LABORATORY OF INFORMATION TECHNOLOGIES

The main directions of the activity of the Laboratory of Information Technologies (LIT) are aimed at the provision of theoretical and experimental studies conducted at the Joint Institute for Nuclear Research (JINR) and JINR Member States with modern telecommunication, network, information support, and new mathematical and computing methods.

This activity is focused on two directions, namely «Information, Computer, and Network Support of JINR's Activity» and «Mathematical Support of Experimental and Theoretical Studies Conducted by JINR». These directions are developed in the framework of the JINR general topic «Networks, Computing, and Computational Physics».

The LIT staff participated in research work done within 20 topics of the Topical Plan for JINR Research and International Cooperation.

Two projects were completed at the Laboratory of Information Technologies in 2009. First was the commissioning of the JINR–Moscow high-speed 20 Gbps telecommunication channel by using the modern DWDM technologies. As the result of the second project realization, increase of the JINR Central Information and Computing Complex (CICC) performance up to 2400 kSI2K and the disk storage capacity up to 500 TB was reached.

NETWORKING, COMPUTING AND INFORMATION SUPPORT

In 2009, the Laboratory provided the reliable operation and development of the JINR networking and information infrastructure. The key components of this infrastructure comprise JINR telecommunication data links, local area network, CICC and base software responsible for integration of the Institute's information and computing resources in a unified environment accessible to all users and with using grid-technologies.

JINR Telecommunication Data Links

In 2009, the agreement between JINR and the Russian Satellite Communications Company (RSCC) on the rent of optical fiber cable for the provision of optical communication links between Moscow and Dubna was realized. The project has been prepared in cooperation by JINR, RSCC, NORTEL, JET Infosystems, RosNIIROS, and the Computer Networks Interaction Center «MCK-IX». A high-throughput Dubna–Moscow channel was constructed on the basis of state-of-the-art technologies DWDM (Dense Wave Division Multiplexing) and 10 Gb Ethernet. In perspective, the mentioned technologies allow one to organize the multiple data streams using one optical fiber, which means that the data link capacity can be easily increased significantly. Now the channel has been launched with a capacity of 20 Gbps (Fig. 1).

For the connection with scientific networks and Internet, the JINR network infrastructure has currently the following virtual lines: direct communication line with CERN — 1 Gbps, with RBnet — 10 Gbps, with RASnet — 10 Gbps, with RadioMSU — 10 Gbps, with GEANT — 10 Gbps, with GLORIAD — 1 Gbps, with Moscow scientific networks — 10 Gbps, with Internet — 10 Gbps.

The Dubna-IX node that serves the remote access of the JINR staff members via VPN from the town networks Lanpolis, Contact, TMPK operates and provides an internetwork peering within the town networks.

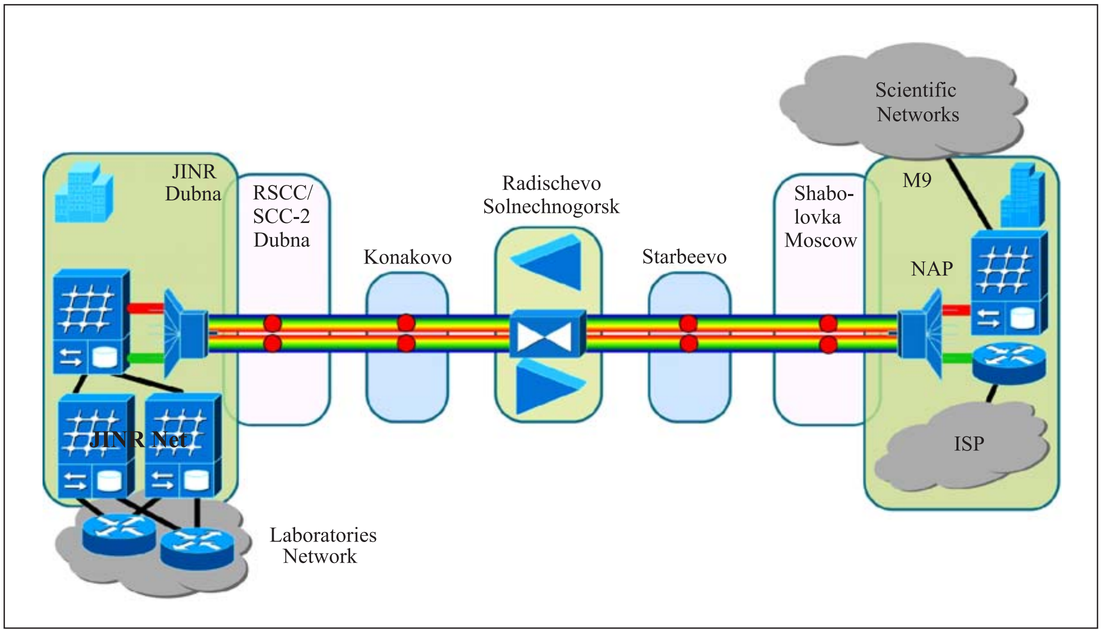

Fig. 1. Scheme of the JINR–Moscow telecommunication channel

Table 1

Subdivision	Incoming, TB	Outgoing, TB
LIT	57.39	79.66
VBLHEP	40.04	50.28
DLNP	32.01	50.81
FLNP	20.72	39.97
BLTP	10.07	10.34
Remote access node	8.46	1.78
Administration	4.15	4.06
FLNR	3.72	0.751
Dubna University	3.03	3.48
LRB	2.69	0.883
UC	2.18	0.487

Table 1 gives the distribution of the incoming traffic among the JINR subdivisions for 2009 (exceeding on the income traffic 1 TB).

