Low Lying Levels of Fe$^{55}$

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Angular distributions of 413 and 1,322 keV gamma rays from the Mn$^{55}(p, n \gamma)$ Fe$^{55}$ reaction and the $(n-\gamma)$ angular correlation measurements have been measured at proton energies below 2.50 MeV. The experimental results show agreement with the Sheldon formula. The multipole mixture parameters for the 933 and 1,322 keV gamma rays in Fe$^{55}$ have been determined. The sum coincidence technique is used to give some information about the scheme of excited levels in the Fe$^{55}$ nucleus.

1. Introduction

The positions of energy levels in Fe$^{55}$ by means of Fe$^{54}(d, p)$Fe$^{55}$, Fe$^{56}(p, d)$Fe$^{55}$ and Mn$^{55}(p, n)$Fe$^{55}$ reactions are obtained. The studies of levels in Fe$^{55}$ have only show two levels at 413 and 933 keV up to 4 MeV excitation energy. Neutron time of flight spectra show two unreported neutron groups in addition to the groups corresponding to 413 and 933 keV in Fe$^{55}$. Kim$^1$ attributed them to two levels at 510 and 680 keV. Alvera$^2$ reported the appearance of a neutron group corresponding to the 510 keV level while the 680 keV was not observed. These two levels were not observed in the work of Uchida$^3$ and Iyengar$^4$.

In view of the lack of agreement among the observations of several investigators regarding the levels excited in Fe$^{55}$, particularly through the Mn$^{55}(p, n \gamma)$Fe$^{55}$ reaction, a search was carried out for studying these two levels (510 and 680 keV) by observing the gamma rays from this reaction employing the sum coincidence technique.

In the present paper we report the results of the cross-section measurements of $(p, n \gamma)$ reaction of Mn$^{55}$ and the $(n-\gamma)$ angular correlations at $E_p \leq 2.50$ MeV.

2. Experimental Procedure

Protons were accelerated by the 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 wall thickness 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-30-9-A type current integrator.

The gamma-ray single spectra are detected with a double scintillation spectrometer consisting of two identical 2" $\times$ 2" thick NaI(TI) crystals, with resolution 7.5% for the 661 keV Cs$^{137}$ line. Since the gamma ray yield from our reaction is small at low energies, the proton beam was used carefully collimated by tantalum diaphragms to reduce the background.

In measuring the angular distributions of the gamma rays following the $(p, n)$ reaction with Mn$^{55}$, one of the two spectrometers is used as a monitor and is fixed at 90° to the proton beam direction while the second is used as a movable one. Angular range from $-30^\circ$ to $120^\circ$ with respect to the direction of the proton beam is covered at interval of $15^\circ$.

A 1.5" $\times$ 1.5" stilbene scintillation crystal mounted on an RCA 6810-A photomultiplier was used for neutron detection. The fast-slow coincidence spectrometer is used in the investigation of $(p, n\gamma)$ reaction with Mn$^{55}$ nucleus. The spectrometer is consisting of one NaI(TI) gamma ray detector and the stilbene neutron detector. The two detectors were located at a distance of 10 cm from the target. The coincidence circuit using a resolving time of $\tau = 80$ ns. Correlation measurement were made in the horizontal plane, when the neutron detector was located in the horizontal plane at $\theta_n = 45$, 90 and 120° and in vertical when it was fixed on top of the chamber with its axis perpendicular to the reaction plane. The measurements were carried out at $E_p = 2.30, 2.40$ and 2.50 MeV since at these energies the yield is high and the neutron energy is high enough to enable a large fraction of the recoil protons to be detected above the noise level of the photomultiplier. The $(n-\gamma)$ angular correlations are detected from $-30^\circ$ to $120^\circ$ in steps of $15^\circ$. The pulse-height window was set on the neutron detector out-put and the angular correlations were derived from the measured spectra by taking the areas under the gamma peak. In some measurements the pulse-height window was set on the NaI(TI) detector output so as to include the full-energy loss of a certain gamma rays. The coincident spectra were recorded by means of a transistorised RCL 512-channel pulse-height analyser. Both measurements give the same results within the experimental errors.