}Ni(p,t)^{56}Ni reaction[7] a triplet of $J^{\pi}=0^+$ states was observed in the excitation energy region where the lowest T=2 state is expected to lie indicating isospin mixing of the double analog states with close lying 0^+ states of lower isospin. In order to examine if this is a general property of the T=2 states in self conjugate nuclei in the $1f_{7/2}$ shell we searched for similar splittings in ^{44}Ti, ^{48}Cr and ^{52}Fe.

The T=2 states were populated via the ^{46}Ti(p,t)^{44}Ti, ^{50}Cr(p,t)^{48}Cr and ^{54}Fe(p,t)^{52}Fe reactions using a 46 MeV proton beam from the Michigan state University Cyclotron. The ^{46}Ti and ^{54}Fe targets were enriched self-supporting foils of 269 μg/cm^2 and 241 μg/cm^2 thickness, respectively. The ^{50}Cr target was 120 μg/cm^2 thick on a 25 μg/cm^2 carbon foil backing. The tritons were analyzed with an Enge split-pole magnetic spectrograph and were detected with a position sensitive Si-detector (1 cm long) and a single wire proportional counter (35 cm long). The Si-detector was used to extract precise excitation energies for levels the vicinity of the T=2 states. The overall resolution was 8 to 10 keV, FWHM. The proportional counter spectra were limited to a resolution of 35 keV, FWHM, and were useful to identify the T=2 states.

Typical spectra as recorded with the Si detector are shown in Fig. 1. The excitation energies obtained in the present work are used to label the peaks corresponding to the T=2 and nearby states. Fig. 2 shows the angular distributions for the ^{44}Ti and ^{48}Cr levels of Fig. 1. Also shown in Fig. 2 are the angular distributions for the T=2 state and the known 0^+ level in ^{52}Fe at 6.84 MeV, as obtained from the wire proportional counter. We were able to make a new assignment of 0^+ to a level at 9.31 MeV in ^{44}Ti and to a level at 8.75 MeV in ^{48}Cr. These assignments were made possible by the very unique shape of the differential cross-section for an L=0 transfer. The unambiguous nature of the new assignments can be seen from Fig. 2. The intensity of the transitions to the 0^+ states found in ^{44}Ti is $\sigma_{9.33}/\sigma_{9.31}$= 4.0±0.4 while that in ^{48}Cr is $\sigma_{8.76}/\sigma_{8.75}$ = 1.1±0.1.

In a previous study of the $^{46}Ti(p,t)^{44}Ti$ reaction, Rapapport, et al.[8] by using nuclear emulsion plates, could obtain an overall resolution comparable to that of our experiment. However, the large deuteron peaks made difficult the identification of weak states in ^{44}Ti above 7.7 MeV. The 0^+, T=2 state in ^{48}Cr was reported by Dorenbusch, et al.[9] These authors identified a doublet at 8.75 MeV, the full angular distribution of which could not be obtained because of competing deuteron groups.

The double analog state in ^{52}Fe was reported by Viano, et al.[10] However, there are at least 2 levels at 8.534 MeV and 9.496 MeV which were not resolved previously from the T=2 state.

We made a tentative $(2^+,4^+)$ assignment for both of them. Because of the poorer quality of our ^{52}Fe data we could not rule out the possibility that there are still unidentified 0^+ levels nearly degenerate with the T=2 state.

The observed cross section ratios and energy splittings can be used to estimate the off-diagonal matrix elements $(\psi_a|H_c|\psi_b)$ of the charge dependent (isospin violating) part of the Hamiltonian (see ref. 11) and the mixing of the states. For ^{44}Ti and ^{48}Cr, respectively, we found values of 8±2 keV and 5±1 keV for the perturbing matrix elements and 20% and 50% for the mixings. In ^{48}Cr the unperturbed levels appear to be nearly degenerate (spacing less than 1 keV). These matrix elements compare favorably with the experimentally obtained values[7] 33±5 keV and 10.0±1.5 keV for ^{56}Co and ^{58}Co and with the theoretical predictions of Bertsch.[6]

In summary we can say that when the T=2 state lies in a region with closely spaced states of lower isospin there is a good chance of a large isospin mixing. The present results show that this is a common occurrence for self conjugate nuclei in the $1f_{7/2}$ shell.

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FIGURE CAPTIONS

Fig. 1 Triton energy spectra to levels in the vicinity of the double analog states. The excitation energies indicated are those deduced in this work and are given in MeV.

Fig. 2 Angular distributions for 0^+ levels in the vicinity of the double analog state.

