

**BRIEF REVIEW
OF THE SCIENTIFIC RESULTS OBTAINED
AT THE JOINT INSTITUTE FOR
NUCLEAR RESEARCH IN 2002**

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Brief Review of the Scientific Results Obtained at the Joint Institute for Nuclear Research in 2002

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Theoretical Physics

The superconformal structure of coset superspaces with the $AdS_m \times S^n$ bosonic subspaces was studied. Contrary to the widespread opinion, the coset supermanifolds $AdS_2 \times S^2$, $AdS_3 \times S^3$ and $AdS_5 \times S^5$, appearing as solutions of $D=4, 6, 10$ supergravities were found to be not superconformally flat. A group-theoretical explanation of this fact was provided and its application in the string theory was discussed. In particular, it was argued that some results obtained under the assumption of superconformal flatness should be revised.

- I. Bandos, E. Ivanov, J. Lukierski, D. Sorokin. JHEP. 2002. Vol. 0206. P. 040.

It is shown that the observed excess of positrons in cosmic rays observed by the HEAT (High-Energy Antimatter Telescope) and AMS (α -Magnetic Spectrometer) collaborations can be explained by the annihilation of neutralinos from the Dark matter in galactic halo. The estimated neutralino mass ~ 100 Gev is compatible with the global fit to all low-energy data within the Minimal Supersymmetric Standard Model.

- W. de Boer, C. Sander, M. Horn, D. Kazakov. Nucl. Phys. Proc. Suppl. 2002. Vol. 113. P. 221.

S-matrix thermodynamical approach was developed to describe processes of hadron multiparticle production. Based on this approach, the phenomenon of thermalization of the finite state was predicted in the very high multiplicity region and later confirmed by the preliminary data obtained in STAR experiments (RHIC, BNL).

- I.D. Manjavidze, A.N. Sissakian. TMF. 2002.
- I.D. Manjavidze, A.N. Sissakian. Mini-rapporteur report, ICHEP-31, Amsterdam, 2002.

- A.N. Sissakian. Report at the scientific session (27.11.02) of Division of Physical Sciences of the Russian Academy of Sciences (to be published in UFN).

On the basis of a combined reanalysis of the available data on the processes $\pi\pi \rightarrow \pi\pi$, $K\bar{K}$ in the channel with the vacuum quantum numbers, the $f_0(600)$ state with properties of the σ -meson is shown to exist. The result on this state is added to the database of a new issue of the "Review of Particle Physics" of 2002. The existence of the $f_0(600)$ meson and obtained $\pi\pi$ -scattering length ($a_0^0 = 0.27m_{\pi^+}^{-1}$) suggest the linear realization of chiral symmetry.

- Yu.S. Surovtsev, D. Krupa, M. Nagy. Eur. Phys. J. 2002. A 15. e-Print Archive: hep-ph/0204007.

A finite rank separable approximation for particle-hole random phase approximation calculations with Skyrme interactions was extended to take into account the pairing correlations. Thus, a possibility of solving the RPA problem in very large configuration space appeared. Properties of low-lying quadrupole and octupole vibrational states in nuclei away from stability were studied.

- A.P. Severyukhin, Ch. Stoyanov, V.V. Voronov, Nguyen Van Giai. Phys. Rev. 2002. C 66. P. 034304.

Recent data of lattice measurements of the gauge-invariant nonlocal scalar quark condensates are analyzed to extract the short-distance correlation length, $1/\lambda_q$, and to construct an admissible Ansatz for the condensate behaviour in a coordinate space. The correlation length values appear in a good agreement with the well-known QCD SR estimates of the mixed quark-gluon condensate, $1/l_{lat}^2 \approx \lambda_q^2 = \langle \bar{q}(ig\sigma_{\mu\nu}G_{\mu\nu})q \rangle / \langle \bar{q}q \rangle = 0.4-0.55 \text{ GeV}^2$.

- A.P. Bakulev, S.V. Mikhailov. Phys. Rev. 2002. D65. P. 114511(14).

The nonperturbative contribution to the asymptotics of the quark form factor is found within the instanton model of the QCD vacuum using the Wilson loop method. It is demonstrated that the instanton effect produces significant corrections to the perturbative part at momenta transfer squared of the order of 1 Gev².

- A.E. Dorokhov, I.O. Cherednikov. Phys. Rev. 2002. D 66. P. 074009.

The new theoretical model was developed to study the ω -meson photoproduction by taking into account all known baryon resonances listed in Particle Data Group, and other mechanisms of photoproduction. The theoretical problem of self-consistent description of the high-spin resonances and their interactions with mesons and nucleons was solved. The model opens a possibility of calculating unpolarized observables and all the spin correlations.

- A.I. Titov and T.S. H. Lee. Phys. Rev. 2002. C 66. P. 015204.

For the free models of statistical mechanics on torus, exact asymptotic expansions of the free energy, the internal energy and the specific heat in the vicinity of the critical point are found. It is shown that there is a direct relation between the terms of the expansion and Kronecker's double series. The latter can be expressed in terms of the elliptic theta-functions in all orders of the asymptotic expansion.

