1. SCIENTIFIC RESEARCH

1.1. CONDENSED MATTER PHYSICS

Organization of research work. In 2001 under theme 1031, neutron scattering investigations in condensed matter physics were mainly conducted at the IBR-2 reactor. Physicists of the Division carried out a number of experiments in neutron laboratories of Europe (ILL, RAL, PSI, BNC) under accepted proposals and with the electrostatic generator EG-5 and the X-ray diffractometer DRON in FLNP.

During the reported year IBR-2 operated 8 cycles for physical research. The IBR-2 spectrometers time was distributed in accordance with experts recommendations on the submitted proposals and existing long-term agreements. In 2001 the following 10 spectrometers were in the spectrometer user list: HRFD, DN-2, DN-12, SKAT, YuMO, SPN, REFLEX-P, KDSOG, NERA and DIN.

Instruments development. On the neutron Fourier diffractometer FSD for internal stress investigations in materials and engineering products, work on the detector system continued. By the end of the year measurements with its prototype consisting of two elements of ZnS(Ag)-screen-based ±90°-detectors and a Li-glass-based back-scattering detector had been conducted. In 2001 a working project for wide-aperture scintillation detectors of the new type was developed (**Fig.1**) and its realization started. The first elements of the new ±90°-detector will be ready by the summer 2002.

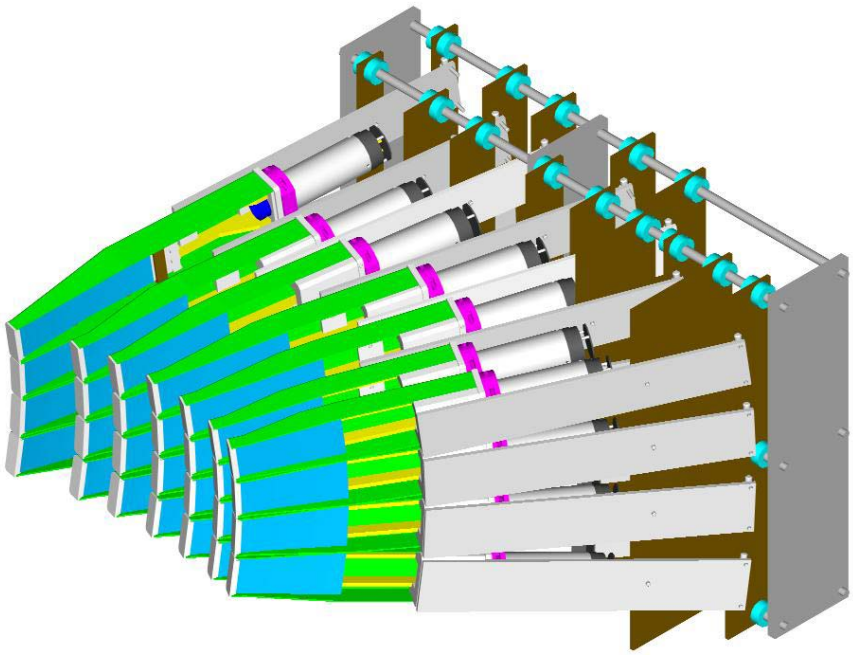

Fig. 1. A general view of the ±90-detectors of the diffractometer FSD made on the basis of ZnS(Ag)-scintillators.

On the spectrometer DN-12, a high-pressure cell of the toroidal type with tungsten carbide anvils made by IHPP (Troitsk) was successfully adapted. In 2001 there were thus created the following possibilities for conducting DN-12 experiments at high pressures. The spectrometer has a set of high-pressure cells with artificial sapphire and tungsten carbide anvils to provide pressure up to 10 GPa over the temperature range 15 to 300 K. The available *d*-spacing range is 0.5 – 12 Å at resolution $\Delta d/d \approx 0.015$. In spectroscopic experiments a cooled beryllium filter in inverted geometry providing the analyzed energy E=4.2 meV, available energy transfer range 5 – 200 meV and the resolution $\Delta E/E \approx 0.1$ and a pyrolytic graphite analyzer providing the analyzed energy E=14.9 meV, available energy transfer range 0 – 50 meV and the resolution $\Delta E/E \approx 0.05$ are used.

The next modernization stage of the small-angle spectrometer YuMO completed. A system for scattered neutron registration consisting of two ring detectors, the parameters of one being much improved, was put into regular operation. The vanadium reference unit for the determination of absolute cross section values is completely renewed. These, together with some other improvements, have increased the data accumulation rate 2 times, extended the momentum transfer dynamic range to 80 (about a 2 times increase) and dropped a low limit of available scattering vectors to $5 \cdot 10^{-3}$ Å^{-1} (for strong scattering samples) and to $6 \cdot 10^{-3}$ Å^{-1} (for medium scattering samples).

On SPN, the new head part containing the new polarization and collimation units was installed. We managed to create vacuum and conducted radiation situation monitoring. In January 2002 investigations of the spectrometer – measurements of the neutron beam and head part parameters, will start. On completion of the SPN project it will be possible to conduct experiments in two small-angle modes: to study voluminous samples (magnetics, superconductors) and layered structures.

An exclusively large volume of work to modernize the detector system was performed on the diffractometer EPSILON. Now the system includes 9 detector blocks with multi-slit radial collimators in front of each. The detectors are arranged on a ring at $2\theta=90°$, which allows an optimal combination of high luminosity and resolution. Compared with a previous variant of EPSILON the luminosity increased about 20 times.

On the diffractometer SKAT, the new system of collimators with an angular dispersion of 45' was tested in 2001. A three times gain in the integral intensity of diffraction peaks compared with previous collimators (18') was observed. At the same time, its relative resolution only decreased by ~25%. To extend the possibilities of rock texture studies, it is decided to restore the diffractormeter NSVR.

A technique for simultaneous in-beam measurements of elastic, deformation, structural and texture characteristics of geo-materials at temperatures up to 600ºC and single-axis compression to 10 kbar was developed in co-operation with IHPP. As a result, on SKAT and EPSILON it has become possible to carry out long-time experiments simulating geo-dynamic effects registering continuously changes in the physical and structure-texture properties of rock samples in the process of their deformation at high temperature and long-term single-axis loads.

