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REDUCTION OF BACKGROUND IN ACTIVATION ANALYSIS WITH X-RAY REGISTRATION BY MEANS OF MAGNETIC FIELD

ОСЛАБЛЕНИЕ ФОНА В АКТИВАЦИОННОМ АНАЛИЗЕ С РЕНТГЕНОВСКОЙ РЕГИСТРАЦИЕЙ ПОД ВОЗДЕЙСТВИЕМ МАГНИТНОГО ПОЛЯ

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The possibility of characteristic X-ray utilization in the activation analysis with 14 MeV neutrons is described. The functions of photomultiplier and proportiional detector in a magnetic field were investigated. A possible reduction of the background by means of deflecting beta particles by the magnetic field is shown.

The positron emitters are often produced in an activation analysis with 14 MeV neutrons. If the sample contains several elements which generate positron emitters by activation, mutual interferences appear in their simultaneous determination. There are few cases only where these interferences can be suppressed by a proper choice of irradiation time and the decay time. The X-ray measurements often enable to determine elements which cannot be determined in a particular sample by gamma radiation measurements. Table 1 presents detection limits for individual elements by the registration of gamma radiation and X-rays or low-energy gamma radiation, respectively [1]. It follows that for some elements the detection limit obtained by the X-ray measurement is lower and in several cases the X-ray measurement represents the only possible detection of the generated radionuclide.

When measuring X-ray spectra in a real sample the single peaks may be superposed on a high background due to stopped beta particles. Such a case is illustrated in Table 2. The samples containing elements given in this Table were irradiated for 200 seconds with 14 MeV neutrons from a neutron generator and after 30 seconds of decay time their activity was measured by a proportional detector for 300 seconds. One can see from Table 2 that the peaks of characteristic X-rays of the individual elements are superposed on the high background of the bremsspectrum. The bremsstrahlung was lowered by deflecting the beta particles by the magnetic field so that they cannot impinge on the detector and the bremsstrahlung is generated beyond the ranges of the detector. The experiment was arranged as shown in Fig. 1 in order to lower the bremsstrahlung background component by deflecting beta particles. The construction steel was used for the construction of the deflection magnet. The area of the pole pieces was 3 cm^2 (1.5×2 cm) and the distance between the poles was 10 mm. The magnet was fed by a regulating source of the direct current (U — 48 V, maximum current 5 A). The intensity of the magnetic field was measured in the centre between the pole pieces of the magnet. The distance between the entrance window of the detector and the deflecting magnet was 35 mm. No shielding of the detector against the magnetic field was used. Lead shielding was used to stop the deflected β^-.

A proportional detector and a NaI(Tl) scintillation detector with a Be entrance window were used for the detection. The detector must be located in the close vicinity of the deflecting magnet in order to

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Table 1

Detection limits of elements obtained by measuring γ-rays (E_γ) and X-rays or low energy γ-rays (E_X). The irradiations were performed with fluxes of 2×10^8 n $cm^{-2}s^{-1}$ 14 MeV neutrons. The activation time used was equal to three half-lives, the waiting time was one half-life and the counting time was three half-lives. The gamma rays were detected by two 76 mm NaI(Tl) crystals [1].

Element	E_X [keV]	Detection limit [mg]	E_γ [MeV]	Detection limit [mg]
As	140	4.6	—	—
Er	49	1.8	0.20	4.0
Eu	90	2.9	0.33	18.0
Ge	140	0.4	0.60	5.8
Ir	63	14.0	0.13	18.0
Lu	55	7.5	—	—
Hg	75	0.4	0.24	2.5
Se	160	0.4	—	—
Tb	44	1.0	—	—
Sn	153	0.7	—	—
Ti	140	2.5	1.76	7.1
W	130	2.5	—	—

Table 2

Experimental results of the measurements of X-ray spectra of elements activated by 14 MeV neutrons

Elements	Energy X-rays [keV]	Area of peak [Counts]	Background [Counts]
Se	11.22	13 152	6 396
Br	11.92	7 901	59 886
Mo	17.48	1 263	4 356
Ag	22.16	64 602	119 502
Cd	23.17	7 419	4 073
Sn	25.27	1 665	16 509
I	28.61	1 034	8 182

reach a maximum detection efficiency. The function of the detector is influenced by the magnetic field and therefore the influence of the magnetic field on the detector operation was investigated.

The flashes of the scintillating crystal were for the sake of simplicity replaced by flashes of a light diode type XP 21 fed by a pulse nanosecond generator while investigating the function of the scintillation detector in the magnetic field. A photomultiplier 56 PK 21 (Fy Tesla) with the output signal amplified and shaped by a preamplifier and a Camberra 2101 amplifier were used. The spectrum was recorded by a ND 4420 multichannel analyser. The influence of the magnetic field on the total amplification and on the resolution of the spectrometric tract was investigated. The resulting dependences are shown in Fig. 2. They can be used for the selection of optimal experimental conditions.