- E.V. Ivashkevich, N.Sh. Izmailian, Chin-Kun Hu. J.Phys. 2002. A Math. Gen. 35. P. 5543.

Several novel phenomena in a twisted superconductor (containing a small annular *SIS*-type contact) under the influence of thermal gradient and applied magnetic field were predicted, including a torsional analog of Josephson piezomagnetism and magnetomechanical effect. A giant enhancement (reaching

500 %) of electronic contribution to the thermal conductivity of a granular superconductor in applied electric field was predicted within the model of inductive Josephson junction arrays.

- S.A. Sergeenkov. JETP Letters. 2002. Vol. 75. P. 317.
- S.A. Sergeenkov. JETP Letters. 2002. Vol. 76. P. 170.

Particle Physics

With considerable contribution of the LPP physicists to the NA48 experiment (CERN) the most precise result on the measurement of the direct CP-violation effect has been obtained from the analysis of data on the decays of neutral kaons into two pions [1]:

$$\text{Re}(\varepsilon' / \varepsilon) = (14,7 \pm 2,2) \times 10^{-4} .$$

The precision measurement of the K_S^0 lifetime has been performed also [2]:

$$\tau(K_S^0) = (0.89598 \pm 0.00048(\text{stat.}) \pm 0.00051(\text{syst.})) \times 10^{-10} \text{ s} ,$$

as well as measurements of the K^0 - and η -meson masses have been considerably improved [3]:

$$m(K^0) = 497,625 \pm 0,031 \text{ MeV}/c^2 , \quad m(\eta) = 547,843 \pm 0,051 \text{ MeV}/c^2 .$$

The decay rate of $K_L^0 \rightarrow \pi^0 \gamma \gamma$ has been measured [3]:

$$\text{Br}(K_L^0 \rightarrow \pi^0 \gamma \gamma) = (1,36 \pm 0,031(\text{stat.}) \pm 0,03(\text{syst.}) \pm 0,03(\text{norm.})) \times 10^{-6} ,$$

and the vector coupling constant for this process is

$$a_v = -0,46 \pm 0,03 (\text{stat.}) \pm 0,0 (\text{syst.})$$

This result indicates that CP-violation effects are dominating in the $K_L^0 \rightarrow \pi^0 \gamma \gamma$ decay [4].

- [1] J.R. Bartley et al., Phys. Lett. 2002. Vol. B544. P. 97.
 [2] A. Lai et al., Phys. Lett. 2002. Vol. B537. P. 28.
 [3] A. Lai et al., Phys. Lett. 2002. Vol. B533. P. 196.
 [4] A. Lai et al., Phys. Lett. 2002. Vol. B536. P. 229.

Dubna group actively participates in the analysis of the **HERMES** (DESY, Hamburg) polarized data to study the Q^2 dependence of the generalized Gerasimov-Drell-Hearn integral for the deuteron and neutron. The deuteron tensor asymmetry and structure function b_1 have been measured for the first time over the kinematic range $0,0021 < x < 0,85$ и $0,1 \text{ GeV}^2 < Q^2 < 20 \text{ GeV}^2$, where x is the Bjorken scaling variable, and Q is momentum transferred. The single spin azimuthal asymmetry in exclusive electro-production of π^+ mesons has been measured also for the first time in deep inelastic scattering of positrons and the longitudinally polarized protons.

- A.Airapetian et al., Phys. Lett., vol. B535 (2002) P. 85.

Data taking and analysis of the data obtained earlier by the **NA49** collaboration are continued. New results have been presented on the study of production of Λ hyperons, charged pions and kaons in central interactions Pb+Pb at 40, 80 and 158 A·GeV.

- S.V. Afanasiev et al., Phys. Lett. 2002. B538. P. 275-281.
- S.V. Afanasiev et al., J. Phys. 2002. G28. P. 1761-1768.
- S.V. Afanasiev et al., Nucl. Phys. 2002. A698. P. 104-111.

Hadron energy reconstruction for the **ATLAS** barrel prototype combined calorimeter, consisting of the lead-liquid argon electromagnetic part and the iron-scintillator hadronic part, in the framework of the non-parametrical method was realized. The essential new feature of the method is that it uses only the known e/h ratios and the electron calibration constants and does not require the determination of any parameters by a minimization technique; therefore this new method can be used for the fast energy reconstruction in the first level trigger. The obtained reconstruction of the mean values of energies is within $\pm 1\%$ with

respect to $\pm 2\%$ in the technical proposal. The results of the study of the longitudinal hadronic shower development are presented. The data have been taken in the H8 beam line of the CERN SPS using pions of 10 – 300 GeV.

- S. Akhmadaliev et al. NIM A. 2002. 480. P. 506-521.

The **DIRAC** experiment is aimed to measure the lifetime of $\pi^+\pi^-$ atoms in the ground state with a 10% precision using the 24 GeV/c proton beam of the CERN Proton Synchrotron. As the value of the above lifetime of the order of 10^{15} s is dictated by a strong interaction at low energy, the precise measurement of this quantity enables one to determine a combination of S-wave pion scattering lengths to 5%. Pion scattering lengths have been calculated in the framework of the chiral perturbation theory with a high precision. Thus, the accurate measurement of these values would put the understanding of chiral symmetry breaking of QCD to a crucial test.

