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PROGRESS REPORT ON NUCLEAR DATA MEASUREMENTS IN NORWAY

Presented to the EANDC-OR Sub-Committee on nuclear data, Paris 9th April, 1965.

I. WORK RECENTLY COMPLETED

CROSS SECTIONS OF SOME REACTIONS INDUCED IN NITROGEN, PHOSPHORUS, COPPER AND BROMINE WITH NEUTRONS OF ENERGY 14.8 MeV *)

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The activities induced in nitrogen, phosphorus, copper and bromine by (n, 2 n) reactions were determined both by registration of β -particles and by registration of coincidences between annihilation quanta. The neutrons were produced in a SAMES J accelerator by the (D, T) reaction.

The agreement between the results obtained with the two methods was quite good for phosphorus and copper, somewhat poorer for bromine. For nitrogen it was impossible to obtain accurate results from registration of β-particles, and no comparison could be made.

Values of the cross sections of the (n, 2 n) reactions mentioned and for (n, p) and (n, α) reactions in the same elements with 14.8 MeV neutrons are presented. The agreement with earlier measurements is in most cases satisfactory. One exception is the reaction $^{81}_{35}Br(n, \alpha)^{78}_{33}As$.

II. WORK IN PROGRESS

NEUTRON SPECTRA FROM BREAKUP OF DEUTERONS BY 14.8 MeV NEUTRONS

S. Messelt, Institute of Physics, University of Oslo, Norway.

Neutron spectra from the D(n, p) 2n reaction at 14.8 MeV have been remeasured with greater accuracy at 13°, 20° and 28° using the same technique as before (1), but improved electronic equipment.

14.8 MeV neutrons were produced by bombarding a titanium-tritium target with 120 keV deuterons from a SAMES J accelerator. The associated

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*) This work was performed in the first half of 1964, and this is the abstract of an article published in Phys. Rev. 137, B 878 (1965).

alpha-particle from the $T(d,n)He^4$ reaction detected by a thin plastic scintillator coupled to a 56AVP photomultiplier tube, was used as a zero signal for the time of flight spectrometer.

Thin walled brass containers, 4 cm in diameter and 7 cm in length, were used to hold the scattering samples, D_2O or H_2O. The scatterer was placed 35 cm from the target. Neutrons scattered through an angle, ϑ, were detected by a scintillation counter, the flight distance was 100 cm. At 13° a 2" x 1½" diam. plastic scintillator (NE102) on a 56 AVP tube was used, while a 2" x 4" diam. Ne 213 scintillator on a 58 AVP tube was used at 20° and 28°.

The neutron flux from the target was monitored by a solid state detector for alpha particles from the target.

The inelastic scattering from deuterium was determined by measuring the difference spectrum between D_2O and H_2O used as scatterer. In this way the inelastic scattering from oxygen was eliminated, and the spectrum of 2 to 8 MeV neutrons could be determined. The absolute values of the cross sections were determined by comparing the results with those obtained for n-p scattering at 45°, 52° and 58° with the H_2O scatterer and the same experimental conditions, using the well known value of this cross section.

The cross section for elastic scattering from deuterium was determined at 13°, 20°, 28°, 40°, 45° and 52° by comparison with n-p scattering at the same angles.

Ref. 1: S. Messelt, Nuclear Physics 48, 512 (1963).

γ - γ ANGULAR CORRELATION MEASUREMENT OF THERMAL NEUTRON CAPTURE γ-RAYS

A. Tveter and M. Hoffman (Fulbright research scholar from Los Alamos). R. Nordhagen, University of Oslo, is adviser for the group.[x)] The work is performed at the Kjeller Research Center.

Equipment, development.

