Mn$^{55}(p, p'\gamma)$Mn$^{55}$ Reaction Low Proton Energies

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Angular distributions of gamma rays following the inelastic scattering of protons from Mn$^{55}$ have been measured at proton energies below 2.50 MeV. The mixture multipole orders for the transition 983→126 keV and 1,530→0 in Mn$^{55}$ have been obtained.

1. Introduction

The statistical compound theory of nuclear reactions has long been applied to the description of the compound cross-sections and its quantitative success has been satisfactory. It has been found that the theory is very successful in explaining numerous measurements of the correlation function for neutron and proton inelastic scattering from medium-heavy nuclei. At lower energies (below 4 MeV) only relatively few experiments performed on $(p, p'\gamma)$ reaction studies have been done under sufficiently good experimental conditions to permit detailed conclusions to be extracted.

Our previous articles$^{1-3}$ on the chromium isotopes showed a satisfactory agreement with the predictions of CN theory. These motivated us to investigate the Mn$^{55}(p, p'\gamma)$Mn$^{55}$ and Mn$^{55}(p, n\gamma)$Fe$^{55}$ reactions.

The levels of Mn$^{55}$ have been observed by different reactions$^{4-7}$. The spins and parities of the low lying levels were determined and were found to be 7/2$^-$, 9/2$^-$, 11/2$^-$ and 3/2$^-$ for 126, 984, 1,290 and 1,530 keV levels.

In this paper we report the results of the cross-section measurements of \((p, p'\gamma)\) reaction on Mn\(^{55}\) in the proton energy region \(E_p = 1.8 \rightarrow 2.5\) MeV.

### 2. Experimental Procedure

Protons were accelerated by the 2.50 MeV electrostatic generator of the U.A.R. Atomic Energy Establishment. After momentum analysis, the incident beam was focused onto a target by quadrupole lenses. The target chamber was a cylindrical brass cup 3.0 cm in diameter with a wall thickness of 0.05 cm. Natural manganese metal of high chemical purity evaporated on thin tantalum backing was used as the target for these measurements. The total charge delivered to the target was measured with an ELCOR-A-30-9A type current integrator. Single gamma ray-spectra were measured using 2" x 2" NaI(Tl) crystal and recorded with a transistorised RCI-512 channel pulse height analyser.

### 3. Data Analysis

Following Sheldon\(^8\) we can write the differential cross-section for the \((\text{Mn}^{55}, \text{Mn}^{55'}\gamma)\) process as,

\[
\frac{d\sigma}{d\Omega} = \frac{\lambda^2}{8} N' C' W' M(\delta) P_v(\cos \theta)
\]

with summation over \(J_1, J_2\) and where \(0 \leq v \leq 2J_1, 2J_2, 2L'\) and

\[
N' = (-)^{J_0 + J_3 - J_2 + \frac{1}{2}} (\hat{J}_1)^4 (\hat{J}_2)^2 (\hat{J}_3)\]

\[
C' = \langle v0 | J_1, 1 - \frac{1}{2} \rangle
\]

\[
W' = W(J_1, J_1, J_1, vJ_0) W(J_1, J_1, J_2, vJ_2),
\]

\[
M(\text{LL'}) = \hat{L}\hat{L'} \langle v0 | \text{LL'} 1 - 1 \rangle W(J_2, J_2, \text{LL'}, vJ_3),
\]

\[
M(\delta) = (1 + \delta^2)^{-1} [M(\text{LL}) + 2\delta M(\text{LL'}) + \delta^2 M(\text{LL'})].
\]

Here, \(\hat{L} = (2L+1)\). The \(\tau\) terms are \(\tau = T_{1\tau}^\pm(E)\). \(T_{1\tau}^\pm(E)/\sum_{\tau} T_{1\tau}^\pm(E)\) where \(T^\pm\) are generalized transmission coefficients\(^8\). The proton and neutron transmission coefficients have been obtained from a square well calculations. The influence of the competitive channels are included in \(\tau\).

The mixing ratio

\[
\delta = \frac{(J_3\|L\|J_2)^2}{(J_3\|L\|J_2)^2}.
\]

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