In 2002 the new third plane of Scintillating Fiber Detector has been produced and implemented in the setup to improve event selection accuracy. A data acquisition run of six-month duration has been conducted at the accelerator PS, CERN.

- L.G. Afanasev, V.V. Karpukhin, A.V. Kulikov and M. Gallas. NIM A. 2002. 479. P.407–411.
- L. Afanasyev et al. NIM A. 2002. 491. P.376-389.
- L. Afanasyev and V. Karpukhin. NIM A. 2002. 492. P.351-355.
- L. Afanasyev et al. (DIRAC Collaboration), Proc. Int. Conf. on High Energy Physics [ICHEP 2002]. 24-31 July 2002. Amsterdam.

Relativistic Nuclear Physics

Three runs of the Nuclotron were performed in 2002. In the March run the intensity of the external beam of magnesium ions was increased up to $\approx 10^8$. The

final calibration of the equipment was carried out on this beam for the joint experiment PAMELA (Italy-Russia)

- CERN Courier, 2002. Vol. 42. Num. 8. P.24-23.

In the summer run of the Nuclotron the ions of argon were accelerated for the first time with the intensity of $1,4 \cdot 10^6$ and $E_K \approx 1$ GeV/n. In December the polarized deuteron beam was accelerated and extracted from the Nuclotron with the energy of more than 2 GeV/n and beam intensity of $1,35 \cdot 10^8$ particles per cycle.

The application of the new generation of the wet turboexpanders has increased the efficiency of the helium refrigerators of the Nuclotron by more than 25%.

- N.N. Agapov et al., Advances in Cryogenic Engineering AIP, Meville, New York. 2002. V.47A. P. 280.

In the frame of the experiment MSU-SPHERE the damping of the analyzing power of the nucleon-nucleon interaction at scattering on the inner nuclear nucleons was measured for the first time at the synchrotron on the beam of stripping polarized protons. A preliminary analysis of the obtained data has shown that the damping of the analyzing power for scattering on protons and neutrons at the investigated energies on nuclei of carbon and copper is practically the same.

On the basis of the reaction $dp \rightarrow (pp)n$, the estimation of the spin-dependent part of the $np \rightarrow pn$ amplitude has been done under the conditions of full geometry.

- V.V. Glagolev et al., Eur. Phys. J. A. 2002. epja1401.

The scientific goal of the FASA project is to study the thermal nuclear multifragmentation induced by the light relativistic ions in the heavy targets (Au).

This corresponds to the onset of the multifragmentation of nucleus entering the phase coexistence (spinodal) region. Due to the density fluctuations, a homogeneous system converts into a mixed phase, consisting of charged droplets (IMF's) surrounded by the nuclear gas. The measured mean life time of the fragmenting system for p (8.1 GeV) + Au collisions is always $\tau \leq 70$ fm/s. The measured time-scale is close to that for the density fluctuation in the diluted nuclear system. So, the thermal multifragmentation can be interpreted as the first order nuclear *liquid-fog* phase transition in the spinodal region.

- S.P. Avdeyev et al., Nucl. Phys. 2002. A 709. P. 392.
- V.K. Rodionov et al., Nucl. Phys. 2002. A 700. P. 457

The facility WASA/PROMICE in the beams of the accelerator CELSIUS (Uppsala, Sweden) has obtained experimental data on the mechanisms of the proton-proton and proton-deuteron interactions in the over threshold energy region. The differential cross-sections of the reaction $pd \rightarrow {}^3\text{He} + \eta$ have been measured in the energy interval of the protons from 930 to 1100 MeV. For the first time in the exclusive performance the reaction $dp \rightarrow dp\gamma$ has been studied experimentally in the energy interval from 436,7 to 559,0 MeV. The reaction $pp \rightarrow pp\pi^+\pi^-$ has been also studied for the first time with the bigger statistics near the energy threshold.

- R. Bilger et al., Phys. Rev. C. 2002. Vol. 65. P. 044608.
- J. Greff et al., Phys. Rev C. 2002. Vol. 65. P. 034009.
- W. Brodski et al., Phys. Rev. Lett. 2002. Vol. 88, n.19. P. 192301.

Heavy Ion Physics

Main attention in 2002 was paid to the experiments aimed at the synthesis of element Z=118 in the reaction ${}^{249}\text{Cf} + {}^{48}\text{Ca}$. In the course of the irradiation of a target with a ${}^{48}\text{Ca}$ ion beam dose of $2.62 \cdot 10^{19}$, the detector system of the Dubna

gas-filled recoil separator registered two events indicating the formation and decay of the nucleus with $Z=118$. A chain of correlated decays $R-\alpha_1-\alpha_2-SF$ and a correlated decay $R-SF$ were observed in the first and second events, respectively. Both events correspond to the excitation energy $E_x=30.0\pm 2.5$ MeV of the compound nucleus $^{297}118$ near the maximum of the $3n$ -evaporation reaction channel with the cross section of about 0.5 pb. It has been established that the sequential α -transitions in the case of the first event correspond to the nuclear decays in the chain $^{294}118 \rightarrow ^{290}116 \rightarrow ^{286}114$.