The total incoming JINR traffic, including the general-access servers and CICC, amounts to 536.15 TB in 2009 (376.51 TB in 2008).

JINR Network

At present the JINR LAN includes 6785 computers and nodes. In 2009 the JINR LAN served 3645 users, more than 1500 users of mail.jinr.ru service and more than 1300 users of remote access VPN. Over 120 network nodes are in round-the-clock monitoring (gateways, servers, basic switchboards, etc.). Fifteen servers are supported and over 50 user inquiries are served per shift. Introduction of new spam protection systems allowed one to fix about one million spam messages a day for central mail-servers.

JINR network security is gained with the implementation of hard- and software products in the network infrastructure. To protect the computing and informational servers, users' workstations and active routing and switching network equipment at JINR, the industry-approved AAA approach (Authentication, Authorization, and Accounting) was used. During the last two years, the AAA system has been successfully gradually integrated into LIT-developed product IPDB — a network data base with multiple features of monitoring and control based on IP-addresses. The IPDB became the main tool for the network and system administrators to maintain their current administrative tasks.

JINR Central Information and Computing Complex

The development of the JINR Central Information and Computing Complex is based on a distributed model of data processing and data storage. Such a model is in agreement with the modern concept of establishing information processing centres for scientific research based on grid-technologies.

The JINR CICC is organized as a unified information-computational resource intended for provision of all directions of JINR's activity. The accounting and data storage resources are managed by the base software that allows the remote users within the international projects (WLCG — Worldwide LHC Computing Grid, EGEE — Enabling Grid for E-sciencE) and the local JINR users to utilize the CICC means.

Options of the CICC software provide optimal use of accounting resources and support of the most universal and protected methods of access to the data storages. Distribution and account of computing resources is realized on the basis of the batch system *torque* and the resource scheduler *maui*. Access to data is organized via dCache and in part via NFS. Access to the general-purpose software and to user directories is realized through AFS and NFS. The *kerberos5* system is used for registration and identification of the JINR users.

A remote installation system (RIS) has been developed at LIT for mass installation of base software in computing nodes (computing machines). It is based on standard means of OS Linux with the use of some elements from Warewulf. It allows one to automate the mass installation of software on new machines and to replace the outdated OS versions.

For the last few years the CICC computing power has grown due to purchasing multiprocessor modules of the leading suppliers of computer facilities. As 2- and 4-core processors contain, accordingly, two and four independent processors per one crystal, at present the CICC comprises 960 64-bit CPUs. All these CPUs are accessible to the JINR users and users of the Grid-environment through a unified batch system.

For the development of the native software and provision of access to the CICC resources for JINR users, five machines with interactive access have been provided. There are some servers supporting the work of users and services of JINR: batch, WWW, DB mysql and Oracle, e-mail, DNS, etc.

The basic system to store enormous data volumes in CICC is the hard- and software complex dCache. At the moment it comprises two servers of basic interfaces of the dCache system and 32 data storage systems (Pool). Several CICC user groups utilize a system of access to remote information XROOTD. For the maintaining of this system, a hardware-software complex has been designed that comprises a server of processing inquiries to the system and six data storage systems. All the storage systems are created with the help of technique called *Redundant Arrays of Inexpensive Disks*, or RAID, now new level RAID 6. The total accessible system capacity is 500 TB.

In order to maintain the JINR WLCG site, 24 servers under the *gLite* system have been installed. In line with the functions of supporting the operating of site JINR-LCG2, part of the servers provides services and functions of supporting the Russian segment of the projects WLCG and EGEE. The CICC structure includes a test farm of eight machines intended for testing and debugging new *gLite* versions.

For the purpose of providing a high throughput of the CICC network and a minimal time of access to data and files, aggregation of several 1-Gb Ethernet connections into a uniform virtual channel with increased throughput is applied. The aggregation technique allows one to satisfy the requirements on the speed of access to data from computing tasks both for the local JINR users and for the users within the WLCG/EGEE environment. This approach allows one not to transfer the main part of the local CICC network to more powerful channels (10 GbE, or Infiniband), which would demand quite a significant financing. Figure 2 gives a structure chart of the JINR CICC.