The detector system of the KDSOG spectrometer was modernized. The mechanical elements of the detector, helium counters and electronic blocks were manufactured. A complete set of equipment of the modernized spectrometer is assembled and tuned on the spectrometer. The conducted experiments showed that an increased registration efficiency of the scattered neutrons resulted in a two times growth of the spectrometer's luminosity. Also, the sensitivity of the spectrometer (signal to background ratio) increased, which is important for the study of the dynamics of atoms in small or weakly scattering samples.

As far back as the late 1970's FLNP mastered the manufacturing of mirror neutron-guides with which some of IBR-2 beams were equipped. They helped increase considerably the thermal neutron flux on the sample and reduce the fast neutron background. In the mid 1980's the production of mirror-guides in FLNP was suspended due to objective reasons and the new IBR-2 spectrometers are equipped with neutron-guides produced by other organizations, first of all by PNPI (Gatchina). The demand for mirror-neutron guides is, however, so high that it was decided to

restore the FLNP line for cutting and spray-coating of neutron-guide mirrors. In 2001 the first stage of the restoration of the vacuum spray-coating facility completed and test coating with natural Ni of a float glass measuring 210 by 80 mm was carried out successfully.

Methodological work on the improvement of the parameters, experimental and primary data procession conditions continued on virtually all the IBR-2 spectrometers. For example, on the diffractometer HRFD control of the low temperature regulator DRC-91C was realized, the system for the accumulationи of high resolution spectra under VME control was improved and some additional functions and possibilities were introduced.

To widen the possibilities of neutron diffraction spectra processing, the program VMRIA was created on the basis of the MRIA packet. It includes Rietveld analysis of spectra from polycrystals, automated three-dimensional Fourier-synthesis, auto-indexing of diffraction reflexes and other necessary options.

Scientific results. <u>Diffraction.</u> The crystalline and magnetic structures of the new complex layered manganese oxides A_2MnGaO_{5+x} (A=Sr, Ca) synthesized in E.V.Antipov's laboratory of the Chemical Faculty in M.V.Lomonosov Moscow State University were studied. Their crystalline structure, which is a derivative of the perovskite structure, belongs to the brounmillerite type and consists of alternating (CaO), (MnO_2), (CaO) and (GaO) or (GaO_{1+x}) layers. Unlike wide-known Ruddlesden-Popper (RP) phases, in A_2MnGaO_{5+x} three cation-oxygen layers separate MnO_2 layers (in RP – two). As a result, the mean distance between manganese atoms in the plane (*a,c*) is usual for manganites (≈3.8 Å) but the distance in the perpendicular direction is about 8 Å and manifestations of two-dimensional (2D) magnetism may be expected.

In 2001, main attention concentrated on the compounds $Sr_2MnGaO_{5.0}$ and $Sr_2MnGaO_{5.5}$. It is established that at δ≈0 (+3 state of Mn) the structure is orthorhombically distorted (space group Ima2) and the size of the cell is about $a_p\sqrt{2}$ in the plane and about $4a_p$ in the perpendicular direction, where a_p≈3.8 Å is the parameter of the cubic perovskite cell. If δ≈0.5 (all Mn in state +4), the crystalline symmetry becomes tetragonal (P4/mmm). In spite of the anisotropy of the distances between Mn both compounds demonstrate a three-dimensional (3D) behavior of the magnetic structure. At the same time, in compounds with δ≈0 the magnetic moments of manganese are ordered antiferromagnetically at $T \le T_N \approx 180$ K, while in the oxidized state (δ≈0.5) the AFM order retains in the plane MnO_2 but changes to the ferromagnetic order in the perpendicular direction (T_N≈100 K). To interpret such an unusual behavior of the magnetic structure, a detail analysis of possible indirect interactions between Mn atoms needs to be carried out.

Another manganite investigated in the last two years is $(Nd_{1-x}Sr_x)(Mn_{1-x}Ru_x)O_3$. The idea of synthesizing such a compound consists of simultaneous and agreed doping of both A- and B-sublattices, which makes it possible to weaken or even exclude completely the double exchange mechanism (DE-mechanism) proposed as far back as the 1950's and since then, has been considered as a basis for the explanation of the metallic state of manganites as the ferromagnetic order arises in them. From this viewpoint, an interesting element to replace Mn in the B-sublattice is Ru as soon as partial overlapping of its 4*d* orbital with oxygen is similar to the interaction of the 3*d* orbital of manganese with oxygen. In addition, a less localization degree of 4*d* electrons in Ru than of 3*d* electrons in Mn must be favorable for the arising of metallic state. Another interesting aspect of the doping of manganites with ruthenium is the possibility of varying its oxidation degree as the states +3, +4, +5 can be obtained by different temperature processing of the compound in the air. Single-phase samples of the compounds $(Nd_{1-x}Sr_x)(Mn_{1-x}Ru_x)O_{3-\delta}$ with x=0.25, 0.5 and 0.75 were successfully synthesized in A.P.Kauli's laboratory of the Chemical Faculty in MSU. They were comprehensively characterized and studied by means of electric and magnetic measurements. To obtain information about the crystalline and magnetic structure of the samples, neutron diffraction experiments were conducted. It is shown that introducing equal amounts of Sr and Ru into the A- and B-sublattices results in stabilization of the ferromagnetic state (**Fig. 2**) but it does not suppress transition to metallic state (for details see Experimental reports).