- Yu.Oganessian, et al., JINR Preprint. 2002. E7-2002-X.

Relatively long half-lives of the isotopes with $Z=108 \div 114$, produced in the ^{48}Ca -induced reactions, open up new opportunities for the investigation of chemical properties of superheavy elements. According to theoretical predictions, element 112 (E112) must belong to the IIB group: Zn-Cd-Hg-E112. The 3-min isotope $^{283}112$ can be produced with a cross section of about 5 pb in the reaction $^{238}\text{U}(^{48}\text{Ca},3n)$. As the first step, we developed a method for the separation and detection of Hg. Experimental data obtained in 2002 showed that the chemical behavior of element 112 is similar to that of a noble gas and differs from that predicted for eka-Hg.

- A.Yakushev, et al. Submitted to Radiochim. Acta.

The mechanisms of formation and decay of heavy and superheavy nuclei were investigated in reactions leading to the formation of nuclei with $Z=102 \div 122$. It has been found that the mass distribution of fission fragments for the compound nuclei $^{286}112$, $^{292}114$, $^{290,296}116$, $^{302}120$ and $^{306}122$ is an asymmetric one, whose nature, in contrast to the asymmetric fission of actinides, is determined by the shell structure of the light fragment with the average mass 132-134. It has also been found that the cross sections of the fusion-fission reactions

between ^{48}Ca and ^{58}Fe change very slowly with an increase in the charge and mass of the target nuclei, which is of great importance for planning new experiments on the synthesis of superheavy nuclei with $Z > 110$.

- M. Itkis, et al., J. Nuc. Radiochem. Sci. 2002. Vol.3. P. 57.

For the theoretical description of the investigated processes a new approach based on the extended version of the double-center shell model was developed. For the first time the lower limits for the fission barrier heights of $^{283-286}_{112}$, $^{288-292}_{114}$ and $^{292-296}_{116}$ (5.5, 6.7 and 6.4 MeV, respectively) were derived. The new data explain the relatively high stability of these nuclei.

- M. Itkis, Yu. Oganessian, V. Zagrebaev, Phys.Rev. 2002. C65. P. 044602.

For further investigations of the resonance states of ^4H and ^5H , transfer reactions occurring in the bombardment of a liquid tritium (deuterium) target with tritons were used. In the reactions $t+d \rightarrow p+^4\text{H}$, $t+t \rightarrow p+^5\text{H}$ and $t+t \rightarrow d+^4\text{H}$, protons/deuterons in coincidence with complementary tritons emitted from the target were detected. A state of ^4H with $E_{\text{res}}=3.22 \pm 0.15$ MeV and $\Gamma_{\text{obs}}=3.33 \pm 0.25$ MeV was obtained in the $t+d$ reaction from the spectra of protons leaving the target at $\theta_{\text{lab}}=18^\circ-32^\circ$ and detected in coincidence with tritons. A substantial fraction of protons detected in the $t+t$ reaction at $\theta_{\text{lab}}=18^\circ-32^\circ$ in ptn coincidence events was attributed to the states of the ^5H nucleus. At ≈ 2.5 MeV above the tnn decay threshold, the ^5H spectrum shows a narrow maximum followed by a wide structure at 4-7 MeV.

- M.Golovkov, et al. Submitted to Phys. Lett. B.

Development of the accelerator technique was focused on the realization of the project DRIBs (production of radioactive ion beams at Dubna cyclotrons). According to the schedule of stage I of the project, a complex for the generation, ionization and separation of ^6He and ^8He ions was created and tested at the ^7Li

beam of the U400M cyclotron. A radioactive beam of ${}^6\text{He}$ was transported from the U400M cyclotron hall to a distance of 120 m and accelerated up to an energy of 15 MeV/A using the U400 cyclotron.

- V. Bashevoy, et al., Nucl. Phys. 2002. A701. P. 592.

Low- and Intermediate-Energy Physics

A new low-background spectrometer TGV-2 with high efficiency was created from construction materials of very low level of radioactive impurities. The spectrometer is intended for the investigation of rare nuclear processes $2\beta 2\nu$, $2\beta 0\nu$ decays of ${}^{48}\text{Ca}$ and $2K2\nu$, $2K0\nu$ decays of ${}^{106}\text{Cd}$. The spectrometer is based on 32 planar type HPGe detectors with a total sensitive volume of about 400 cm^3 (about 3 kg of Ge) and consists of a cryogenic system, an electronic scheme of events registration, a passive shielding and methods of active suppression of various components of natural background. The TGV-2 spectrometer was mounted in the Modane underground laboratory (4800 m w.e.), France.

Measurements with an external source of 24.6 g of enriched ${}^{48}\text{CaF}_2$ (about of 10 g of ${}^{48}\text{Ca}$) were performed and new limits on β^- decay of ${}^{48}\text{Ca} \rightarrow {}^{48}\text{Sc}$ and β^- decay of ${}^{48}\text{Ca}$ to excited states of ${}^{48}\text{Ti}$ were obtained.

- A. Bakalyarov et al., Nuclear Physics. 2002. A 799. P. 17-24.
- A. Bakalyarov et al., Pis'ma v JETP. 2002. Vol.76. No.9. P. 643-644.

