Level Density Parameters of $^{47}$Ti and $^{50}$V

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The energy distribution of the protons and $\alpha$-particles from the reactions $^{47}$Ti($\alpha,\alpha'$), $^{47}$Ti($\alpha,p$) and $^{50}$V($p,\alpha$) was measured in the angular range from 60° to 150°. The energies of the incoming particles were 15.35 MeV for $\alpha$-particles and 13.85 MeV for protons. The results can be described in the frame of the statistical model of the nuclear reactions. The level density parameters could be determined by comparing the experimental data with the theoretical results. The values for the backshifted Fermi gas model are

$^{47}$Ti: $a=6.6 \pm 0.6$ MeV$^{-1}$, $\Delta = -0.5 \pm 0.3$ MeV

$^{50}$V: $a=6.3 \pm 0.6$ MeV$^{-1}$, $\Delta = -1.0 \pm 0.3$ MeV.

1. Introduction

The investigation of particle spectra for compound nucleus reactions is used already for some time to determine level densities [1]. Nevertheless the corresponding data are by no means as complete as level density data obtained from neutron resonances, and many nuclei have not been investigated in that way. To close this gap, in the present paper three more compound reactions were investigated: $^{50}$V($p,\alpha$), $^{47}$Ti($\alpha,\alpha'$) and $^{47}$Ti($\alpha,p$); the level density parameters of these two nuclei were determined. The main reason for the choice of these reactions leading all to the compound nucleus $^{51}$Cr is the fact, that it is one of the few nuclei, which can be generated by $n$, $p$- and $\alpha$-absorption (from $^{50}$Cr, $^{50}$V and $^{47}$Ti); it is therefore an ideal test of the statistical model of nuclear reactions. The $^{50}$Cr($n,p$) and ($n,\alpha$) reactions are under investigation elsewhere [2].

The analysis of the evaporation spectra is using the statistical theory of the nuclear reactions considering angular momentum effects exactly; the Fermi gas model with fictive groundstate (backshifted Fermi gas model) is used to parametrize the nuclear level density.

2. Experimental

2.1. Targets

The main problem of this work was the production of appropriate targets of $^{50}$V and $^{47}$Ti; these isotopes exist with an abundance of 0.25 %, resp. 7.5 % in the natural isotope mixture.

For the investigation of compound nucleus reactions it is necessary to have an enrichment of more than 90 % of the considered isotopes. The targets were produced with the aid of the Munich Mass Separator by bombarding carbon foils with the separated isotope beam directly. In the case of $^{47}$Ti the above demand could be fulfilled using natural isotope mixture as charge material. For $^{50}$V it was necessary to use pre-enriched material—in this case V$_2$O$_5$ powder enriched to 40 % in $^{50}$V.

For the production of homogeneous as possible targets and to avoid a mechanical destruction of the carbon foils a moveable targetholder and a special stopping collector were developed [3].

Both isotopes could be produced with an isotopic purity of more than 99 %, which was checked in the Munich Q3D spectrograph [4] with the aid of elastic
proton scattering. Though the targets were very thin: the $^{50}$V target, resp. the $^{47}$Ti target had thicknesses of $15 \mu g/cm^2$, resp. $50 \mu g/cm^2$. Carbon foils were used with thickness of $10 \mu g/cm^2$. The target thickness was measured with Rutherford scattering during the experiment.

2.2. Experimental Assembly for the Measurement of the Evaporation Spectra

The measurements of the evaporation spectra, i.e. of the energy spectra of the $\alpha$-particles and protons from the reactions $^{50}$V$(p, \alpha)$, $^{47}$Ti$(\alpha, \alpha')$ and $^{47}$Ti$(\alpha, p)$ were done in the scattering chamber [5] of the Munich Tandem Accelerator [6].

3 single solid state detectors (150$\mu$) and 3 $\Delta E - E$ telescopes (50$\mu$/2000$\mu$) were used. In addition, a single counter was mounted in the scattering chamber for determining the target thickness by Rutherford scattering.

The $\alpha$-particles were detected by the single counters with thicknesses just sufficient to stop the most energetic $\alpha$-particles; the protons were identified with telescopes.

The events were gathered with conventional electronics and handled by the computer program ON-LINE [7] with a PDP8-PDP10 computer system.

2.3. Procedure of Measurements

In this experiment the compound system $^{51}$Cr was studied at an excitation energy of 23 MeV. The composite system was formed in the reactions $^{50}$V$(p, \alpha)$ and $^{47}$Ti$+\alpha$ with 13.85 MeV protons and 15.35 MeV $\alpha$-particles. Both energies were chosen for matching the same excitation energy of a composite system, which is formed in the reaction $^{50}$Cr$+n$. Neutrons with energy of 14.1 MeV are available for this experiment, which is prepared at the Institut für Radiumforschung in Vienna.

Spectra of the carbon foils were studied for getting additional information about background and impurities, mainly caused by oxygen.

3. Experimental Results

Figures 1–3 show representative raw spectra and also spectra of pure carbon foils.

After removing the discrete particle lines, caused by scattering and reactions on $^{12}$C and $^{16}$O, and the relatively weak continuous background spectrum, whose origin is not clear, the various cross sections were computed using the code CSECT [8]. The angle integrated cross section $d\sigma/dE_\theta(\theta_0)$ mb/MeV was cal-

![Fig. 1. a Spectrum of $^{50}$V$(p, \alpha)$ at $120^\circ$, 466$\mu$C. b Spectrum of $^{12}$C$(p, \alpha)$ at $120^\circ$, 160$\mu$C.](image)

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* Energies: c.m. energies of the emitted particles

Table 1. Angle integrated energy distribution. Cross sections in mb/MeV