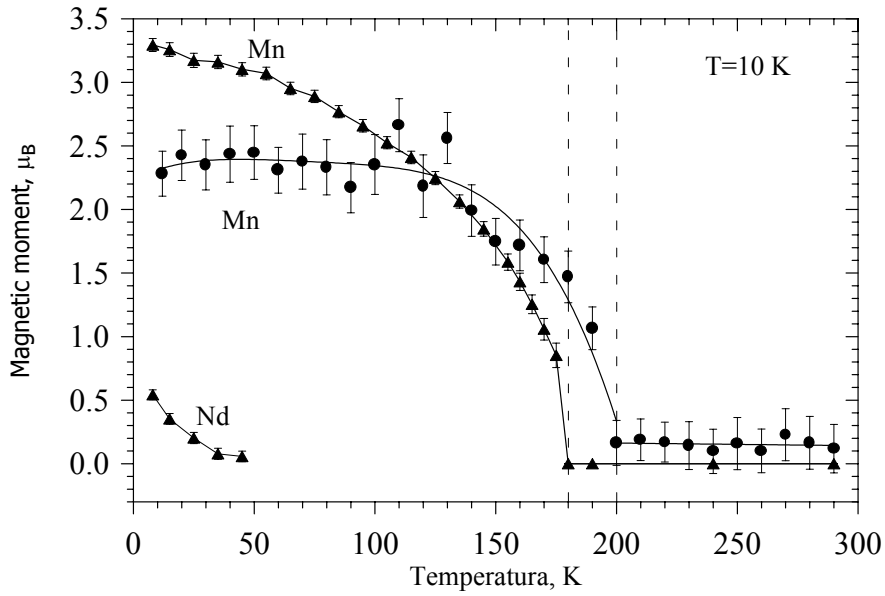

Fig. 2. The dependence of the Mn ordered magnetic momentum on the temperature for the compounds $(Nd_{0.5}Sr_{0.5})(Mn_{0.5}Ru_{0.5})O_3$ (●) and $(Nd_{0.75}Sr_{0.25})(Mn_{0.75}Ru_{0.25})O_3$ (▲). In the compound $(Nd_{0.75}Sr_{0.25})(Mn_{0.75}Ru_{0.25})O_3$ there also takes place the ordering of Nd at temperatures below 50 K. The dash line marks the temperatures of ferromagnetic phase transitions.

On DN-12, systematic investigations of the effect of high pressure on the atomic and magnetic structure of manganites started. As model compositions to be experimentally studied there was chosen $La_{0.67}Ca_{0.33}MnO_3$, that has a transition to the FM phase with a simultaneous transition from metallic to dielectric state at normal pressure, and $Pr_{0.8}Na_{0.2}MnO_3$ with single-valence cation replacement in the A-sublattice. In $La_{0.67}Ca_{0.33}MnO_3$ there was observed a transition from ferromagnetic to antiferromagnetic state at a pressure of 4 GPa with decreasing temperature (**Fig.3**) and in $Pr_{0.8}Na_{0.2}MnO_3$ there was discovered a change in the type of the antiferromagnetic structure with growing pressure.

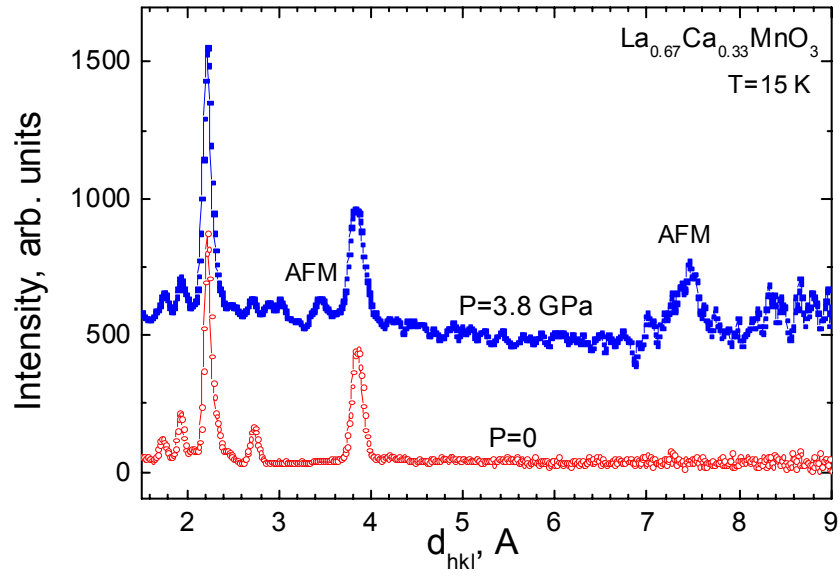

***Fig. 3**. A change in the diffraction spectrum of $La_{0.67}Ca_{0.33}MnO_3$ at 4 GPa due to transition of the structure from ferromagnetic to antiferromagnetic state.*

Magnetic phase transitions in manganese compounds – MnAs, Mn_2Sb, were investigated. In MnAs at the pressure P=4 GPa and the temperature below 80 K we have observed a magnetic phase transition to an earlier unknown phase. The atomic and magnetic structure of the high-pressure phase is determined. In Mn_2Sb at P=2.8 GPa and room temperature a spin-reorientation magnetic phase transition resulting in a deviation of Mn magnetic moments from the axis *c* of the tetragonal structure is observed.

Polarized neutrons and neutron optics. The fundamental issues of the physics of superconductors, namely the conditions of coexistence of superconducting and ferromagnetic states, were studied with the SPN spectrometer by the method of neutron reflection of Fe/V bilayers. Superconducting profiles of the reflection coefficient were measured. The experiment was conducted at temperatures above and below T=5 K which is a critical temperature of superconducting transition for voluminous vanadium. The obtained results point to the existence of the superconducting state at some temperature above the critical or the existence of temperature-reversal superconductivity. This is a new observation in the case of bilayer systems and it is necessary to be verified.

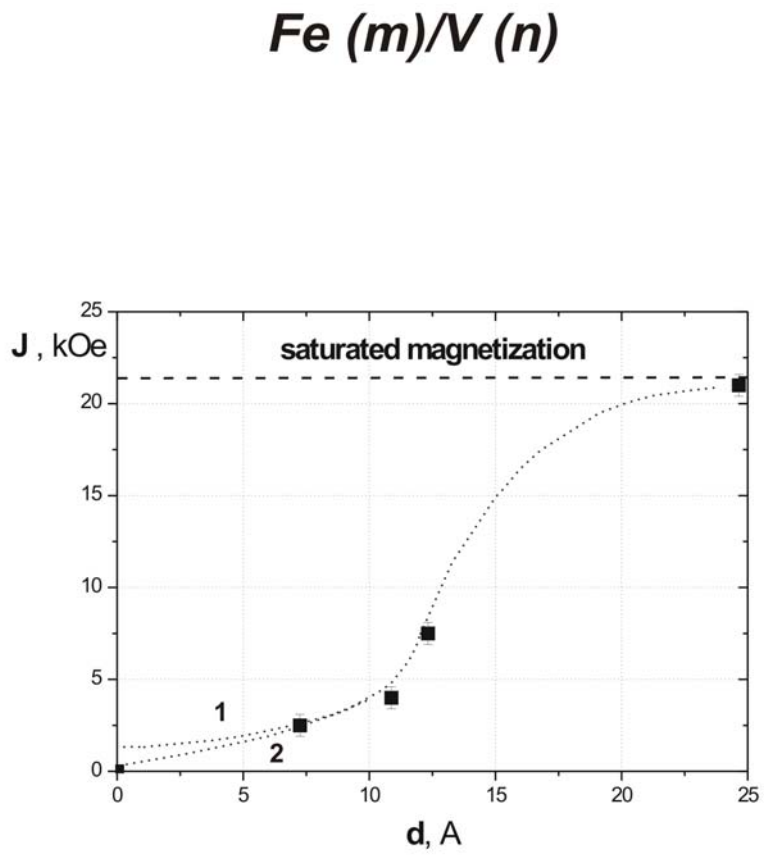

Fig. 4. *The magnetization of the iron layer in the periodic structure Fe(m)/V(n) as a function of the parameter p=m+n, where m and n are the number of Fe- and V-layers, respectively.*