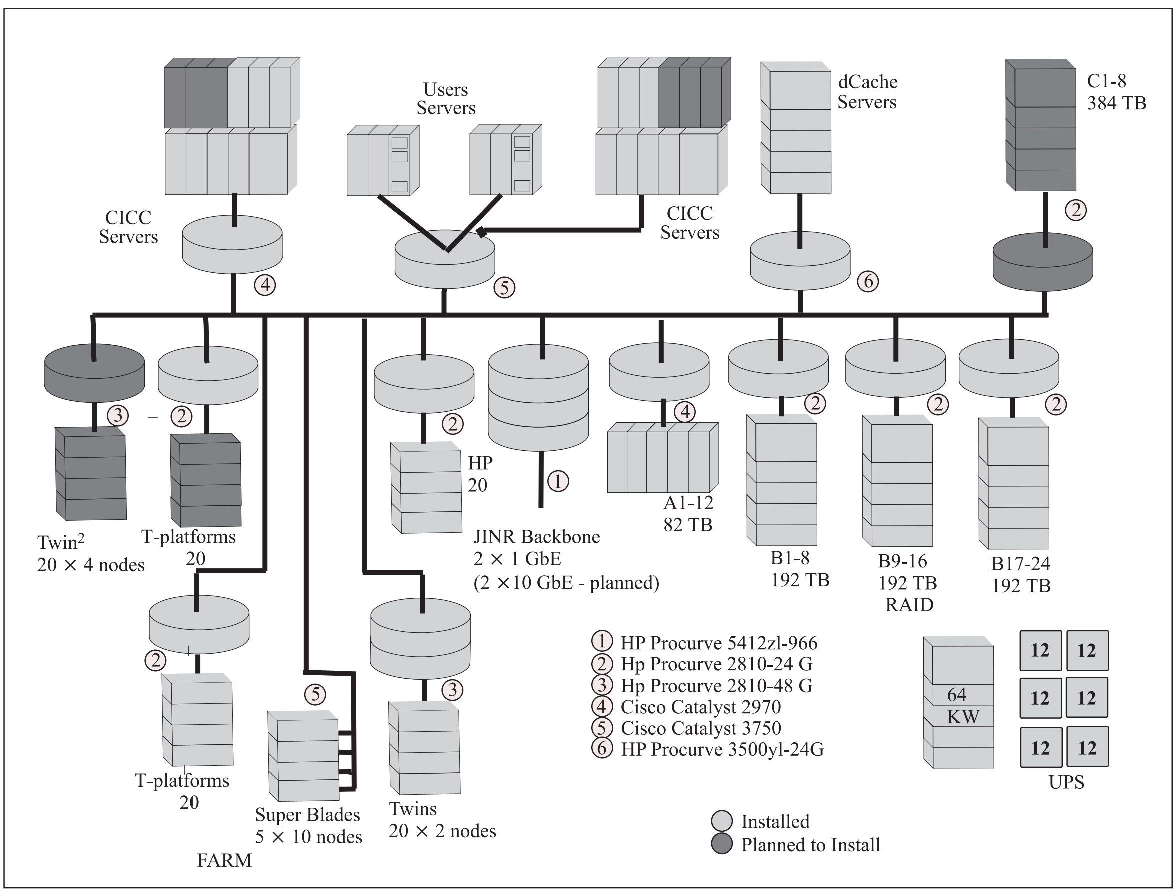

Fig. 2. Scheme of the CICC network connections

The base CICC operating system is OS Linux, namely, a distribution kit Scientific Linux — SL4.8 and SL5.4. This distribution kit is maintained by CERN and FNAL. It is also selected as a base OS within the projects WLCG and EGEE.

For the enhancement of the work of the local CICC users, some additional software has been provided that optimizes Intel compilers, paralleling problems system, graphic utilities and others. The CICC infrastructure also has several specialized machines to support the projects of JINR and international collaborations such as NICA/MPD, PANDA-GRID and CBM. These machines are supplied with specialized software for concrete experiments; startup of computing problems is organized through the batch system. The same machines support NFS service for specialized software on computing machines.

Table 2 shows the distribution of batch jobs over the Institute's subdivisions and user groups, excluding the participants of grid-projects in 2009.

Table 2

Laboratory/Group	LIT	BLTP	FLNP	panda	DLNP	LPP	foton2	FLNR	cbm
CPU time (kSi2K·h)	433268.86	346675.86	66234.77	56796.54	46702.42	33597.35	3099.79	5.13	0.21
Number of jobs	1261	2352	368	29110	3896	340	40	51	4
Astronomical time (kSi2K·h)	24815.06	338347.43	12072.25	86809.80	55613.54	33973.20	3134.37	4.53	11.38

JINR Grid-Environment

JINR takes an active part in two large-scale worldwide grid projects: Worldwide LHC Computing Grid (WLCG) (http://lcg.web.cern.ch/LCG/) and Enabling Grid for E-sciencE (EGEE) (http://www.eu-egee.org/).

Participation in WLCG/EGEE includes: WLCG-infrastructure support and development at JINR of the Grid-infrastructure in accordance with the requirements of the experiments for the LHC running phase; participation in WLCG middleware testing/evaluation; grid monitoring tools development; JINR WLCG portal support and development, MCDB development; user training and induction to grid; support of the JINR Member States in the WLCG activities, etc.

Since 2004, JINR CICC has been a component of the global computing grid-infrastructure in the framework of the Russian grid-infrastructure for intensive operations with data (RDIG). The current contribution of the CICC computing resources with regard to the whole Russian WLCG community is 40–50% and a little bit less as to the data storage resources. The JINR Site is one of the most effective working sites within the whole WLCG infrastructure.

In 2009 enormous work was done on preparation of the environment for data receiving and processing for experiments the ALICE, ATLAS and CMS at JINR according to plans of experiments as to real data taking from the LHC and according to the experiments' computing models. They include provision of the experiments with computer resources in accordance with the requests, opportunity of using these resources within the global WLCG/EGEE infrastructure, installation and maintenance at JINR of the required middleware, specialized grid-services and required applied software. Table 3 shows the result on using the JINR CICC Grid-infrastructure by the virtual organizations (VO) within RDIG/WLCG/EGEE in 2009.

