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The Development of the Setup for the Study of P-Even Correlations in p-Wave Resonances

A.Yergashov[1,2], C. Hramko[1], Yu.N. Kopatch[1], V.L. Kuznetsov[1], L.V. Mitsyna[1], N.V. Rebrova[1], P.V. Sedyshev[1]

[1]*Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, Russia*
[2]*Institute of Nuclear Physics, Almaty, Republic of Kazakhstan*

Studying the properties of p-wave neutron resonances in the low-energy region is much more difficult than s-wave ones, because of the centrifugal barrier, which significantly reduces the probability of neutron capture with $l \geq 1$. Meanwhile, p-wave resonances have specific properties that are not inherent in s-resonances. These properties include the two-component nature of the neutron widths Γ_p^n upon excitation of compound states with spins $J = I \pm 1/2$. In the representation of the total momentum of the neutron, $j = l + s$, $j = 1/2$ or $3/2$, and $\Gamma_p^n = \Gamma_{p1/2}^n + \Gamma_{p\,3/2}^n$. Accordingly, to represent the channel spin $S = I + s$ ($S = I \pm 1/2$) we have $\Gamma_p^n = \Gamma_{p\;I+1/2}^n + \Gamma_{p\,I-1/2}^n$. Experimental data on the Γ_p^n components are very poor.

In recent years, in connection with the discovery of parity non-conservation effects in p-wave resonances, an additional incentive to study the structure of Γ_p^n has appeared, since the theoretical interpretation of these effects requires knowing the quantities $x = (\Gamma_{p1/2}^n/\Gamma_{p\,3/2}^n)^{1/2}$. It should be noted that experiments to determine the values of x for these resonances present significant difficulties due to the smallness of the neutron widths $\Gamma_p^n \leq 10^{-6}$ eV, which makes it practically impossible to observe resonance scattering and complicates measurements with γ-quanta. The scheme of the experiment for a study of the angular distribution of γ-quanta of the direct transition after capture by the ^{81}Br nucleus of neutrons with energies close to the energy of the p-wave resonance of this nucleus with $E_p = 0.88$ eV is shown in Figure 1. The studies were carried out with unpolarized neutrons and were aimed at obtaining information about the parameters of this resonance, first of all, about the value of x. In Figures 2 and 3 the TOF spectrum and its part with the KBr resonance of interest were presented.

The measurements were carried out on the 4th channel of the IREN facility, on 11 m base. The characteristics of the IREN resonant neutron source are given in Table 1.

Table 1. IREN parameters

Maximum current (A)	3
Repetition frequency (Hz)	50
Duration of the electronic pulse (ns)	100
Electron energy (MeV)	70
Beam power (kW)	0.5

The results of measuring thermal Φ(th) and resonance Φ(res) neutron flux on the 4th channel of the IREN experimental hall, using gold foils by two methods, are presented below.

1. Monitor pair method with and without cadmium –

$$\Phi(\mathrm{th}) = 8.66\times10^3\ \mathrm{n/cm^2\,s}\ ; \quad \Phi(\mathrm{res}) = 4.75\times10^3\ \mathrm{n/cm^2\,s};$$

2. Golden Screen Method – $\Phi(\mathrm{th}) = 1.48\times10^4\ \mathrm{n/cm^2\,s}$.

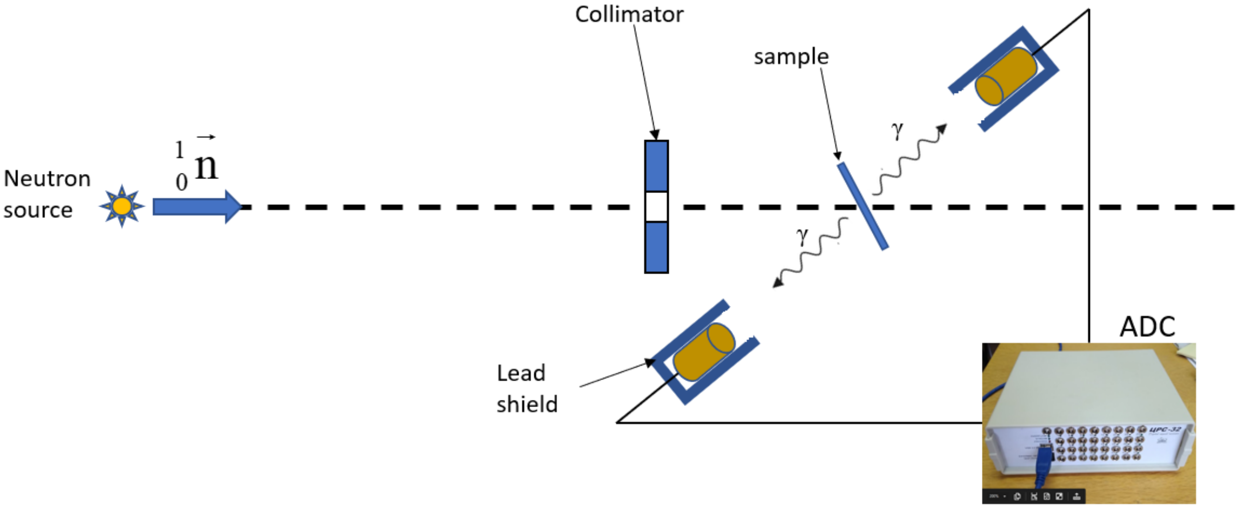


Figure 1. Scheme of the experiment.