This very Fe/V-structure is also used in experiments aimed at uncovering the reason for a decrease of the magnetic layer magnetization as its thickness increases, changes in magnetization over the thickness of the ferromagnetic layer and disagreement between the data on the local field on the iron nucleus and magnetization values. To this end, neutron reflection coefficients from the periodic structure Fe(m)/V(n) were measured for the different number of monolayers m and n. The experimental data confirmed by appropriate theoretical calculations show that the magnetization of the iron layer in the periodic structure Fe(m)/V(n) decreases with decreasing mean thickness of the layer d(Å)=1.45×(m+n)/2 (**Fig. 4**). For particular structures, such as Fe(5)/V(5), Fe(10)/V(5),

Fe(7)/V(10) and Fe(20)/V(14) characterized by the parameter *d*=7.25, 10.9, 12.3 and 24.7 Å, the mean magnetization of iron is 2.5, 4.0, 7.5 and 21.0 κOe, respectively. In addition, it has been established that magnetization changes over the thickness of the Fe/V bilayer, which definitely indicates that there occurs interpenetration of atoms in the neighboring layers.

The interaction between neutron radiation and an ultrasonic wave-excited structure has been investigated. For this purpose, measurements of the neutron reflection coefficient as a function the transferred momentum at total reflection from glass, diffractive reflection from a layered Fe/Cr structure, neutron wave field enhancement in the wave resonator and at neutron wave channeling in a titanium layer were conducted. The measurements were carried out with longitudinal and transversal sonic waves. It is obtained that in the case of transversal waves, the reflection probability is 5 times larger than in the case of longitudinal waves. This possibly points to the fact that in the case of longitudinal waves, the reflection of neutrons is from the nodes of the standing sonic wave. The phenomenon of a sound-stimulated transition of neutrons from one to another channeling mode is observed. The probability of such transition depends on the roughness of the interface, which can be used to increase the sensitivity of determination of parameters characterizing the interface (correlation length, mean square amplitude).

Formation of interphases and surfaces with self-recovering polymer multilayers was studied by registering two-dimensional distributions at specular and off-specular neutron reflection. To do this, multilayers of symmetric polystyrene-polybutylmetacrylate two-block copolymers P(dS-b-nBMA) were used. Modeling of the obtained results shows that main peculiarities observed at off-specular neutron reflection arise due to randomly distributed islands and holes in lamelar films and interphase structure (**Fig.5**). Estimation of the geometrical parameters of islands, holes and interphase fluctuations was performed.

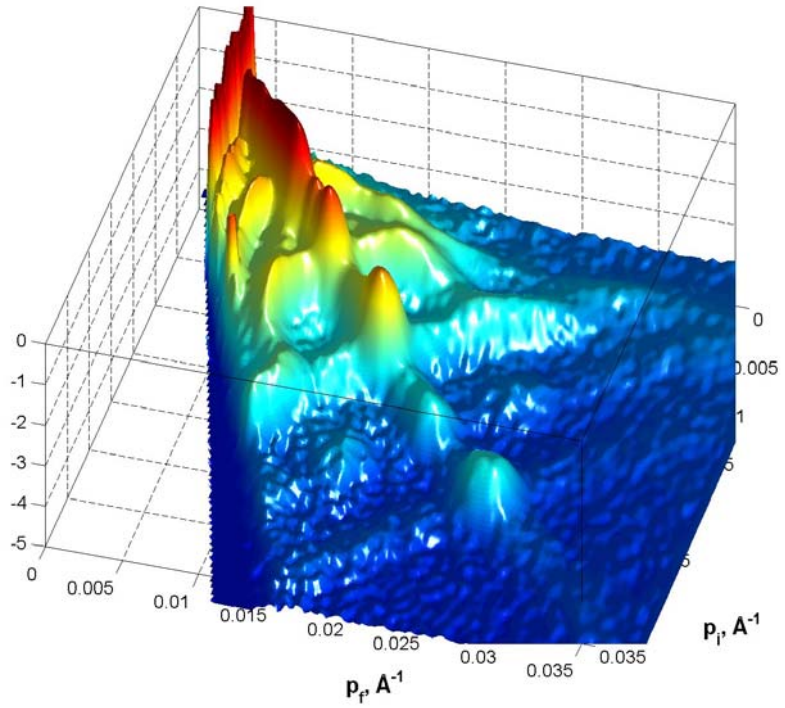

Fig. 5. *The coefficient of neutron off-specular reflection from multilayers of symmetric polystyrene-polybutylmetacrylate two-block copolymers P(dS-b-nBMA).*

Neutron wave channelling experiments continued with the aim to develop a new sensitive method for interphase investigations. To verify basic assumptions of the existence of the wave distribution of neutrons in the layer thickness of several thousand angstroms, different thickness layered structures were produced and measured on the spectrometers of polarized neutrons in FLNP

and Laue-Langevin Institute (Grenoble, France). The intensity dependence of neutrons emitted from a titanium layer 3000 Å thick was obtained and the channeling length was measured to be 10 mm. The conclusion is that the channeling length does not only depend on neutron capture in titanium but also on scattering on copper-titanium interphase roughnesses .

Experiments to observe surface magnons were carried out with a record level of sensitivity on the reflectometer REFLEX (**Fig. 6**). A ZnS(Ag)-scintillator-based detector of special design provided a background level of about 10^{-7} of the intensity level registered at neutron reflection from the surface of a FeCo multilayered structure. As model calculations have shown, the reflection curve leaving the reflection plane in the specular channel must have a kinematic cut off if the quadratic dispersion law holds for surface magnons. Preliminary experiments with a FeCo multilayer structure showed that though the cross section of neutron scattering on surface magnons is very small, the effect is above the sensitivity threshold and it can be measured.