For the present experiment a well collimated beam at thermal neutrons to bombard the target to be studied is required. The neutron source is a

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x) The work was started by K. Abrahams, RCN, Holland.

graphite scatterer placed in one of the throughgoing channels in the JEEP-I reactor. The neutron flux at the target position is approximately $4 \cdot 10^5$ n/s cm^2. Two NaJ(Tl) scintillation spectrometers are used to study the γ-ray cascades. One of the spectrometers consisted of a stationary and heavily shielded scintillation crystal 5" in diameter and 4" high, mounted on a 6364 Du Mont photomultiplier. The other crystal $1\frac{1}{2}$" in diameter and 2" high mounted on RCA 6655 A photomultiplier was used to select low energy γ-rays. This spectrometer was surrounded with a lighter shielding and could be moved in the plane perpendicular to the neutron beam. Both crystals faced the target and the angle ϑ between their central axes could be varied between 90° and 180°. Recently we have built transistorized double-delay-line clipped amplifiers, single channel analysers and coincidence circuits for the equipment (1). The coincidence resolving time (2τ) for the system is 40 n sec. The coincidence spectra are analysed in a multichannel pulse height analyser of the type Intertechnique model SA40. The data for the different angles ϑ are punched out on paper tape and analysed in a computer (UNIVAC 1107). In the future we hope to perform the experiment with two identical NaJ(Tl) detectors 4" x 5" in size and with a 10 times stronger neutron beam in JEEP-II. We are also planning to perform coincidence experiments between one NaJ(Tl) crystal and a Li drifted Ge crystal in order to improve the resolution.

Measurements.

The angular correlation of two subsequent γ-rays can be expressed by (2):

$$W(\vartheta) = 1 + \sum_{\nu} A_{\nu} P_{\nu} (\cos \vartheta)$$

where ϑ is the angle between the emission directions of the two γ-rays, ν is even and greater than zero, and $P_{\nu}(\cos \vartheta)$ is the Legrende polynominal of order ν. A_{ν} is a function of the multipole amplitude mixing ratio of each of the two γ-ray transitions and of the spins of the three levels involved in these two transitions. For a triple γ-ray cascade information regarding multipolarities of transitions and spins of levels involved in these transitions might be obtained by studying angular correlations between the first and the third γ-ray, even if the second γ-ray is not observed. It can be shown that any anisotropy excludes the value $\frac{1}{2}$ for the spins of the two intermediate levels.

Angular correlation measurements have been done for neutron capture γ-rays with the even nuclei ^{40}Ca, ^{58}Ni and ^{32}S as targets. In these cases the analysis was simplified by the fact that J of the compound state is $\frac{1}{2}^+$. Table I shows the measured correlations and the corresponding spins and multipole mixtures. (Sulphur was used only for calibration purposes).

Table I

Experimental values of A_2 for the correlation function

$$W(\vartheta) = 1 + \sum_{\nu} A_{\nu} P_{\nu}(\cos \vartheta) \text{ for } \gamma\text{-}\gamma \text{ cascades (3)(4)}$$

Sample	Cascade γ-rays	A_2	Spin determinations and multiple mixtures		
			Level	Spin	δ(mixing ratio)
Sulphur	5.43-3.25	-0.12 ± 0.07	3.25	3/2	
	5.43-2.41	0.23 ± 0.07	0.85	1/2	
	5.43-0.85	0.03 ± 0.04			
Calcium	6.41-1.95	-0.07 ± 0.03	1.95	3/2	$\delta_{6.41} = 0.00 \pm 0.15$
	4.75-1.15	0.21 ± 0.13	3.62	3/2	
	4.75-1.95	0.10 ± 0.07	3.62	3/2	
	4.4 -1.95	$+0.02 \pm 0.04$	3.95	1/2	
	2.00-1.95	-0.01 ± 0.02			$\delta_{2.00} = 0.18 \pm 0.08$
	1.48-1.95	0.11 ± 0.05	2.47	3/2	
	5.90-1.95	0.04 ± 0.02	2.47	3/2	
Nickel	8.54-0.46	0.02 ± 0.03	0.46	1/2	

At present we are running a Ce target to investigate the mixing ratio of the 0.47 MeV transition which seems to be very closely related to a 0.52 MeV transition in Ca^{41}. Both transitions start from an extra $3/2^-$ excited state to the $3/2^-$ first excited state. A theoretical study to explain the second $3/2^-$ states both in Ca^{41} and in Ce^{141} is in progress. In future experiments we would like to study enriched isotopes where we can expect octupole transitions: Ti^{50}, Cr^{52} and Fe^{54}.

References.

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