Table 3

VO	CPU time (kSi2K·h)	Number of jobs
Atlas	5204619.87	777996
Alice	2949151.97	234057
Cms	2472183.90	479948
Lhcb	1955205.91	68707
Fusion	497976.03	9108
Biomed	156795.87	26142
Hone	89959.07	7702
Ops	2655.99	66217
Dteam	16.22	6595
Total	13328564.84	1676472

In summer 2009, JINR took a successful part in the STEP09 run of the large-scale testing of the WLCG environment for the experiments ALICE, ATLAS and CMS. Table 4 shows the use of the JINR computing resources during the STEP09 run.

Table 4

Experiment	CPU time (SpectInt2000·h = 1000)	%
ALICE	524952.36	46.6
ATLAS	293298.98	26.1
CMS	152172.29	13.5
LHCb	154996.34	13.8
Total	1125419.97	100

The monitoring and accounting system of using the resources of the RDIG infrastructures developed and maintained by JINR (http://rocmon.jinr.ru:8080) has been advanced. Work has begun on monitoring the use of the data storage system within the grid-environment realized on the basis of the system dCache. The monitoring system will allow not only observation of the current state (quantity of processes of record-reading, size of busy space, peak loadings, etc.), but also optimization in the future of using the data storage resources.

The JINR specialists make a noticeable contribution to the development of the monitoring system for LHC virtual organizations (Dashboard) developed and maintained by the Information Technologies Division at CERN. The work includes the development of database tables and user interfaces as well as perfection of the approaches to the monitored data acquisition and representation. In the course of the construction of the system of visualization of monitoring the grid-infrastructure EGEE as a geographically distributed system, a new functionality with the use of the Google Earth application for the real-time dynamic monitoring has been developed and introduced in Dashboard [1].

One of the most significant results of the team TDAQ ATLAS at LIT was the participation in the development of the TDAQ ATLAS project at CERN and preparation for the startup of the ATLAS experiment. The results of the work on creating the multilevel distributed computing systems of data processing within the TDAQ ATLAS project were reported to international conferences [2]. The work was started in 2008 by the team TDAQ ATLAS LIT in collaboration with JINR physicists on the creation of a system of remote access to data acquisition and processing in the experiment TDAQ ATLAS CERN has been progressing. This system is a component of the general data processing system integrating the computing resources in the unified global distributed grid-system of processing, storing and transferring data received within LHC experiments at CERN. The work was supported by the Federal Agency on Science and Innovations of Russia and reported to the resulting conferences (http://www.sci-innov.ru/icatalog_new/entry_68452.htm; http://www.sci-innov.ru/icatalog_new/ entry_79275.htm).

Information and Software Support

The traditional provision of information, algorithmic and software support of the JINR research-and-production activity included a large spectrum of activities at both LIT and JINR levels. This activity traditionally includes development and support of information WWW/FTP/DBMS-servers of JINR and LIT, creation and storage of electronic documents related to the JINR scientific and administrative activity, development, creation and support of information web-sites of workshops and conferences, administration and support of web-sites of JINR subdivisions and various conferences in a hosting mode as well as support, modernization and maintenance of computer systems of administrative databases (in cooperation with STD AMS JINR). Besides, work should be noted on developing and supporting the automated system of bibliographic data processing for the JINR Science and Technology Library (in cooperation with the JINR STL).

The portal technology is a key performance technology for all modern investigation projects due to the large-scale and world-wide nature of most scientific and especially experimental collaborations in nuclear and particle physics. This technology is actively used at LIT in the process of development and creation of various information systems with web-interfaces. For instance, for the portals of the journals «Particles and Nuclei» and «Particles and Nuclei, Letters» (http://pepan.jinr.ru) functioning, a specialized interface has been designed for the authors, editors, referees and administrators, providing interconnections with the databases of the journals. Work on the maintenance and development of the portal is in progress.

Special software for design, development and support of special and general-purpose web-servers based on modern portal service-oriented technologies has been worked out. This software includes a specific database and a set of adjustable web-interfaces (online participant registration, abstract submission and upload of presentation files, keeping news, forming mailing lists, etc.). For example, the following web-sites were developed using this software: http://www.jinr.ru — site of JINR, http://newuc.jinr.ru/ — site of the JINR University Centre; sites of numerous conferences under JINR supervision.

Another traditional direction of LIT activity is a consecutive development and support of the library JINRLIB as well as support of program libraries developed by other research centres and organizations, and information and technical help to users. The information on the JINR program libraries is available at the specialized WWW-server http://www.jinr.ru/programs/.

On the ftp-server lxpub01 of the CICC, a number of free software systems for symbolic algebraic computation, such as Reduce, Axiom, Gap, Form, and Maxima, have been implemented and thus made accessible for JINR users. Besides, Common Lisp based system Reduce was ported that allows the users at JINR to use the full memory (RAM) available on 32-bit computers in distinction to the standard Reduce version on PSL (Portable Standard Lisp). The last version allows one to use not more than 128 Mb memory. In addition, the new (i.e., Common Lisp based) version of Reduce has more effective and user-friendly debugging facilities.

A PFUMILI code has been created which is a modification of the well-known FUMILI software product. It permits its effective use in both the traditional sequential computing systems and the modern clusters integrating hundreds of equitype processors [3].