Small angle neutron scattering (SANS). The physical chemistry of surface active substances (surfactants) was studied on the example of tetramethylammonium bromide by putting it in different solutions and by varying temperature. It has been shown that the size of micelles forming in the solution decreases with temperature. An interesting change in the form of micelles was observed. For example their spherical form changes to anisometric. As the concentration of NaBr in the solution increases, micelles change their form to rod-like. The experiment conducted at different electrolyte concentrations showed that changes in the form of micelles could occur due to their gradual dehydration.

The architecture of molecular rods formed in sulfonated poly(p-phenylene was studied in the polymeric net of polyacrylamide. This problem is related to the problem of increasing absorbing ability of hydrogels due to worsening of their mechanical properties at swelling. It is thought that new opportunities will open if rod-like electrolytes playing the role of reinforcing material are put in the hydrogel. SANS really helped to show that in the interior of the polymeric gel there could actually be formed liquid crystalline self-assembling rods (of nematic type). The interrelation between the parameters of the gel and the rods was also studied.

Small angle neutron scattering was used to study the structure of a bilayer of single-layer lipid vesicles. On the basis of a model describing the distribution density of the scattering ability of the bilayer's matter as a step-like function the thickness of the hydrophobic and hydrophilic components of the bilayer as well as the number of water molecules penetrating into the hydrophilic area of the membrane were determined from small angle scattering spectra. A promising step in small angle scattering spectra analysis is the creation of a model of separated form factors of lipid vesicles which would allow a transition from description of the scattering ability density across the membrane as a step-like function to description using more complicated functions.

The molecules of phospholipids have the anisotropy of diamagnetic susceptibility $\Delta\chi$. For a DMPC molecule in the liquid crystalline phase $\Delta\chi_{DMPC} = -1.06 \cdot 10^{-29}$ erg·G^{-2}. In spite of the smallness of $\Delta\chi$, submolecular ensembles of phospholipid molecules (vesicles, rod-like micelles) containing a large number of molecules ($>10^7$) could be oriented in strong magnetic fields of several teslas. At the same time, phospholipid aggregates could get deformed under the action of the magnetic field. The neutron diffraction method with DMPC multilayer vesicles oriented in the magnetic field helped establish the fact that their population is a mixture of spherical and elliptical vesicles (**Fig. 7**). It was experimentally proved that the extent of vesicle deformation (deviation from spherical form) depends on the phase of the membrane. In the liquid crystalline phase of the membrane the extent of deformation is approximately two times larger than in the gel state, which reflects the difference in the elastic properties of the membrane in the different phases. Applying the method of magnetic field orientation of mixed lipid/detergent aggregates we were able to refine the structure of the state formed before the rise of a lipid bilayer of mixed lipid/detergent micelles. This structure is a polymeric Gauss ball whose constituent element is a rod-like micelle of constant length. A nonstationary element of this polymer is the ends of rod-like micelles that seem to have an increased content of detergent. The experiments were performed with a mixed DMPC/$C_{12}E_8$ system.

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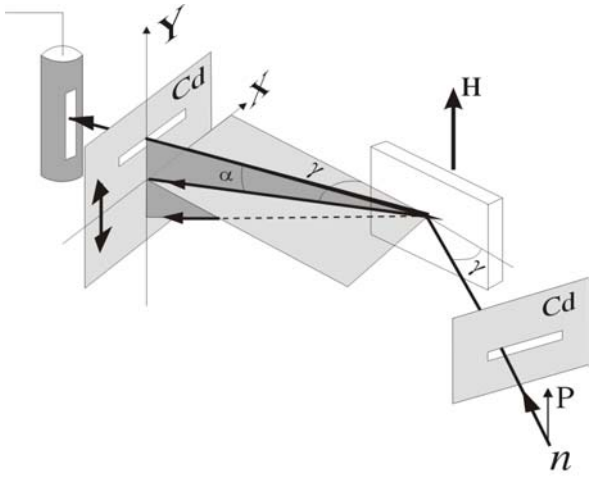

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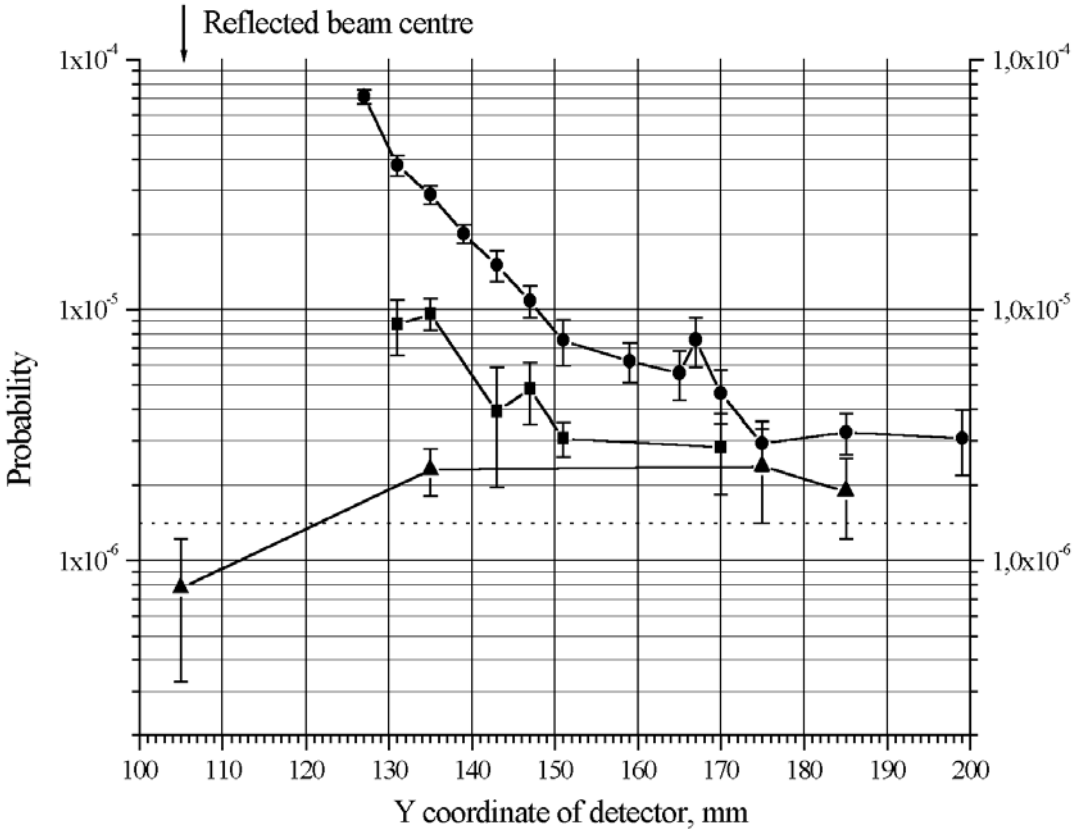