The reaction of the meson-less deuteron break-up $p+d \rightarrow p+p+n$ at high momentum transfer is studied with the ANKE spectrometer at the internal beam of the proton synchrotron COSY /Jülich/. The ANKE collaboration has obtained the data on the break-up with emission of a pair of fast protons with low energy E_{pp} of the relative motion in the pair. The pairs are emitted at small angles to the direction of the proton beam. The break-up differential cross section, integrated over $E_{pp} < 3\text{ MeV}$ and averaged over the pair ejection polar angle from 0° to 8° ,

was determined. The obtained cross sections decrease with increase of the proton beam energy (which energy is varied from 0.6 to 1.9 GeV) in the same way as the proton-deuteron backward elastic scattering $pd \rightarrow dp$ cross section does, but the values are two orders of magnitude less.

- V. Komarov, et al. Submitted to Phys.Lett.B. 2002. *nucl-ex/0210017*.

Under joint project of JINR and INFN, Italy (DUBTO), the goal of which consists in the investigation of pion-nuclear interactions at energies below the Delta-resonance, the experimental setup STREAMER was created. The setup is a self-shunted streamer chamber, filled with helium. The chamber is situated in a magnetic field. In 2002 the accumulated statistics reached 5000 events of pion-helium interactions.

- E.M. Andreev et al., Nucl. Instr. and Meth. 2002. A489. P. 99.

Under LESI project measurements are performed of the ion energy distribution in a deuterium liner accelerated in the inverse Z-pinch, in which the plasma is accelerated electrostatically from the liner axis. Experiments were carried out in a high-current pulsed accelerator ($I = 950$ kA, $\tau = 80$ ns) at the Institute of High-Current Electronics of the Siberian Division of the Russian Academy of Sciences (Tomsk, Russia). In the initial state, the liner is a supersonic hollow deuterium jet 32 mm in diameter and 20 mm in length. The results obtained by simultaneously analyzing the data from magnetic probes, optical detectors, and neutron detectors point to the possibility of using a rather simple method for measuring the parameters of the liner accelerated up to energies of 3-6 keV.

- Vit.M. Bystritskii, Viatch.M. Bystritsky, J. Wozniak et al., Technical Physics. 2002. Vol. 72. No. 9. P.29-37

The interference of the two transition radiations has been discovered near the threshold of the Vavilov-Cherenkov irradiation while the relativistic lead nuclei were passing through gaseous helium.

- J. Ruzicka et al., NIM A. 2002. 488. P.74-84

Nuclear Physics with Neutrons

For the first time the quantum phenomenon – quantization of the neutron energy levels in potential field, formed with gravitational forces – was theoretically predicted in FLNP JINR and experimentally discovered at ILL (Grenoble, France). This experiment gave a demonstration of the universality of matter's quantum properties. For the first time the experiment on the level of 10^{-12} eV and unique investigations of ultracold neutron energy separation in a special dish-like trap (a horizontal polished plane surrounded with an 18-micron barrier) were performed. Fermi potential, describing neutron reflection from the bottom of the trap, and the gravitational potential, connected with the Earth gravity, form a potential well with a set of quantum levels. The levels' quantization was discovered, which corresponds to the neutron lifting height of about 10 microns.

- V. Nesvizhevsky et al. Nature. 2002. Vol. 415. P. 297-299.

The experiments aimed at the search of the subbarrier neutron p-resonance in lead isotopes continued to explain the effects connected with the violation of the spatial parity in neutron-nucleus interactions. On the 1st channel of IBR-2 gamma-spectra measurements of the radiation neutron capture on lead sample with concentrated ^{204}Pb isotope were performed using the gamma-spectrometer COCOS. The principal possibility for conducting a precision gamma-spectroscopy of small quantities of the lead isotope in unfavorable background conditions of the impulse neutron beam was demonstrated, as well as

the efficiency of the chosen methodological approach. In the preliminary obtained results a manifestation of this resonance for ^{204}Pb isotope was not detected in the framework of 15% of errors, which can be connected with the existence of an additional prohibition of the direct transition to the basic condition of compound nuclei for p-resonance.

- JINR Workshops on SPIN Research Program “SYMMETRY AND SPIN”, Prague, Czech Republic. 2002. July 14-27.

The processing and analysis of the currently accumulated experimental information about two-step cascades in the unexplored nuclei were continued. The analysis of such data for ^{60}Co and ^{184}W nuclei was completed. For composite nuclei $^{185,187}\text{W}$ and $^{191,193}\text{Os}$ from the intensities of two-step cascades the intervals of the most probable valuations of level density excited by primary dipole transitions during heat neutron capture and their radiative force functions were determined. For tungsten isotopes the above mentioned parameters of the neutron resonance cascade gamma-decay were obtained with the least statistic and systematic error in comparison with the earlier obtained data.

- E.V.Vasiljeva, A.M.Suhovoj, V.A.Khitrov, RAS Transactions, ser. Phys. 2002. Vol. 66. № 5. P. 674-679.
- E.V.Vasiljeva, A.M.Suhovoj, V.A.Khitrov, RAS Transactions, ser. Phys. 2002. Vol. 66. № 5. P. 680-684.