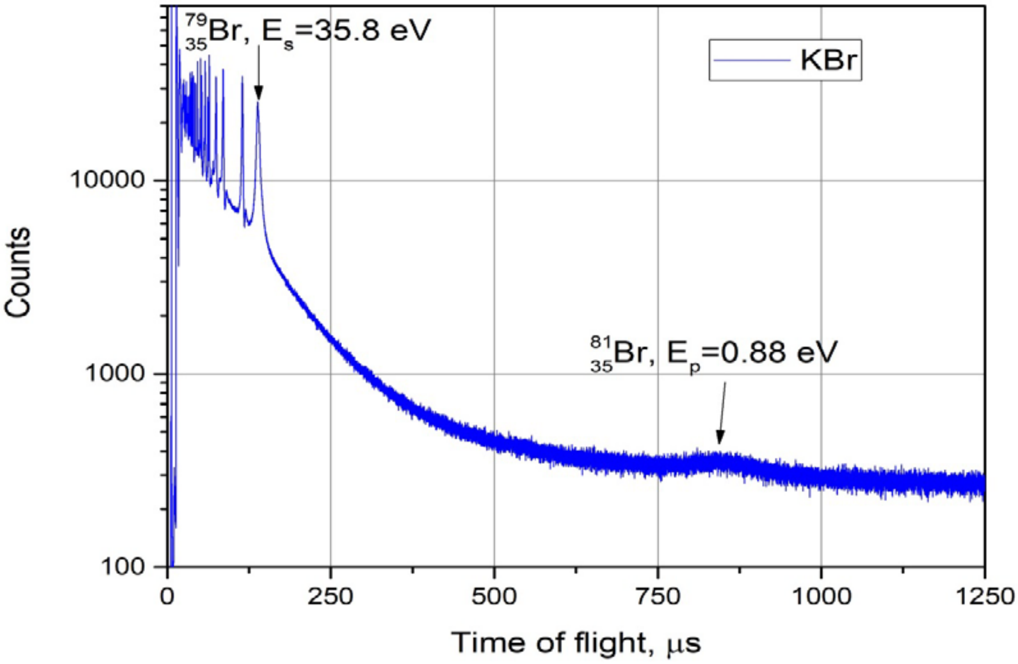
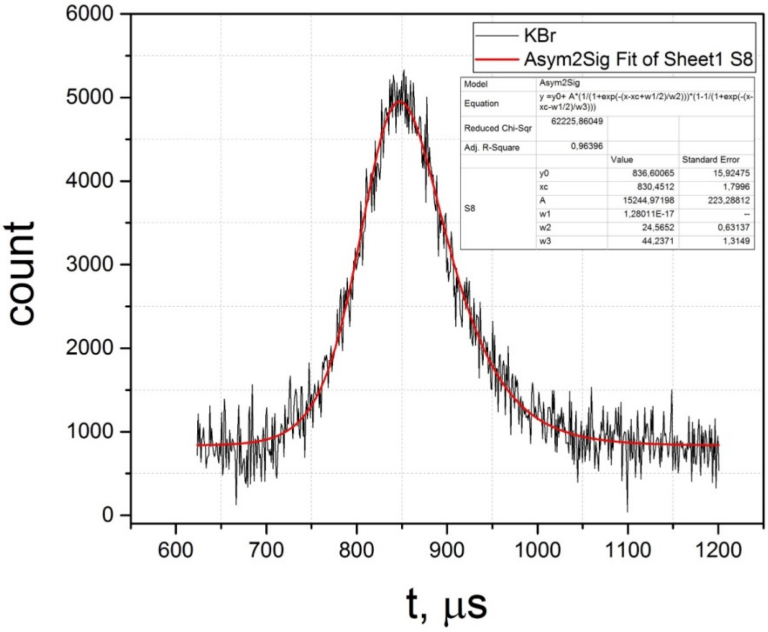


Figure 2. TOF spectrum of KBr.

In addition to the measurements with KBr, measurements were also made with the following samples: Ag, Co, Sn. Figure 4 shows a fragment of the TOF spectrum of ^{59}Co measured with the BGO detector. The scattered neutron from the sample, hitting BGO and interacting with it, gives rise to a resonance on Ge with the energy of 102 eV, it adjusts to a ^{59}Co resonance with an energy of 132 eV.

In order to protect the gamma detector from scattered neutrons, which, having interacted with the detector substance, can give an additional background, it was decided to put helium counters in front of the gamma detectors. Figure 5 shows the design of a new detector system for detecting p-wave neutron resonances in the low energy region. The system consists of 24 NaI(Tl) gamma detectors and 13 CHM-17 helium counters with a longitudinal through channel.