Fig. 6. The scheme of the experiment to search surface magnons (a). The beam of polarized neutrons collimated in a vertical plane reflects from a magnetized mirror in a horizontal plane at an angle of specular reflection γ. For a fixed angle of the detector, $\gamma_d=\gamma$, the detector executes vertical scanning (depending on the angle α). The intensity distribution of inelastically scattered neutrons (b). Circles – the ration of the scattered intensity in a vertical direction to the intensity of the specularly reflected beam. Squares – the same after reversing the incident beam polarization. The difference between the curves indicates that the scattering is of magnetic nature. The background is shown with triangles.

A real-time SANS experiment was made to register structural changes in the cubic lipid phase in the process of crystallization of bacteriorhodopsin (BR) from Halobium Salinarium with the aim of clearing up the mechanism of crystallization. The obtained data were then used to crystallize BR membrane proteins forming a proton pump and a membrane complex consisting of signal receptors and a transformer. As a result, we managed to obtain crystals of above components of extreme quality – it was possible to observe the diffraction pattern from them up to d≈1.2 Å. There is every reason to think that a three-dimensional diffraction experiment with the obtained crystals will make it possible to determine the atomic structure with a high resolution.

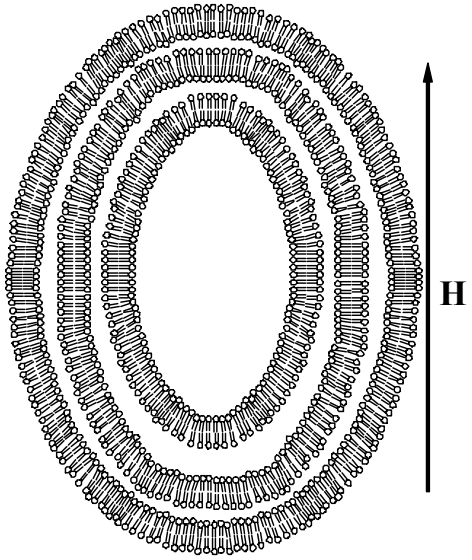

Fig. 7. *A schematic view of a multilayer lipid vesicle deformed in the magnetic field* ***H****.*

Inelastic neutron scattering. On the spectrometer KDSOG inelastic neutron scattering spectra of the recently discovered superconductor MgB_2 were measured and its generalized phonon state density was deduced. The first report about the superconductivity of MgB_2 by the group of J.Akimitsu appeared in January 2001 (see for details J.Nagamatsu et al., Nature, 410 (2001) 63) and it caused a great stir in connection with an unusually high superconducting temperature of T_c≈39 K for copper-free compounds. Moreover, this compound is remarkable for an extremely simple crystalline structure. Already in February 2001, several articles describing the properties of the new superconductor came to print stating that the majority of the described properties are in good agreement with estimates based on the classical BCS model, i.e. the setting on mechanism of superconductivity is electron-phonon. This determined the greatest importance of MgB_2 phonon state density measurements that were first conducted in FLNP. The measurements were carried out using a sample of natural boron isotope mixture, which caused serious experimental difficulties due to large absorption cross section. A high luminosity of the spectrometer and the right choice of the experimental geometry made it possible to measure the phonon spectrum with a high level of statistics **(Fig. 8).** The results of measurements allowed separation of several characteristic phonon bands to estimate the effective constant of electron-phonon interaction (see for details Experimental reports).

On the spectrometer NERA-PR neutron diffraction and neutron inelastic scattering investigations of dynamic properties and phase transitions in molecular and ion-molecular compounds continued. Attention focused on the study of dynamic disorder and glass-like phases in solid solutions and compounds containing molecular groups of the type CH_3, CH_4, H_2O and OH. These studies are being carried out in co-operation with institutes in Poland and Russia. The

obtained experimental results are checked with model calculations of the dynamics of crystals and molecules performed by molecular dynamics and theoretical quantum chemistry methods.

On DN-2 vibrational spectra of the ammonium halides NH_4Cl, NH_4Br, NH_4I were investigated at up to 8-10 GPa, which is a record pressure in the case of inelastic neutron scattering. In the area of the phase transition from disordered cubic to ordered cubic structure of the type CsCl, in NH_4Cl and NH_4Br there was observed a breaking on the baric dependence of the librational mode of ammonium. In NH_4I, hybridization of transverse optical and librational modes was observed at pressures higher than 6 GPa. The observed peculiarities in the dynamics of halides help understand better what causes the observed structural phase transitions in them.

Inelastic neutron scattering investigations of crystalline electric field effects (CEF) in the systems $RAgSb_2$ (R=Er, Tm, Ho) were performed. The CEF parameters, level schemes and the wave functions of each compound were determined. The temperature dependence of the magnetic susceptibility calculated along different crystallographic directions is in good agreement with the results of measurements of single crystals. Analysis of the results shows that the magnetocrystalline anysotropy in such compounds is mainly due to CEF.

