A Study of the $^{50}\text{Cr}(d, n)^{51}\text{Mn}$ and $^{54}\text{Fe}(d, n)^{55}\text{Co}$ Reactions

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The $^{50}\text{Cr}(d, n)^{51}\text{Mn}$ and $^{54}\text{Fe}(d, n)^{55}\text{Co}$ reactions have been studied at an incident deuteron energy of 5.5 MeV. Angular distributions of neutron groups to a number of low-lying levels in the residual nuclei have been recorded. Time-of-flight techniques have been used to record neutron spectra. A liquid scintillator with pulse-shape discrimination property has been used as neutron detector. DWBA calculations have been performed and relative spectroscopic strengths determined for transitions with various $l_v$ values. The ratios between spectroscopic strengths for $l_p=3$ and $l_p=1$ transitions were found to be considerably larger than corresponding ratios obtained from the $(^3\text{He}, d)$ reactions. Two-step stripping processes competing with the direct stripping process are suggested as explanation of the discrepancy between the $(d, n)$ and the $(^3\text{He}, d)$ results.

Introduction

Great efforts have been made to study low-lying neutron states in the $1f_{7/2}$ shell. Neutron transfer reactions such as $(d, p)$ and $(t, d)$ have been used to investigate the particle states. The hole states have been studied by means of the corresponding pick-up reactions $(p, d)$ and $(d, t)$. During the last few years a large number of experiments dealing with proton states in the $1f_{7/2}$ shell have been performed. Most of the investigations have been performed by $(^3\text{He}, d)$ reactions, but also $(d, n)$ reactions have been used in some cases.

Excited levels in $^{51}\text{Mn}$ and $^{55}\text{Co}$ have been studied mainly by $(^3\text{He}, d)$ reactions at various incident particle energies. By the $^{50}\text{Cr}(^3\text{He}, d)^{51}\text{Mn}$ reaction Rapaport et al. have investigated 39 excited levels in $^{51}\text{Mn}$. Recently this reaction has also been used by

Čujec and Szöghy\textsuperscript{2} who have investigated 17 levels in $^{51}\text{Mn}$. In these papers differential cross sections, orbital angular momentum transfers $l_p$ and spectroscopic strengths $(2J+1)SC^2$ are given for most of the levels. The estimated uncertainties concerning the energies of the excited levels are from 15 to 20 keV. More accurate energy values have been given by Wall and Erlandsson\textsuperscript{6}, who have studied the $^{50}\text{Cr}(p, \gamma)^{51}\text{Mn}$ reaction. Erlandsson\textsuperscript{7} has also reported spins and parities for several excited levels from $(p, \gamma)$ angular distribution measurements. The $(^3\text{He}, d)$ reaction has also been used to study excited levels in $^{55}\text{Co}$. Rosner and Holbrow\textsuperscript{3}, Armstrong and Blair\textsuperscript{4} and O'Brien \textit{et al.}\textsuperscript{5} have given excitation energies, differential cross sections, $l_p$ values and $(2J+1)SC^2$ values which generally are in reasonable agreement with each other. The $^{55}\text{Co}$ nucleus has also been studied by the $^{54}\text{Fe}(p, \gamma)^{55}\text{Co}$ reaction by Erlandsson\textsuperscript{8} and by Maripuu\textsuperscript{9}.

The $(d, n)$ reaction with 11.8 MeV deuterons has been used by Okorokov \textit{et al.}\textsuperscript{10,11} to determine properties of low-lying levels in nuclei in the mass region $A = 40 - 70$. The quantities for levels in $^{51}\text{Mn}$ and $^{55}\text{Co}$ obtained from this study may be compared directly with the quantities extracted from the corresponding $(^3\text{He}, d)$ reactions. The agreement is reasonable except for the energy values of some excited levels. The $(d, n)$ reaction with 7.5 MeV deuterons has been used by Gemmel \textit{et al.}\textsuperscript{12} to study levels in $^{55}\text{Co}$. Excitation energies for six levels in $^{55}\text{Co}$ are given together with the probable values of the orbital angular momentum $l_p$ of the transferred protons.

The $(^3\text{He}, d)$ and $(d, n)$ reactions both involve the transfer of a proton to the target nucleus, but do not always give the same spectroscopic factor for a given final level. Siemssen \textit{et al.}\textsuperscript{13}, for example, have reported that population of isobaric analogue ($T_>$) states in some light odd-odd nuclei by the $(d, n)$ reaction gives spectroscopic factors which are roughly a factor of 2 smaller than those obtained from the $(^3\text{He}, d)$ reaction. The spectroscopic factors for $T_<$ states are closely similar. It was also found\textsuperscript{13} that the $(^3\text{He}, d)$ spectroscopic factors for $T_>$ states

\textsuperscript{6} Wall, N., Erlandsson, B.: Arkiv Fysik 34, 325 (1967).
\textsuperscript{7} Erlandsson, B.: Arkiv Fysik 34, 285 (1967).
\textsuperscript{8} Erlandsson, B.: Arkiv Fysik 34, 263 (1967).
\textsuperscript{9} Maripuu, S.: Arkiv Fysik 37, 97 (1968).