Model	Asym2Sig		
Equation	y =y0+ A*(1/(1+exp(-(x-xc+w1/2)/w2)))*(1-1/(1+exp(-(x-xc-w1/2)/w3)))		
Reduced Chi-Sqr	62225,86049		
Adj. R-Square	0,96396		
		Value	Standard Error
S8	y0	836,60065	15,92475
	xc	830,4512	1,7996
	A	15244,97198	223,28812
	w1	1,28011E-17	--
	w2	24,5652	0,63137
	w3	44,2371	1,3149

Figure 3. Part of TOF spectrum of KBr with the resonance of interest with the energy *E*=0.88 eV.

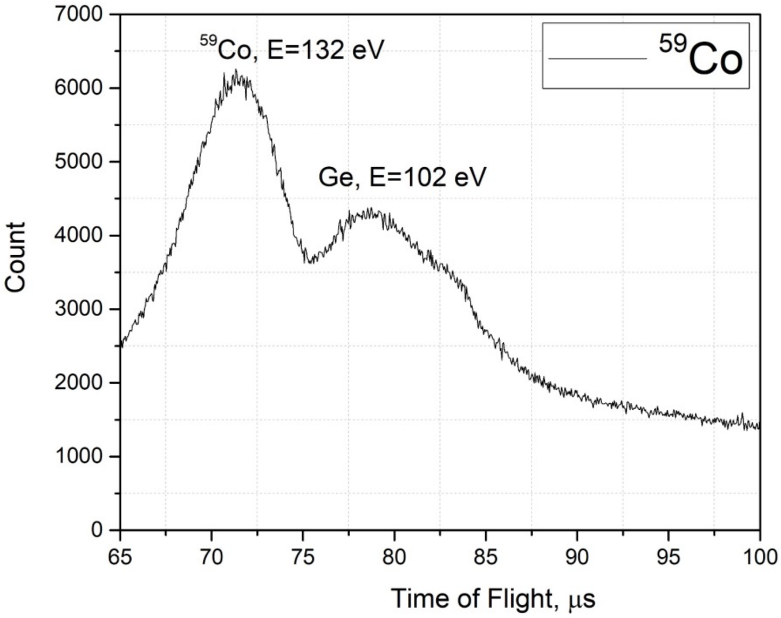


Figure 4. Part of TOF spectrum of ^{59}Co.

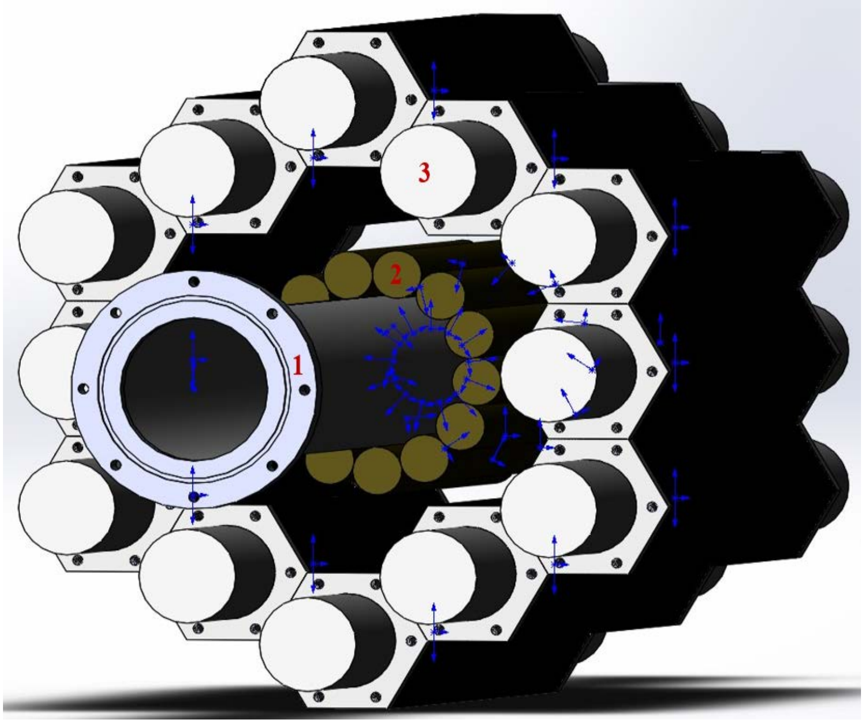


Figure 5. General view of the new detector system. 1 - neutron guide, 2 – CHM-17, 3 – NaI(Tl).

Forward-backward asymmetry will be investigated as shown in Figure 1, with a large number of detectors, and helium counters will be placed in front of the gamma detectors. To reduce the background and detect angular correlations, additional measurements are made on a larger flight base.

The angular distribution is analyzed under the assumption of interference between the s- and p-wave amplitudes, and the partial neutron width of the p-wave resonance will be obtained. This result should indicate that the T-breaking effect can increase in the same order as the P-breaking effect for the p-wave resonance. Therefore, an experiment to study T-violation in compound nuclear states is possible.

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