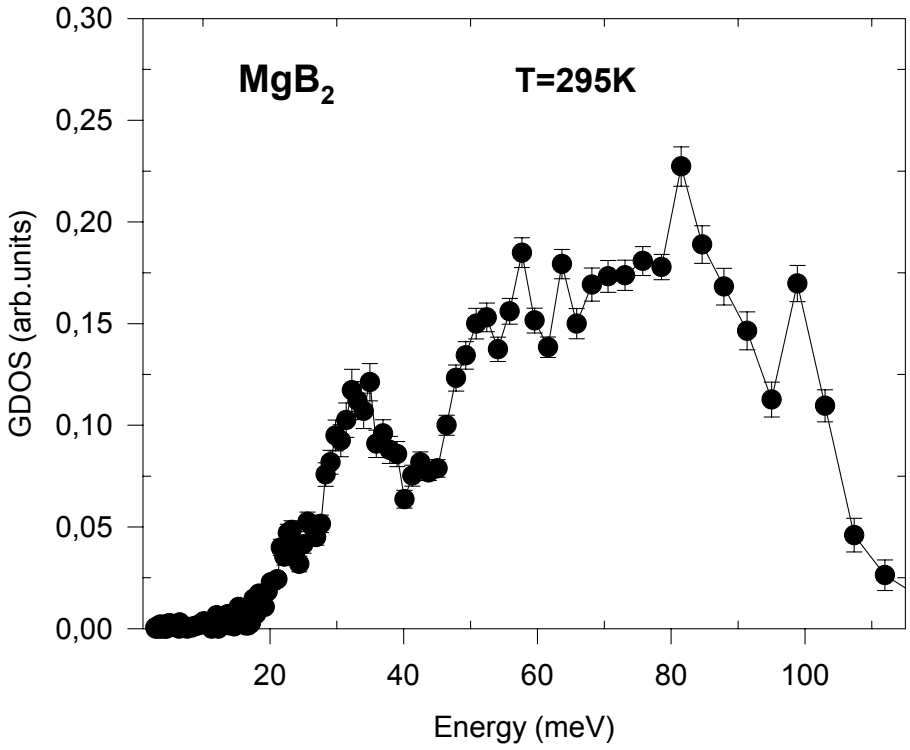

Fig. 8. *The generalized phonon states density of the new superconductor MgB_2 first measured with the spectrometer KDSOG in FLNP.*

On the spectrometer DIN-2PI complex investigations of microdynamic properties of the alloy Pb-K were carried out in the framework of a program for studies of prospective heavy heat-transfer agents for reactors of the new generation. There was investigated the microstructure of a Pb-K alloy around its eutectic composition at a temperature of 660 K for pure lead and Pb-K alloy and four concentrations of potassium: 25.0, 21.8, 14.1, 5.1%atm. It is observed that at lead concentrations lower than 10%, in the area of Q~1 $Å^{-1}$ there virtually disappears a peculiarity in the structural form factor that is conventionally considered to be evidence of the existence of clusters in the alloy and is clearly seen at higher potassium concentrations. Consequently, a Pb-K liquid metal system is an interstitial solution at lead concentrations around or lower than eutectic (9%atm). This means that addition of potassium actually modifies the physicochemical properties of lead in the required direction reducing its oxidation potential, which is particularly important for the perfecting

of the technology of liquid metal heat-transfer agents. It can be expected that such liquid metal system will have a number of advantages compared with pure lead when used as a heat-transfer agent in the reactor BREST.

Incoherent inelastic neutron scattering investigations of the dynamics of the metal-organic compounds A_2MeX_4, where A is the organic radical ($N(CH_3)_4^+$, $N(C_2H_5)_4^+$), Me is a metal (Zn, Cu, Cl), X is a halide, were conducted over a wide range of temperatures above and below phase transition points. Such compounds are of interest because of a strong complex effect of complete or partial organic group replacement on the structural organization and different types of structural instability. As a result of the conducted investigations, the mechanism of the observed phase transitions is proposed.

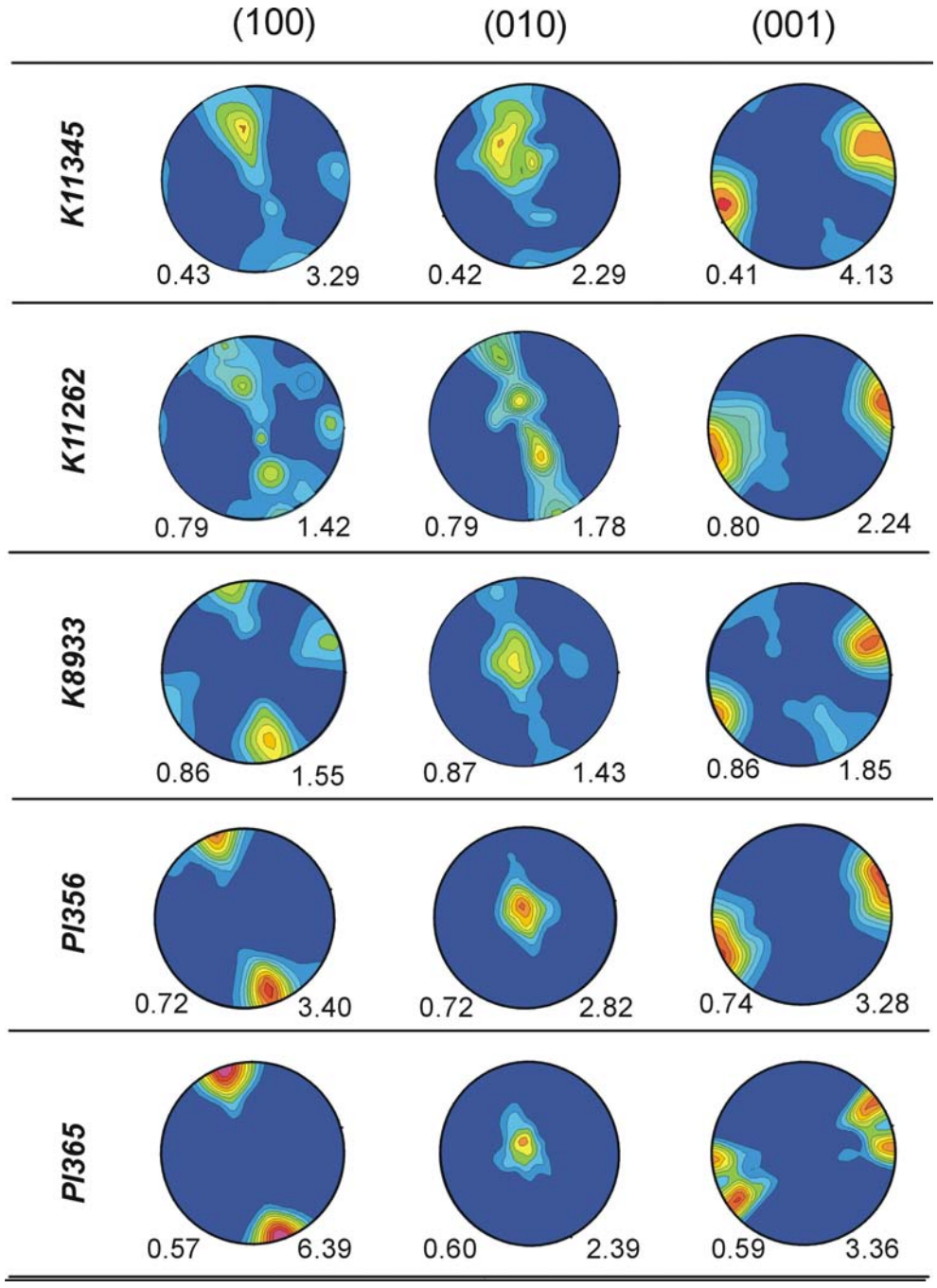

Fig. 9. *A comparison of the texture of mineral components in rocks recovered from various depths of the superdeep well SD-3 in Kola Peninsula with that of rocks in the natural outcrop.*