Condensed Matter Physics

In 2002, as the investigations of the $(\text{La}_{1-y}\text{Pr}_y)_{0.7}\text{Ca}_{0.3}\text{MnO}_3$ (LPCM-y) compound continued, a series of neutron diffraction experiments to obtain information on the magnetic phase diagram of the compounds with the predominance of ^{18}O isotope (up to 75%) were carried out. Their main result is that the phase diagrams of LPCM-y/ ^{16}O and LPCM-y/ ^{18}O are qualitatively

identical. This gives grounds to believe that the giant isotopic effect in electroresistance, observed earlier for the LPCM compound with $y=0.75$, is a manifestation of a transition to another phase state.

- A.M. Balagurov et.al. Phys. Rev. B v.64 (2001), P. 024420-1-10.
- V.Yu. Pomjakushin et.al. Applied Physics A: Materials Science & Processing. 2002. Vol. 75. in press.

The conformation of the elongation factor eEF1A from mammal cells (rabbit) in solutions was investigated by means of small-angle neutron scattering and scanning microcalorimetry. It was found that in contrast to a bacterial analogue protein has no fixed structure in solution. This follows from the fact that the radius of gyration, 5.2 nm, determined from the small-angle scattering curves is considerably greater than that of the prokaryotic eEF1A, while the specific heat of denaturation of the studied eEF1A, 4 cal/g, obtained by the scanning microcalorimetry is significantly lower than 7 cal/g for the prokaryotic eEF1A calculated for the same denaturation temperature. The small-angle neutron scattering data suggest that the studied eEF1A becomes more compact when forming a complex with the diacyl-tRNA.

- V. Aksenov et.al. Biochemistry, accepted for publication.

The diffraction study of textures of amphibolites and gneisses from the section of the super deep borehole SG-3 in Kola Peninsula and their analogues from the surface continued. The modeling of the elastic wave speed distribution in the studied samples was conducted using the quantitative information on the texture and data on elastic modules of minerals forming rocks. The analysis of the obtained data will allow us to find out the contribution of the oriented mineral components into the total elastic anisotropy of rocks. It is necessary to establish regularities between texture peculiarities and deformation mechanisms, as well as

metamorphic processes responsible for the texture formation in the process of evolution of lithosphere.

- A.N. Nikitin. Earth Physics, in press.

Radiation and Radiobiological Research

Experiments with mammalian and human cells were performed on the Nuclotron beams (^{12}C ions, 473 MeV/nucleons, and the protons, 1 GeV) and on the ^{60}Co γ -irradiation. Nonlinear dependence of the number of cells with chromosomal damage on the dose is established. The obtained data show that the inducible repair at ^{12}C ion irradiation occurs at lower doses and repair chromosomal damage more effectively than at gamma-ray action. No essential quantitative difference in the frequency of the cells with chromosomal damages was obtained, although the LET value of ^{12}C ions was more than 10 times higher than LET of the protons (10.65 keV/ μm and 0.218 keV/ μm , respectively). There was no efficiency difference in the case of γ -irradiation either.

- N.L. Shmakova et al. Medical Radiology and Radiation Safety. 2002. Vol. 47. Num. 3. P. 5-13

Chromosomal damage induced by low doses of ^{60}Co γ -irradiation in human peripheral blood lymphocytes has been studied. At the dose range 0,01-0,05 Gy the cells have shown the highest radiosensitivity; at 0,05-0,5 Gy the dose-independent induction of chromosome damage has been revealed. At the doses of 0,5-1,0 Gy the dose-effect curves have become linear with the decreased slope compared to the initial one (by factor of 5 to 10 for different criteria), reflecting higher radioresistance of cells.

At GSI (Darmstadt, Germany) in collaboration with Biophysics Group the investigation of cellular response to radiation of different quality of normal

healthy human tissue cells has been performed. To further investigate the cellular response of normal human fibroblasts to radiation of different LET confluent AG1522B cells were exposed to accelerated carbon ions 200 and 16 MeV/u, Ni ions 11 MeV/u (LET 16, 155 and 2455 keV/ μm , respectively) and X-rays. A slight increase in the frequencies of aberrant cells and aberrations with sampling time has been found after the exposure of human fibroblasts to X-rays and 200 MeV/u C ions, while a more pronounced increase was detected after irradiation with 11 MeV/u C and Ni ions indicating the transient cell cycle delay of most heavily damaged cells.

- R.D. Govorun et al. Adv.Space Res. 2002. Vol. 30. No 4. P. 885-890.
- K.A. Lyubimova, N.A. Koltovaya, E.A. Krasavin Proceedings II International Symposium "Problems in Biochemistry, Radiation and Space Biology". Dubna. 2002. Vol.1. P. 171-173.

The study of mutation induction of different nature on ionising radiation using yeast *Saccharomyces cerevisiae* as model system of eucaryotic cells was continued.

The study of genetic control of DNA damage-induced arrest of cell cycle progression, named checkpoint-control, was continued. It was determined that *CDC28* and *RAD53* genes belong to two different branches of the pathway controlling the radiosensitivity.