A sample with a ^{57}Co X-ray source and a $^{90}Sr/^{90}Y$ emitter was prepared as a source of beta particles

(energy 0.5 MeV) while investigating the function of the proportional counter. The low-energy (6.4 keV) radiation spectrum was measured at various intensities of the magnetic field. Fig. 3 indicates that the 6.4 keV line is not interfered with the $^{90}Sr/^{90}Y$ beta rays in the applied magnetic field of 0.1 T. The dependence of resolution and amplification of the proportional counter on the magnetic field is small. The intensity 0.1 T of the magnetic field was the maximum intensity obtainable by means of the used feeding source.

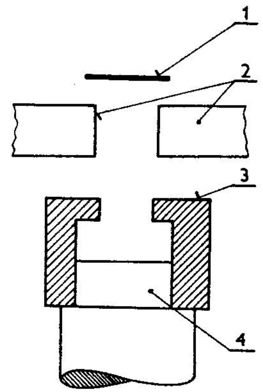

Fig. 1. Experimental arrangement for measuring the influence of the magnetic field on the action of detector.
1 — source of radiation or flashes of light, 2 — pole pieces of the magnet, 3 — collimator, 4 — detector.

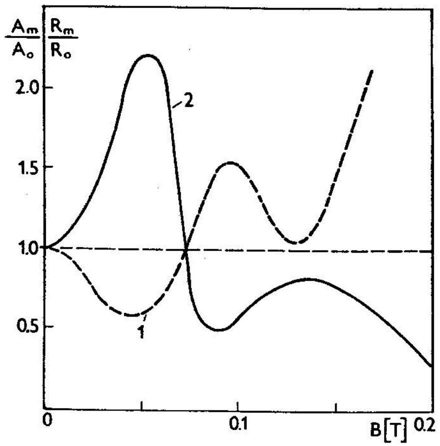

Fig. 2. The dependence of the relative resolution R_m/R_0 (1) and relative amplification A_m/A_0 (2) of the photomultiplier on the magnetic field.

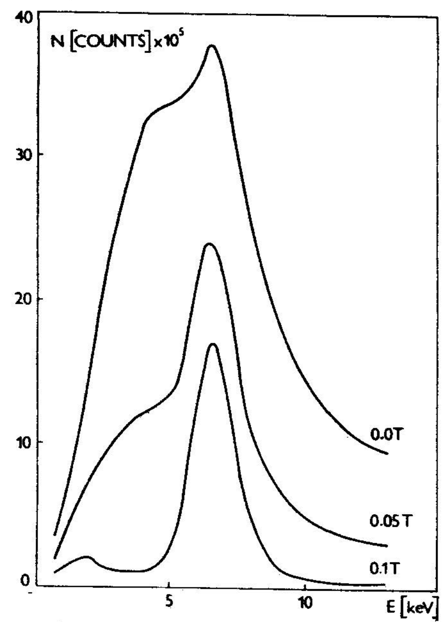

Fig. 3. The X-ray spectra of ^{57}Co — $^{90}Sr/^{90}Y$ measured by a proportional counter in magnetic field of different intensity.

The proportional counter was further used for measuring the X-ray spectrum of a sample containing Ag. 14 MeV neutrons were produced by the neutron generator NG1, which was constructed in the Institute of Physics of the SAS. The sample was irradiated by 14 MeV neutrons (10^9 ns^{-1}) for 2.5 minutes and after 20 seconds the X-ray spectrum without the magnetic field was measured. After further irradiation the same spectrum was measured in the presence of the magnetic field. The two measured spectra are shown in Fig. 4. The spectrum measured without the magnetic field (upper curve) has only the bremsstrahlung portion while the spectrum measured at applied magnetic field (lower curve) exhibits well visible K X-rays of silver. The ratio of the background in the region of K_α of silver in the spectrum measured without the magnetic field to the background in the same region of the spectrum measured with the magnetic field is 9.3.

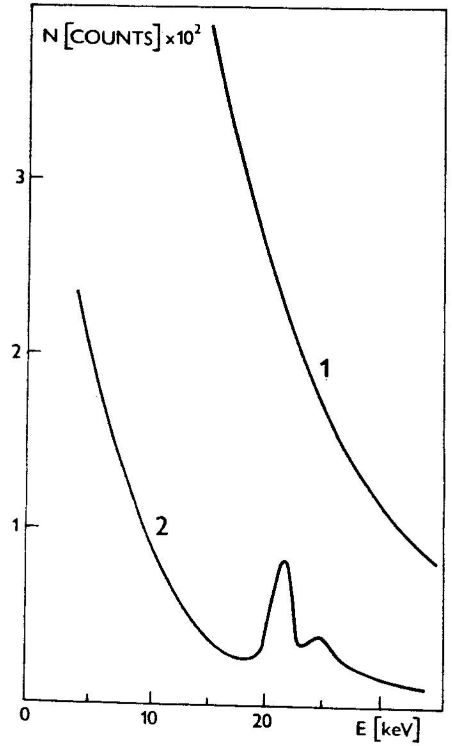

Fig. 4. The X-ray spectra of Ag activated by 14 MeV neutrons and measured by a proportional counter. 1 — spectrum measured without the magnetic field, 2 — spectrum measured with the magnetic field.

The presented experimental results show that the background due to stopping the charged particles in the detector can be depressed by applying the magnetic field. The characteristic X-rays of radionuclides produced by activation can be successfully registered, thus extending the possibility of utilization of the activation analysis by neutrons of a 14 MeV energy.

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