Geophysical investigations. Unique experimental data on the texture of rocks in the crust and upper mantle of the earth have been obtained. A collection of olivine-bearing mantle rock samples from the different areas in Europe was investigated. The quantitative texture analysis was applied to reconstruct the texture functions of ODF, and spatial distributions of elastic wave velocities in each of the investigated samples were theoretically modeled. The pole figures (PF) measured for olivine samples and data on the condition of plastic deformation in olivine were used as a basis for the determination of systems of slipping, as well as possible thermodynamic conditions and depths of texture formation.

Samples of Archean rocks from a super deep well СГ-3 in Kola Peninsula were studied. Their striking similarity not only in mineral composition but also in mineral component textures to the natural outcrop of rocks in a Kola series was discovered **(Fig. 9).** Microstructural and neutron diffraction investigations of samples taken deep from the earth crust as well as of their analogs from the surface reveal new peculiarities in the texture of these rocks, e.g., a more perfect dominating orientation of hornblende than of plagioclase grains and of plagioclase compared to quartz grains. Complex experiments at different hydrostatic pressures showed that the anisotropy coefficients of amphibolites from different depths in the SD-3 well decrease as the pressure, and correspondingly the depth, grows. The results have made it possible to explain the character of rock anisotropy at different depths on the basis of the new model of a texturised inhomogeneous fractured-porous medium.

Investigations of the effect of one-axis compression on internal microstresses in dolomite samples were conducted using a special deforming device. Under the action of different external loads there was investigated the value of residual strains and stresses in these samples. From the experimental data the Young coefficient values are obtained. The results of the texture measurements performed previous to the deformation experiments indicated the existence of a weak dominating orientation corresponding to the layered texture plane in dolomite.

Engineering investigations. Measurements of residual stresses in the elements of the VVER-1000 reactor jacket were performed in cooperation with research institutes of the RF Ministry of Atomic Energy. The investigated sample was a two-layer plate whose basic layer is made from the construction ferrite steel 15HGMFAA and the melted layer is from austenite stainless steel 12X18H10T. The σ_y component of the shell templet of the reactor jacket was investigated as a basic metal and as a melt. An analysis of the diffraction peak intensities revealed a strong texture in the austenite phase of the melt (for details see Experimental reports).

The first measurements to investigate residual stresses in graphite rods used in nuclear reactors were conducted. They show that there exists a clearly expressed broadening of diffraction peaks. This is possibly due to existence of strong microstresses in their graphite material.

Element analysis. The electrostatic generator EG-5 was successfully used for analytical investigations of the composition and structure of solid bodies **(Fig. 10).** Particularly, a number of investigations of SiC samples with implanted Fe^+ ions, hydrogen bearing fullerenes, carborundum films containing hydrogen, some geological samples, gallium arsenide implanted with indium were performed. The depth profiles of H, C, N, O and Si in carborundum samples from the Electrotechnical Institute in Bratislava were measured. In geological samples from Egypt a number of basic- and micro-elements from lithium to cadmium were discovered.

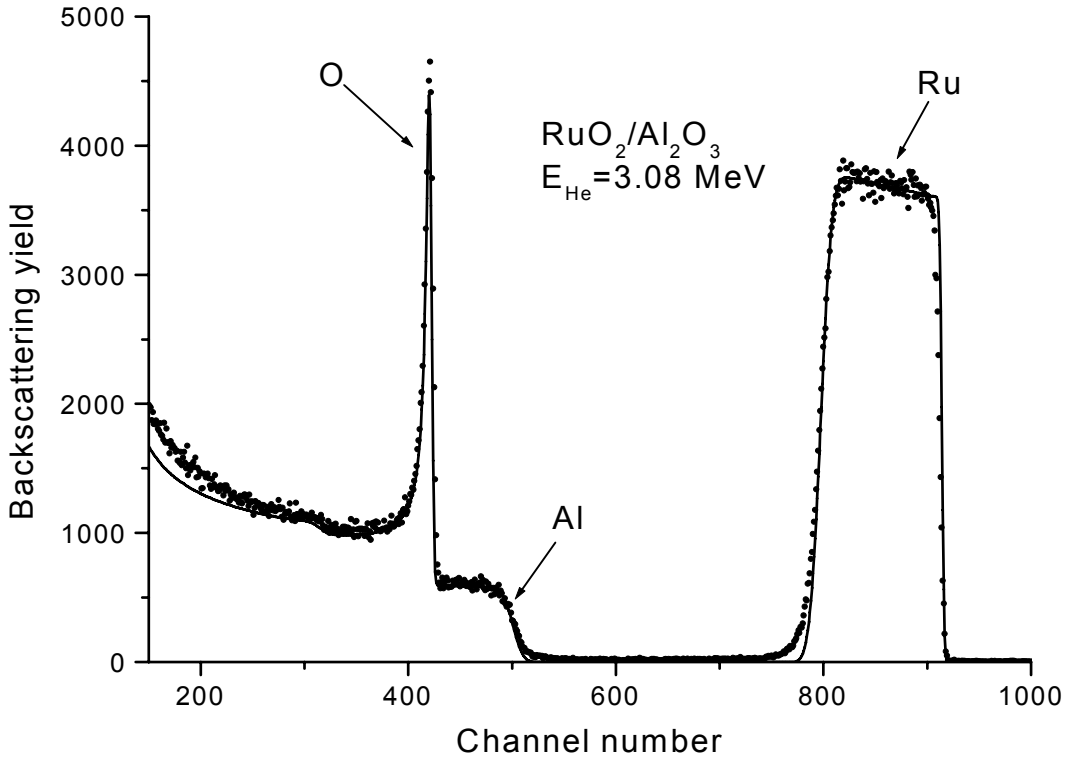

Fig. 10. *The experimental and calculated (solid line) spectra of the $^4He^+$ ions back scattered on a 680 nm RuO_2 film on a sapphire substrate.*