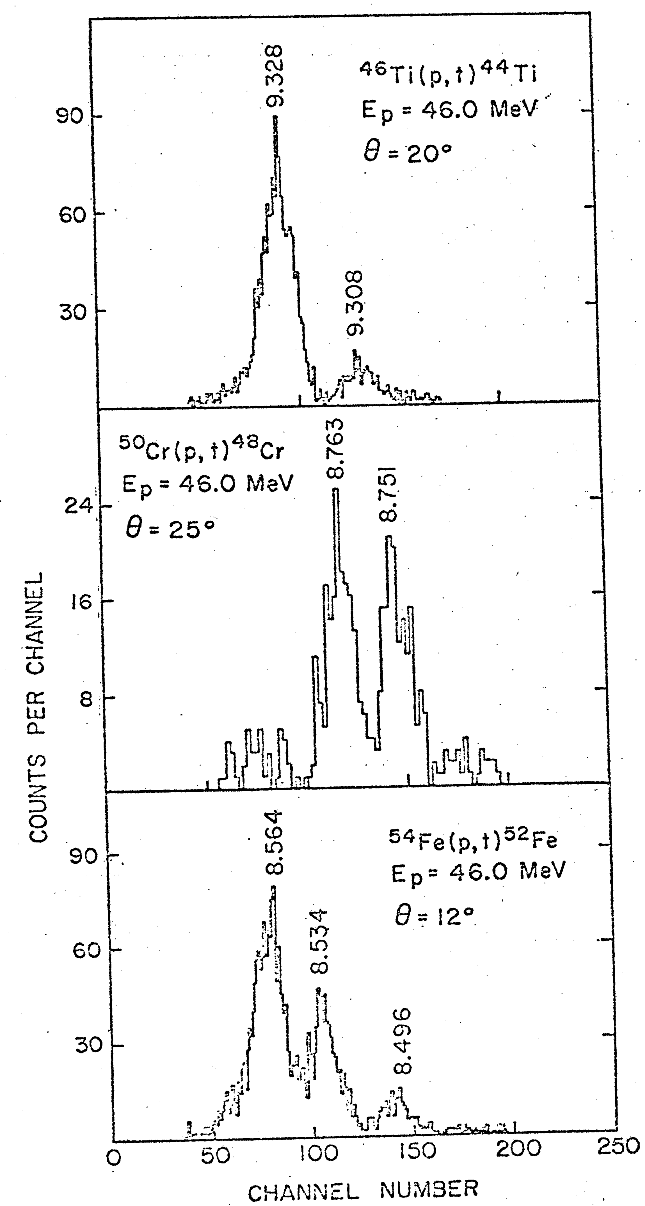
9.328
9.308
$^{46}Ti(p,t)^{44}Ti$
E_p = 46.0 MeV
θ = 20°
$^{50}Cr(p,t)^{48}Cr$
E_p = 46.0 MeV
θ = 25°
8.763
8.751
$^{54}Fe(p,t)^{52}Fe$
E_p = 46.0 MeV
θ = 12°
8.564
8.534
8.496
COUNTS PER CHANNEL
CHANNEL NUMBER

Fig. 1

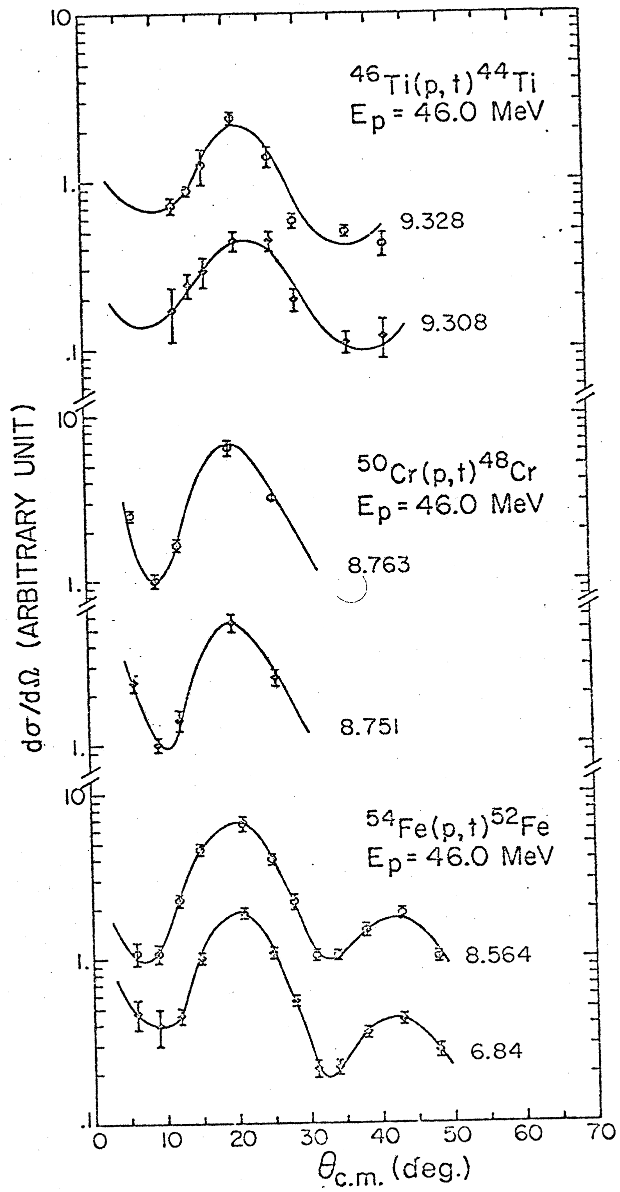
$^{46}Ti(p,t)^{44}Ti$
E_p = 46.0 MeV
9.328
9.308
$^{50}Cr(p,t)^{48}Cr$
E_p = 46.0 MeV
8.763
8.751
$^{54}Fe(p,t)^{52}Fe$
E_p = 46.0 MeV
8.564
6.84
dσ/dΩ (ARBITRARY UNIT)
$\theta_{c.m.}$ (deg.)

Fig. 2