MATHEMATICAL SUPPORT OF EXPERIMENTAL AND THEORETICAL STUDIES

The main purpose of this research area at LIT is to provide the mathematical, algorithmic and software support of experimental and theoretical studies underway at JINR. In 2009 the obtained results were reported in more than 200 papers, 89 works being published in the leading journals. More than 90 reports were presented at international conferences.

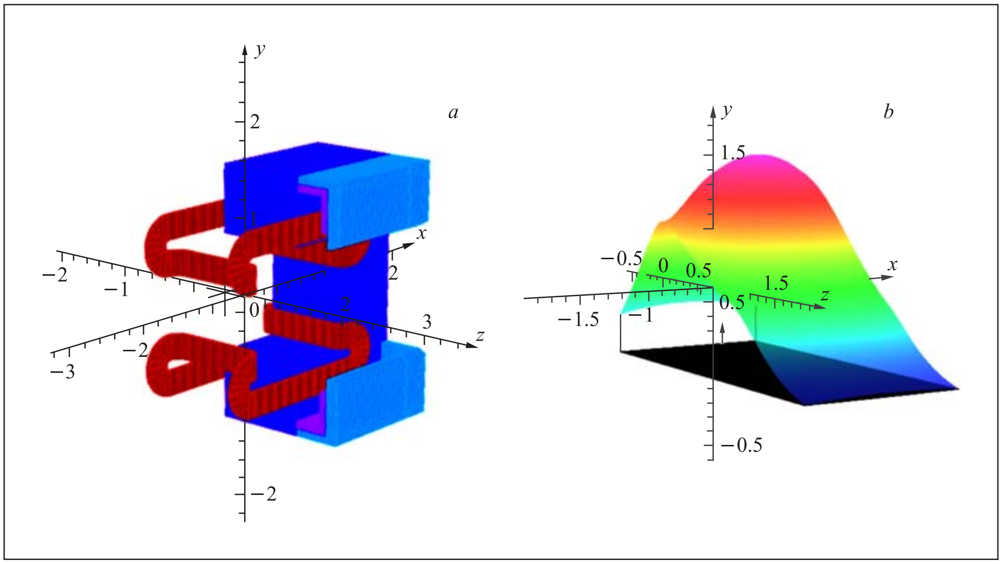

Fig. 3. Model of 1/2 of superconducting dipole magnet for CBM (*a*) and the magnetic fields (*b*) calculated with the computer code TOSCA

The Fritiof model, significantly improved for the last years at LIT, has been included in the well-known package GEANT4. Beginning from the version GEANT 4-4.9.1, the software product is available in combinations (Physics Lists) FTFP_BERT and FTFP_BIC and is used by LHC collaborations [4].

As part of the work on designing a magnetic system for the CBM experiment (FAIR, Germany), a series of calculations have been performed for various versions of the superconducting dipole magnet. Figure 3 gives the results of modeling one of the variants of the dipole magnet and calculation of the distribution of the main component of the magnetic field at the median plane of the magnet carried out with the computer code TOSCA.

The comparison of the distributions of the e/π energy losses in the TRD prototype and GEANT3 simulation of the n-layered TRD realized in the framework of the CBM ROOT at $p = 1.5$ GeV/c has shown that the simulation quite well reproduces real data. However, contrary to the real measurements, using the most powerful method based on a likelihood functions ratio test, this does not permit one to obtain a comparable level of pion suppression. It is shown that the procedure of preparation of data sets corresponding to the n-layered TRD based on prototype measurements is a reason of reaching an erroneous and highly overestimated level of pion suppression. It is also demonstrated that the high level of pion suppression could be achieved using a combined method, which is more simple for practical application [5].

The fast algorithms for the Cherenkov ring recognition algorithm and electron identification based on the Hough transform method (HTM), which allow one to speed up the HTM algorithm considerably, have been developed. An ellipse fitting algorithm has been elaborated because most of the CBM RICH rings have elliptic shapes; moreover, it helps to improve the ring–track matching and electron identification procedures. An elaborated procedure of the radius correction is also worked out and the procedure of fake rings eliminating by artificial neural networks is implemented. All the developed algorithms were tested on large statistics of simulated events and are included into the CBM software framework [6].

A new approach to construction of functional equations for multiloop Feynman integrals was suggested. This approach allows one to construct functional equations for integrals that correspond to the two-, three- and four-dot diagrams. Just due to this method it became possible to formulate for the first time quite a general procedure for analytic continuation of Feynman integrals that depend on many variables. The results obtained are very important for computation of radiation corrections which are necessary to compare theoretical predictions with experimental data from the LHC at CERN [7].

The kaons decays to pairs of charged and neutral pions are considered in the framework of the nonrelativistic quantum mechanics. The general expressions for the decay amplitudes to the two different channels accounting for the strong interaction between pions are obtained. The developed approach allows one to estimate the contribution of terms of any order in strong interaction and correctly takes into account the electromagnetic interaction between the hadrons as, for instance, K_{e4} decay [8].

Results «from first principles» for the Landau-gauge gluon and ghost propagators in $SU(3)$ lattice gluodynamics have been obtained using the modeling on a sequence of lattices with linear extension ranging from $L = 64$ to $L = 96$ at $\beta = 5.70$, thus reaching «deep infrared» momenta down to 75 MeV [9]. This gauge-fixing procedure essentially uses a simulated annealing technique which allows one to reach gauge-functional values closer to the global maxima than standard approaches do. The results obtained are consistent with the so-called «decoupling» solutions found quite recently for Dyson–Schwinger equations.