- N.A. Koltovaya, A.B. Devin. Reports of Russian Acad. Sci. 2002. Vol. 387. P. 1-4.

The consequences of transposon Tn10 precise excision in *Escherichia coli* induced by heavy ions with different LET were studied. Survival curves were obtained to define radiosensitivity of the cells after accelerated helium ions irradiation with LET from 20 to 100 keV/ μm , and accelerated carbon ions C with LET 200 keV/ μm . The relative biological effectiveness (RBE) maximum by the

lethal action criterion was found after accelerated ^4He ions irradiation with $\text{LET} = 100 \text{ keV}/\mu\text{m}$. From the calculation of the reversions in the *E. coli* gene *cysC95::Tn10* the relative frequency of the precise excision as the function of the different heavy ions irradiation doses was found. The maximum of this RBE function was found in the interval from 20 to 50 $\text{keV}/\mu\text{m}$. From this fact the conclusion can be drawn that on the background of the initiation of the induced precise excision lies the same cluster DNA breaks, as for the induction of the gene mutations.

- D.V. Zhuravel, A.V. Boreiko Radiation Biology. Radioecology. 2002. Vol. 42. No 5. P. 488-491.

Information Technologies and Computational Physics

In 2002, work to create the JINR GRID segment and to incorporate it into the global GRID structure was actively held. First steps towards creating a system of the global monitoring of the resources of the large scale RICC-LHC virtual organization, including LAN segments of several institutes (SINP MSU, JINR, ITEP, IHEP, IAM RAS) in accordance with GRID architecture were initiated. The monitoring system operates in a test mode; its experimental use for CMS, ALICE, ATLAS experiments is in progress. First results of practical application of the hierarchical mass storage system control in the GRID-LHC virtual organization with optimal use of the backup means, fragmentation and replication of data are achieved.

The series of work to develop statistical and kinematics models of information traffic was performed. The models provide a basis for development of new effective tools of optimal traffic control in computer networks as well as suggest some new possibilities targeted to protect the computer networks from unauthorized intrusions.

- P. Akritas et al. "Chaos, Solitons & Fractals". 2002. Vol.14(4). P. 595-606.
- I. Antoniou et al: Physica. 2002. A308. P. 533-544.

- I. Antoniou et al: *Physica*. 2002. D167. P. 72-85.
- I. Antoniou et al: submitted to *Nucl. Instr. & Meth. in Phys. Res.*
- I. Antoniou et al: (sub. to *Physica D*).
- I. Antoniou et al: (sub. to *Physica A*).

The electronuclear systems consisting of two cascade sub-critical zones, a liquid-metallic reactor on fast neutrons used as a booster, and a heat reactor, in which there is a major energy output, was studied by means of Monte-Carlo modelling. Research results show that the cascade electronuclear systems with an enriched uranium booster and a liquid cadmium valve are most effective from the viewpoint of high output characteristics and safe functioning.

- S.A. Bznuni et al. *Journal of Computational Methods in Sciences and Engineering*. 2002. Vol. 2. N 1-2. P. 21-29
- S.A. Bznuni et al. *Atomnaya energiya*. 2002. Vol. 92. No. 5. P. 344-351.
- S.A. Bznuni et al. *Atomnaya energiya*. 2002. Vol. 93.

A high-order accuracy approximation method for linear evolutionary operators in Gilbert space has been successfully created and theoretically proved. The method has been applied to numerical calculation of a time-dependent Schrödinger equation describing over-threshold laser pulse ionization process of a hydrogen atom.

- A.V. Selin, *JCM&MP*. 2002. Vol. 42. No. 7. P. 937-949.

A new variation-iteration method providing a predetermined accuracy was worked out, realized and tested using appropriate exactly solvable models for solving bound state and three quantum particle scattering problems with point or coulomb pair interactions in the adiabatic representation.

- O. Chuluunbaatar, I.V. Puzynin, S.I. Vinitsky Journal of Computational Methods in Sciences and Engineering. 2002. V. 2. P. 37-49.
- O. Chuluunbaatar et al. J. Phys. A, Mathematical and General. 2002. V. 35. P. L513-L525.
- Yu.V. Popov et al. JETP. 2002. Vol. 122. P. 717-722.
- V.V. Serov et al. Phys. Rev. 2002. A 65. P. 062708-1-7.

Some restrictions on applicability of the involutive bases technique to optimization problems of integer programming have been revealed with the use of computer experiments. The original algorithms and programs were applied to investigate the gauge invariant mechanical problem formulated in a light cone form. It has been found that this problem in comparison to the earlier studied mechanical models of a similar type possesses not only the first-class constraints but also the second-class ones.

- V.P. Gerdt. Programirovanie. 2002. Vol. 28. No. 2. P. 62-65.
- V.P. Gerdt. Journal of Mathematical Sciences. 2002. 108(6). P. 1034-1051.
- V.P. Gerdt, A.M. Khvedelidze, D.M. Mladenov. In: "Computer Algebra and its Application to Physics". 2002. P. 83-92.
- A.M. Khvedelidze et al. Eur. Phys. J. 2002. C 24. P. 137-141.

