1.2. NUCLEAR PHYSICS WITH NEUTRONS

According to the recommendations of the VIII-th session of the JINR Program Advisory Committee for nuclear physics in the frame of scientific theme -0974-, a limited research program was realized in 1998 on the basis of the IBR-30 and other neutron sources, e.g., in ILL, LANL, FZK Karlsruhe, Peking and Kyoto Universities. The following main results were obtained.

Methodological investigations. Essential results were obtained in the creation of the new set-up KATRIN [7] for investigations of time invariance violation (TIV) in neutron induced reactions. The first polarization in a ^{3}He-based neutron polarizer with optical pumping was carried out in collaboration with a Lebedev institute group. Work to design and construct a prototype of the installation for investigations of fundamental symmetry violations (PNC and TIV) started in the frame of the new ISTC project (JINR-ITEP-Pulse Technique Institute collaboration). The aim of the project is the creation of a neutron polarizer and analyser with superconducting magnets and a large volume polarized nuclear target of the new type.

In 1998, in the first test of the new polarizer the neutron polarization about 45% was obtained (the rated value is 95 %).

A complex test of the KOLHIDA set-up was carried out on neutron beam #1 of the IBR-2 reactor. The first experiments confirmed the expected characteristics of the polarized neutron beam. These were verified by polarized neutron diffraction from a crystalline sample.

The first section (7m) of the new vacuum mirror neutron guide was assembled on beam #11 of IBR-2. After completion, this neutron guide is expected to increase the thermal neutron beam intensity over one order of magnitude.

Experimental investigations. At UGRA there were two experimental runs:

- the first measurements of the anisotropy of the elastic scattering of neutrons on a ^{238}U target in the keV energy range to estimate the possibilities of the extraction of information on the electric polarizability of the neutron;
- an investigation of a unique doublet of neutron resonances in 89Y at the neutron energy 11.6 keV with strong interference effects.

In the framework of the TRIPLE collaboration (Los Alamos) new important results were obtained for the mass dependence of the weak interaction spreading width (Fig.1):

$$\Gamma = 2\pi M / D.$$

Significant PNC effects were observed for ~ 70 p-wave neutron resonances in isotopic Nb, Rh, Ag, Pd, Cd, In, Sn, Sb, I, Cs, Xe, Th, and U targets.

The program of investigations of nuclear fission by resonance neutrons continued with the aim to study the process in the conditions when the spin and parity of a fissioning system are known. The realization is to conduct the most complete study of the investigated target nucleus. A typical example is a ^{235}U nucleus (spins of s-wave resonances are known from previous experiments with polarized neutrons and target nuclei). The measurements conducted at IBR-30 (in collaboration with Gatchina, Obninsk, Bratislava and Delft University) are: *P-even angular correlations of fission fragments* -Forward-backward, left-right (with polarized neutrons) and A2 anisotropy (with aligned target nuclei) (Fig.2); *P-odd angular correlations of fission fragments; mass&TKE distributions of f.fr. as functions of the neutron energy.*

The quantitative analysis of the results (doubled in statistics during 1998) of measurements of the fission fragment anisotropy of the s-wave resonance neutron induced fission of a ^{235}U aligned target was completed. The basic fission amplitudes described by parity π, spin J and its projection K onto the fission axis were extracted for all neutron resonances in the neutron energy range 0- 20 eV. It allows one to estimate, for the first time, in a direct and consistent way the

K-dependence of fission barriers for $J\pi$=3- states of the fissioning system ^{236}U and the degree of openness of different $J\pi K$ fission channels [8].

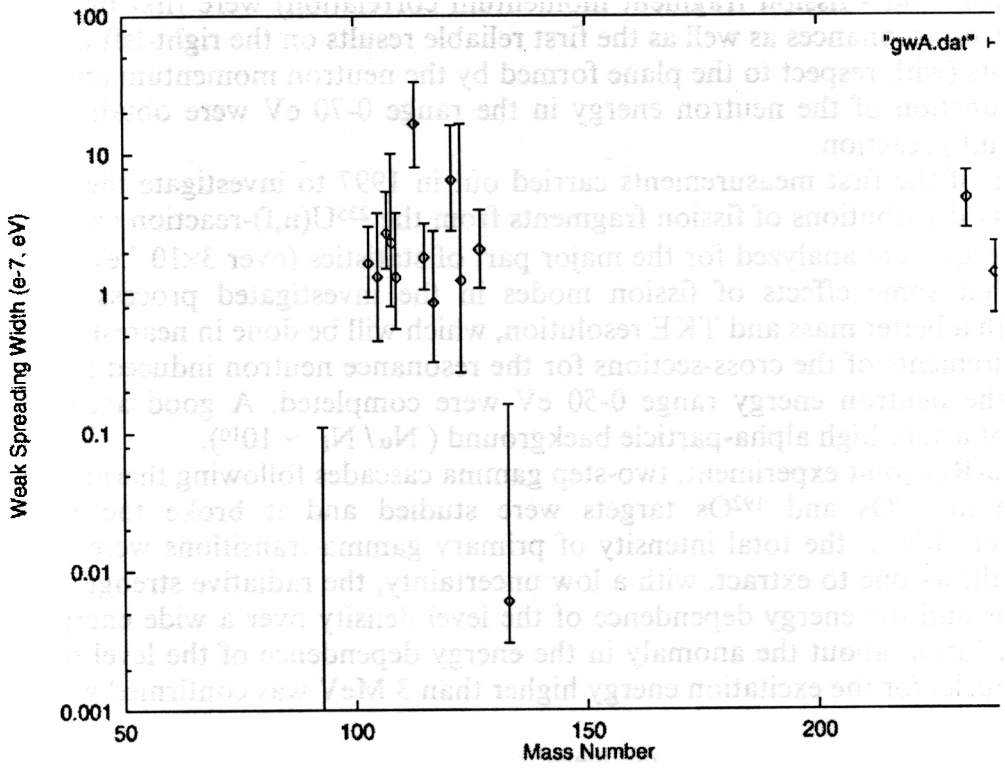

Fig.1. Mass dependence of the weak interaction spreading width.