Two main principles of the Bayesian approach to the automatic adaptive quadrature are formulated. The first is building a subrange binary tree under numerically efficient enforcement of the zero measure contribution of the isolated irregular points of the integrand, as well as reliable resolution of the regular integrand profiles over subranges. The second is eliminating the unnecessary integrand computation and enhancing the reliability of the local quadrature rules prior to their activation, by early identification of the integrand features which result in conspicuously spurious output. The implementation of these principles uses the Bayesian inference through a validation mechanism comprising a number of hierarchically ordered conditioning criteria. The proposed approach makes possible the advancement to the right solution in the case of difficult numerical experiments, where it is impossible to know in advance the change of the integrand behaviour under the modification of the physical system parameters [10].

The basic element method (BEM) for decomposition of the algebraic polynomial via one cubic and three quadratic parabolas (basic elements) is developed within the 4-point transformation technique. Representation of the polynomial via basic elements gives a lever at solving various tasks of applied mathematics. So, in the polynomial approximation and smoothing problems the BEM presentation allows one to reduce the computational complexity of algorithms and increase their stability for error by choosing the internal relationship structure between variable and control parameters [11].

A method for constructive quantization of discrete dynamical systems has been proposed. The method generalizes the standard Feynman's quantization and is based on introduction of gauge connection of a special kind. Simple models for studying the properties of the suggested quantization have been constructed [12].

A calculation is made of the $^8\mathrm{He} + p$ microscopic optical potential (OP), its real part — in the folding model, and the imaginary part — in framework of the high-energy approximation. On this basis, the experimental differential elastic cross sections at energies lower than 100 MeV/nucleon have been analyzed. Conclusions are made on the applicability of the model of OP and also on the selection of the adequate model of the ^{8}He structure. Comparison of numerical and measured cross sections has shown that this approach is acceptable for interpretation and analysis of experimental data (Fig. 4). The investigation is performed in the framework of the Cooperation Programme between JINR and Bulgarian scientific centres [13].

The interaction of channeling particles is considered as a possible solution to the problem of synthesis of light elements and interaction of low-energy nuclei. In the study «The Cross-Section of Two Charged Particles in a Crystal's Channel», the problem of interaction of two channeling similarly charged particles in the center-of-mass system is reduced to the Schrödinger equation in spherical coordinates with an additional oscillator potential. Preliminary estimations have been obtained and a nonmonotonic behaviour of the multiplication factor of nuclear reactions on the collision energy has been revealed [14].

For the first time the existence of exotic breather-type asymptotics was proved for solutions to nonstandard linear differential equations with discontinuity initial data. These equations arise in studying the wave motion in periodic stratified media. These solutions have a very oscillating behaviour and therefore could not be obtained by standard numerical computations. Asymptotic solutions for $t \to \infty$ are constructed for solving the problem for the case of $b = 1$ confirming the validity of the processes of breather deformation obtained by numerical simulations. Theorems are proved that describe the behavior of the real part of the solution for various x [15].

Temperatures in two-layer structures, presenting a massive substrate and a surface covered by a relatively thin layer from another material under irradiation with

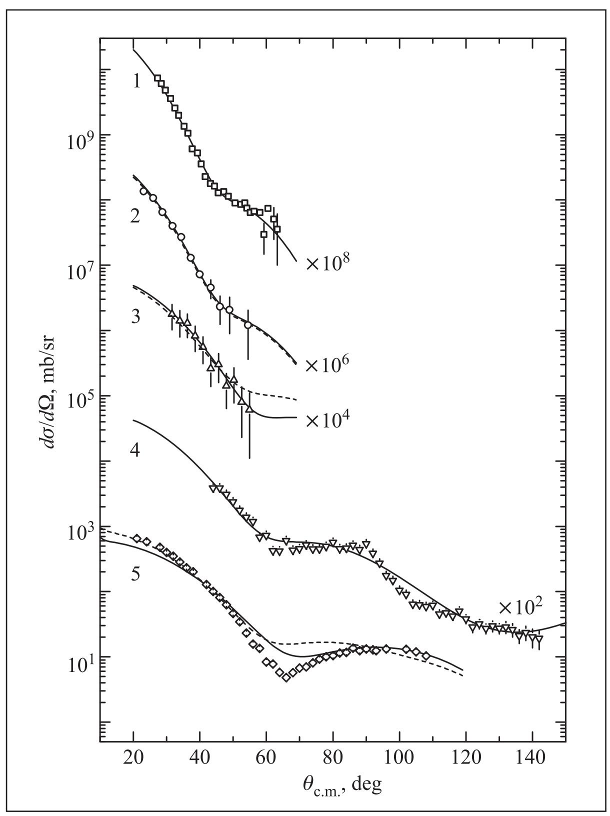

Fig. 4. The $^8\mathrm{He} + p$ elastic scattering cross sections at different energies calculated using re-normalized microscopic optical potential and the LSSM density of ^{8}He

swift heavy ions with high ionizing energy loss in the framework of a thermal spike model for a three-dimensional case were calculated. The temperature changes near a separate boundary of such a two-layer structure on the example of Ni–W of the convective warm exchanging coefficient Θ are studied in detail. The parameter Θ characterizes the changes of temperature gradient near the separate boundary, i.e., determines a type of the heat contact. Calculus were done both for a nonlinear model (characterized by thermal physical coefficients depending on the temperature) and for a linear model (characterized by thermal physical coefficients without dependence on the temperature). The peculiarity of the nonlinear model is characterized by the following: the characteristic time of the thermal processes for such a crystalline lattice runs more slowly than for a linear model. It was shown that transition from a nonideal case of the heat contact to an ideal case of the heat contact takes place at increasing coefficient Θ [16].

