INFLUENCE OF INELASTIC SCATTERING
ON \((n, 2n)\) CROSS-SECTIONS OF \(\text{Cl}^{35}\) AND \(\text{K}^{39}\)

By

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The cross-sections of the reactions \(\text{Cl}^{35} (n, 2n) \text{Cl}^{34g, m}\) and \(\text{K}^{39} (n, 2n) \text{K}^{38g, m}\) were determined; the results are 1.7; 7.6 and 5.1; 0.8 mb, respectively. The excitation function of the reaction \(\text{K}^{39} (n, 2n) \text{K}^{38g}\) was measured in the neutron energy region 13.4—15 MeV. The discrepancy between the experimental \((n, 2n)\) data and the values calculated on the basis of the statistical model can be explained by the actual spectrum shape of inelastically scattered neutrons.

Introduction

The strong \(N-Z\) dependence observed experimentally in \((n, 2n)\) reaction cross-sections \([2]\) and in the \(\sigma_{n,2n}^{exp}/\sigma_{n,2n}^{calc}\) ratio \([1]\) shows the importance of the concurrent \((n, n')\) processes \([3, 5]\). Two explanations seem plausible.

1. The gamma de-excitation is not negligible comparing to neutron emission above the binding energy of the last neutron in the target nuclei \([1, 6]\).

2. The cross-sections of inelastic scattering leading to excited levels under the binding energy of the last neutron are much higher than that given by the statistical model \([3]\).

The aim of our investigations was to clarify the mechanism of the influence of inelastic scattering on \((n, 2n)\) reactions in the case of \(\text{Cl}^{35}\) and \(\text{K}^{39}\) isotopes.

Experimental procedure

The bombarding neutrons of 15.0 \(\pm\) 0.3 MeV were produced by a 300 kV neutron generator in \(\text{D} \to \text{T}\) reaction. The samples were irradiated for 2 sec in the case of short half-lives and transported by a pneumatic rabbit tube to the measuring device. The \(\text{K}_2\text{CO}_3\) and \(\text{C}_2\text{Cl}_6\) samples were in a polyethylene holder. The annihilation gammas from the short half-life \(\beta^+\) activity were detected by a coincidence system.

The neutron flux was monitored by the pulses corresponding to gamma energies higher than 2 MeV, arising from one of the scintillators. In that gamma energy region during the measurement the self-activity of the crystal was negligible. The monitor pulses and pulses from the coincidence device...
were recorded by a 400 channel TMC analyser operated in multiscaler mode. The two types of input signals were gated by the ion current.

The cross-sections were determined relative to the cross-section of reaction $\text{Pr}^{141}(n, 2n)\text{Pr}^{140}$. The measurement of the PrO$_2$ sample was performed under the same conditions.

For measuring the long-lived components a KCl sample was irradiated in the same geometrical arrangement as in the case of short activations. The intensities belonging to the 510 keV annihilation gammas were determined by registering the spectrum in successive time intervals in order to obtain the half-lives. $\text{Pr}^{141}(n, 2n)\text{Pr}^{140}$ and $\text{Cu}^{63}(n, 2n)\text{Cu}^{62}$ reactions served as monitors.

$\text{K}^{39}(n, 2n)\text{K}^{38}$ excitation function was determined by simultaneous irradiation of $\text{K}_2\text{CO}_3$ samples placed at different angles to the deuteron beam. The activities were measured by GM counters.

**Results**

The half-lives were checked by graphical analysis of the complex decay curves. The obtained values agreed with the data available in the literature to within 10 per cent. For the determination of the cross-sections the data of Nuclear Data Sheets were accepted.

We also determined the $\sigma_{n, 2n}$ for $\text{Pr}^{141}$ because available data show high discrepancies. We obtained $\sigma = (2050 \pm 10)$ mb for $\text{Pr}^{141}(n, 2n)\text{Pr}^{140}$ accepting $(560 \pm 30)$ mb for the cross-section of $\text{Cu}^{63}(n, 2n)\text{Cu}^{62}$ [12].

The cross-sections obtained for $\text{K}^{39}$ and $\text{Cl}^{35}$ are summarised in Table 1, listing also the data found in the literature.

The relative excitation function of the reaction $\text{K}^{39}(n, 2n)\text{K}^{38}$ measured near the threshold was fitted at 15 MeV. These data can be found in Table 1.

**Discussion**

The investigated total $(n, 2n)$ cross-sections for $\text{K}^{39}$ and $\text{Cl}^{35}$ are small compared with the values given by the statistical model.

The excitation function for the reaction $\text{K}^{39}(n, 2n)\text{K}^{38} + n$ is plotted in Fig. 1. Present results are plotted by circles, while the other data taken from [7] and [8] are indicated by dots. The shape of this excitation function can be well described by the simple Weisskopf estimation [4] assuming the evaporation spectrum shape, but the calculated cross-section value is higher than the experimental one by an order of magnitude.

On the basis of the measurements of G. C. Bonazzola and E. Chia-Vassa [9] one can give a lower limit for the inelastic scattering cross-sections.