The JINR University Centre

In 2002, the UC's total enrolment was 215 students from higher education institutions of JINR Member States. The distribution of the UC students over their home institutions is as follows: 38 of Moscow Institute of Physics and Technology; 17 of Moscow Engineering Physics Institute; 17 of Moscow State University; and 44 of higher education institutions of other JINR Member States (Armenia, Belarus, the Czech Republic, Georgia, Russia, Slovakia, and Ukraine). Besides, 99 students of Moscow Institute of Radio Engineering, Electronics, and Automatics attend studies at the UC. The UC offers special programmes to separate student groups.

At the UC, graduate students traditionally complete their higher education in the following areas: nuclear physics; elementary particle physics; condensed matter physics; theoretical physics; technical physics, and radiobiology.

In 2002, the following courses were given within the lecture cycle "Modern Problems of Natural Sciences":

- Prof. Yu.V. Gaponov (Federal Research Centre "The Kurchatov Institute," Moscow). Lecture cycle "Problems of Weak Interaction Physics at Low Energies";
- Prof. Gerard Smadja (Claude Bernard University, Lyon, France). Geometry of the Expansion of the Universe. Friedmann's Equation and Measurements with Supernovae;
- Prof. V.N. Pervushin (JINR). Lecture cycle "New Astrophysical Data and Unified Field Theory".

The list of the UC textbooks has been supplemented by the following publications:

- S.A. Gritsenko, V.V. Krasilnikov, and E.A. Kurayev. Equations of Mathematical Physics. Part I. VHIQ-2002-14;

- Yu.V. Zanevsky, L.P. Smykov, G.A. Cheryomukhina, and S.P. Chernenko. Two-Coordinate Detector of Soft X-Ray Radiation. VHIJ-2002-15.

In 2002, JINR continued its postgraduate programmes in 10 specialties of physics and mathematics. In 2002, the UC's total enrolment was 62. By now, 11 former UC postgraduates have defended their Candidate's theses.

In 2002, the UC was actively developing its established ties with foreign universities. Within the Leonard Euler Scholarship Programme of the German Service of Academic Exchanges, supported in 2000 – 2001, and prolonged for 2002 – 2003, was the joint project by the UC and the Institute of Theoretical Physics of Giessen University (Germany). Realizing the project, the UC students, postgraduates, and scientists perform theoretical research in heavy ion physics and are paid additional scholarship. The results of this research were presented in two reports to the Symposium on Nuclear Clusters: from Light Exotic Nuclei to Super-Heavy Nuclei (Rauschenholzhausen near Marburg, August, 2002).

In October, 2002, a delegation from the UC, jointly with students and postgraduates of the Adam Mickiewicz University (Poznan, Poland) and Prague Technical University, visited a number of research centres and universities of Poland and the Czech Republic.

To attend a specialized practicum and have consultations with scientific supervisors within the educational part of the Bogoliubov – Infeld Programme, ten student groups, two secondary school student groups, and 11 postgraduate groups from the universities of Gdansk, Katowice, Krakow, Lodz, Poznan, Szczecin, and Warsaw (Poland) – a total of 115, including the teaching staff – visited JINR in 2002.

With the same purpose, 20 Romanian and 23 Czech students visited JINR in 2002. They were supported by grants from the Plenipotentiaries of the Czech Republic and Romania at JINR.

A special laboratory for the demonstration of experiments in physics to secondary school students is being created at the UC. The laboratory is being

completed with equipment and materials (by now, the Mechanics-1, Mechanics-2, and Optics installations have been received). In the future, the practicum is going to be extended to senior secondary school students.

Publications by JINR Authors

(received by the JINR Library in 2002 up to 16 December)

□ Books – 6

- S.A. Gritsenko. Equations of Mathematical Physics: Manual /S.A. Gritsenko, V.V. Krasilnikov and Eh.A. Kuraev. Part 1. – Dubna: JINR, 2002-46 P./
- Yu.V. Zanevsky. Two-coordinate X-Ray Detector of Soft X-Ray Radiation. Manual /Yu.V. Zanevsky, L.P. Smykov, G.A. Cheremukhina and S.P. Chernenko. – Dubna: JINR, 2002 – 28 P.: ill./
- B.N. Zakhariev. Obedient Quantum Mechanics: New Status of Theory in the Inverse Problem Approach /B.N. Zakhariev and V.M. Chabanov. – M.: In-t of Computer Research, 2002. – 299 P.: ill./
- V.N. Samoilov. Theoretical-Informational Analysis of Complex Systems /V.N. Samoilov – Dubna: JINR, 2002. – 330 P.:ill./
- V.N. Samoilov. Automized Information Systems in Financial Administration /V.N. Samoilov and T.V. Tyupikova. – Dubna: JINR, 2002. – 194 P.:ill./
- M.G. Shafranova. Joint Institute for Nuclear Research: Inf.-biograph. Reference Book /M.G. Shafranova. – second ed-n with suppliments. – M.:Fizmatlit, 2002. –285 P./

□ Articles in Journals – 537

□ Publications in Conferences' Proceedings – 170

□ Preprints – 167

□ Thesis Abstracts – 35

□ Total number: 915 publications.

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