In accordance with the research in quantum computation and quantum information, in order to select the most optimal candidates for physical realization of qubits and related quantum circuits, a new model was suggested to control entanglement of spin particles by means of their interaction with strong laser field [17].

A self-consistent system of nonlinear spinor and Bianchi type-I (BI) gravitational field in the presence of a viscous fluid and cosmological constant has been considered. Self-consistent solutions to the spinor, scalar and gravitational fields are obtained and expressed in terms of τ, where τ is the volume scale of BI metric. A system of equations for τ, generalized Hubble parameter H and energy density of viscous fluid ε has been deduced. Exact solutions to this system have been obtained for some special choices of spinor field nonlinearity and viscosity. A comprehensive qualitative analysis of evolution on the boundaries has been performed and numerical solutions for some especially interesting cases have been obtained. In particular, it has been shown that the system allows Big Rip type solution which is distinctive for phantom matters [18].

Current increasing interest in the peculiarities of electromagnetic response of ultrafine particles (nano- and microdimensions) of different materials is motivated by their practical utilization for biomedical purposes. A study has been performed on possibilities of using nonmetallic nanoparticles for application as biolabels. The optically induced oscillatory response of a spherical two-component, shell-core structured, nanoparticle by nodeless elastic vibrations of soft peripheral shell against hard and dynamically immobile inner core was considered. The eigenfrequencies of the even-parity, spheroidal and odd-parity torsional vibrational modes trapped in the finite-depth shell are obtained which are of practical interest for modal specification of individual resonances in spectra of the resonant scattering of long-wavelength ultrafine particles [19].

INTERNATIONAL COOPERATION

The research work underway at LIT is conducted in a close collaboration with researchers and specialists of the JINR Member States and many other research centres worldwide. Some areas of this cooperation should be noted. Protocols of cooperation have been concluded with INRNE (Bulgaria), ArmeSFo (Armenia), FZK Karlsruhe GmbH (Germany), IHEPI TSU (Georgia), NC PHEP BSU (Belarus), KFTI NASU (Ukraine), IMIT UAZ (Uzbekistan), WUT (Wroclav, Poland), IFIN-HH (Romania) and others. LIT continues work within the BMBF grant «Development of the Grid-Infrastructure and Tools to Provide Joint Investigations Performed with Participation of JINR and German Research Centres» as well as within the CERN–JINR Cooperation Agreement on several topics. Work was successfully performed within participation in common projects: NATO project EAP.NIG 982956 «DREAMS-ASIA» (Development of gRid EnAbling technology in Medicine&Science for Central ASIA), CERN–INTAS, Worldwide LHC Computing Grid (WLCG), Enabling Grids for E-sciencE (EGEEIII) as well as SKIF-GRID project within the programme of the Belarusian–Russian Union State and the Grid National Nanotechnology Network (GridNNN) project performed under the federal target programme of development of the nanoindustry infrastructure in the Russian Federation in 2008–2010.

The exploitation and development of grid-technologies continues in a close cooperation with the Russian institutes and the research centres of the JINR Member States: Ukraine, Belarus, Czechia, Germany, RSA, Bulgaria, Armenia, Georgia, Azerbaijan, Uzbekistan, Romania. To carry out JINR's obligations within its participation in the projects and with the purpose of popularization of grid-technologies, an education&research and test grid-infrastructure was set up and is successfully used at LIT [20]. At present the distributed training complex for work within the gLite environment consists of three JINR grid-sites as well as IHEP grid-sites (Protvino), IMIT UAS (Tashkent, Uzbekistan) and Sofia University «St. Kliment Ohridski» (Sofia, Bulgaria). The infrastructure has been set up for solving tasks in the Grid area in the framework of carrying out the JINR obligations within the international projects EGEE and SKIF-GRID as well as for training users, system administrators and students to work in the grid-environment.

In cooperation with Brest Technical University (Belarus) and University of Applied Sciences (Weingarten, Germany), the 1st version of Mathematica program called QuantumCircuit for simulation of quantum computation was created. The program has a user-friendly interface to input and draw an arbitrary quantum circuit and contains quite a comprehensive date base of quantum gates. This is necessary to test and analyze quantum algorithms. By this time, QuantumCircuit has built-in Quantum Fourier Transform that forms a basis of most known quantum algorithms and Grover's search algorithm in unsorted data base [21].

In the framework of the RSA–JINR collaboration, research has been performed on the parametrically driven damped nonlinear Schrödinger (NLS) equation that describes a number of resonant phenomena in nonlinear media. In [22], the time-periodic solitons of the NLS equation are determined, numerically, as solutions of the boundary-value problem on a two-dimensional domain. The obtained results shed a new light on the form of the attractor chart for the NLS equation. In particular, a new type of stable temporally periodic two-soliton bound state has been found.