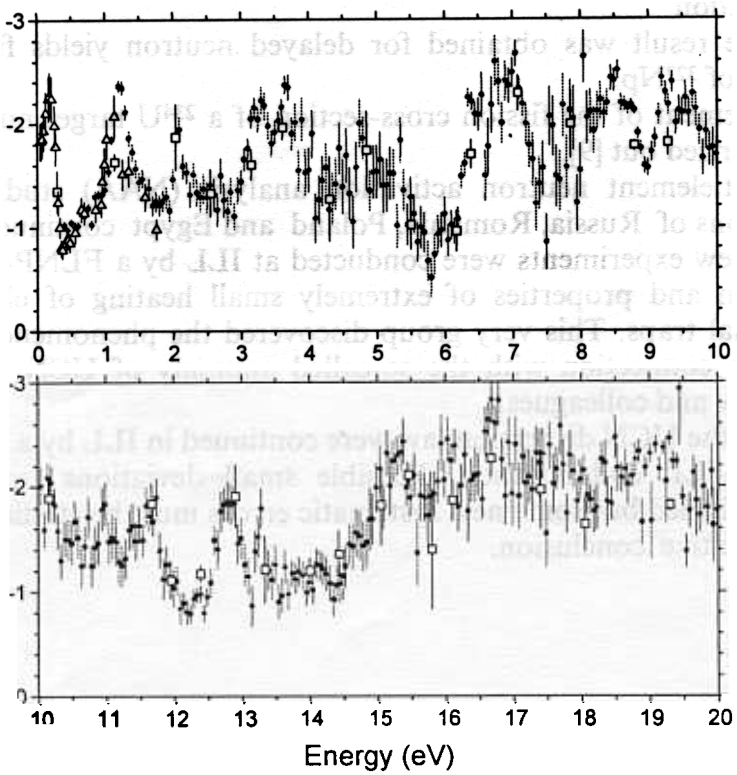

Fig.2. Energy dependence of the anisotropy coefficient A_2. Squares and triangles - data of Pattenden and Postma.

With the POLYANA set-up parity violating effects in the neutron induced fission of a ^{233}U target (neutron spin - fission fragment momentum correlation) were first observed for some p-wave neutron resonances as well as the first reliable results on the right-left asymmetry of fission fragments (with respect to the plane formed by the neutron momentum and the spin directions) as a function of the neutron energy in the range 0-70 eV were obtained for the investigated $^{233}U(n,f)$ reaction.

The results of the first measurements carried out in 1997 to investigate the mass and total kinetic energy distributions of fission fragments from the $^{235}U(n,f)$-reaction as a function of the neutron energy were analyzed for the major part of statistics (over 3×10^{7} events). The analysis shows that some effects of fission modes in the investigated process need new measurements with a better mass and TKE resolution, which will be done in nearest future.

The measurements of the cross-sections for the resonance neutron induced fission of a ^{243}Am target in the neutron energy range 0-50 eV were completed. A good accuracy was achieved in spite of a very high alpha-particle background ($N_\alpha / N_f \sim 10^{10}$).

In a Dubna-Rez joint experiment, two-step gamma cascades following thermal neutron radiative capture in ^{190}Os and ^{192}Os targets were studied and it broke the record of completeness. Over 90% of the total intensity of primary gamma-transitions were measured and analyzed. It allows one to extract, with a low uncertainty, the radiative strength function of such transitions and the energy dependence of the level density over a wide energy range. The previous conclusion about the anomaly in the energy dependence of the level density of heavy deformed nuclei for the excitation energy higher than 3 MeV was confirmed with a high level of confidence.

New nuclear data for astrophysics were obtained by a Dubna-TU Vienna-FZK Karlsruhe-University Tuebingen collaboration for very small 46 and 48Ca samples delivered from Dubna.

The total neutron transmission through thick ^{232}Th and ^{237}Np samples was measured in the neutron energy range 2 eV - 100 keV. These are important for solving the problem of nuclear waste transmutation

A more accurate result was obtained for delayed neutron yields from the thermal neutron induced fission of ^{327}Np.

The first measurement of the fission cross-section of a ^{234}U target nucleus induced by thermal neutrons was carried out [9].

A series of multielement neutron activation analysis (NAA) studies of ecological samples from some regions of Russia, Romania, Poland and Egypt continued successfully.

Three cycles of new experiments were conducted at ILL by a FLNP-PINP-ILL group to study the mechanism and properties of extremely small heating of ultracold neutrons (UCN) stored in material traps. This very group discovered the phenomenon in 1997 and it excited great interest in connection with the so-called anomaly of UCN storage observed earlier by Dr. A. Strelkov and colleagues.

Precision tests of the UCN dispersion law were continued in ILL by a FLNP- RRC KI-Melbourne University-ILL collaboration. Possible small deviations from the standard dispersion law were confirmed but some new systematic errors must be studied and eliminated to make the final quantitative conclusion.