In cooperation with the National Polytechnic Institute Sol San Pedro Zacatenco (Mexico), LIT scientists conduct research on algebraic transformations of the generalized Schrödinger equation for stationary and nonstationary cases. The generalized Schrödinger equation with a position-dependent (effective) mass and a weighted energy is used in the physics of semiconductor nanostructures. The study was performed for analyses of the algebra of intertwining relations, supersymmetry and Darboux transformations. Intertwiners are obtained in an explicit form. With their help the arbitrary-order Darboux transformations were constructed for the mentioned class of equations. A corresponding supersymmetric formulation has been developed and equivalence of the Darboux transformations with the supersymmetry formalism has been proved. It was shown that those Darboux transformations could also be constructed by means of point transformations, avoiding the use of intertwiners. The Darboux transformations for a generalized Schrödinger equation by means of the intertwining operator method were constructed [23]. Darboux n-order transformations are constructed for a generalized, linear time-dependent Schrödinger equation, special cases of which correspond to the time-dependent Hamiltonian coupled to a magnetic field with position-dependent mass and with weighted energy [24]. The obtained Darboux transformations reduce correctly to their particular cases and to the new generalized Schrödinger equation. Moreover, the fundamental properties of the conventional Darboux transformations, such as factorization and existence of a reality condition for the transformed potentials, are preserved.

CONFERENCES

On 7–11 July 2009 the Laboratory of Information Technologies hosted the International Conference «Mathematical Modeling and Computational Physics 2009» (MMCP2009). The Conference continues the rich traditions of the previous conferences of its kind which were repeatedly organized in Dubna: «Numerical Modelling and Computing in Physics» (1996), «Modern Trends in Computational Physics» (1998), the V International Congress on Mathematical Modeling (2002), and in Slovakia: «Mathematical Modeling and Computational Physics» (2006).

Specialized sections were organized in the framework of MMCP2009 which covered the research fields related to two traditional workshops organized in Dubna earlier: «Computer Algebra» and «Quantum Physics and Information». A reason for joining these subjects is that a lot of scientific problems from the mentioned areas can be solved only with the use of mathematical simulations and computational methods. The overlapping of the subjects has allowed scientists to get acquainted with the results of research in adjacent areas and the problems arising in the course of their solving, exchange views and probably find areas for mutually beneficial cooperation.

251 scientists from 23 countries: Armenia, Belarus, Belgium, Bulgaria, Great Britain, Hungary, Vietnam, Germany, Georgia, Kazakhstan, Lithuania, Moldova, Mongolia, Poland, Russia, Romania, Slovakia, Slovenia, Ukraine, France, Finland, Czechia, South Africa, and from JINR, including 79 students and postgraduates, attended the event. Russia was presented by attendees from 50 universities and research institutes.

The Conference received a financial support from the Russian Foundation for Basic Research (RFBR). It should be particularly noted that the most interesting and significant contributions submitted to the Conference, have been supported by RFBR grants (49 reports). The Conference programme included 79 reports performed in collaboration of Russian and foreign researchers. Twenty three research works conducted in cooperation with foreign scientists are supported by various national and European programmes and grants.

A status plenary report delivered by Corresponding Member of RAS B. N. Chetverushkin «High-Performance Computing: Fundamental Problems and Solutions» reviewed the development of the mentioned direction. It was marked that at present the user can use computing systems of more than 10 Tflops and multi-core processors. This opens up new avenues for modeling scientific, industrial, economic, ecological and other problems. The use of modern computer facilities demands a radical changeover of methods and approaches to solving the problems. Similar questions were considered in the report «Enabling Science through Emerging HPC Technologies» delivered by the Editor-in-Chief of the journal «Computer Physics Communications» (CPC) and the director of the CPC Program Library Prof. N. S. Scott (Belfast, Great Britain). Its was noted that modern computing systems were a challenge for high-performance computing: there is a need in the algorithms that use the memory hierarchy, mixed precision algorithms, an opportunity for performance porting, adaptive and self-adapting algorithms and finally new programming methods.

A total of 33 plenary reports were presented to the Conference attendees. The Conference comprised 7 sections. A total of 126 sectional reports were presented at the Conference. The greatest number of reports was presented within the field «Mathematical Modelling and Computational Physics». A programme, theses and presentations are available on the official Conference site http://mmcp2009.jinr.ru.

On 7–14 September, Varna (Bulgaria) hosted the traditional 22nd International Symposium on Nuclear Electronics and Computing (NEC'2009) organized jointly by JINR, CERN and the Institute of Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences (INRNE BAS, Sofia). Almost 100 scientists from 13 countries (Belarus, Bulgaria, Vietnam, Italy, Poland, Russia, Serbia, Slovakia, USA, Ukraine, France, Czechia and Switzerland) attended the event, 22 participants being 36 years old and younger (from Bulgaria, Belarus, Poland, Russia, Serbia, France and Czechia). The participation of 12 young scientists was supported by special grants provided by the Directorates of CERN and JINR. For the first time specialists from Serbia and Slovakia attended the Symposium.

Fifty-six oral reports and 26 posters, among them 17 oral reports and 3 posters made by young participants, were submitted. On the closing day, young participants A. Verkhoglyadov and O. Denisova (JINR), A. Zemla (Poland), G. Mitev (Bulgaria) and S. Janush (Belarus) were announced the best young lecturers of the Symposium.

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