LABORATORY OF INFORMATION TECHNOLOGIES

The investigations performed at the Laboratory of Information Technologies (LIT) in 2012 within the JINR general topic «Networks, Computing, and Computational Physics» were focused on two first priority themes, namely, «Information, Computer, and Network Support of the JINR Activity» and «Mathematical Support of Experimental and Theoretical Studies Conducted by JINR». In frames of cooperation with other JINR Laboratories, the LIT staff participated in research work within 25 themes of the Topical Plan for JINR research and international cooperation.

The JINR Central Information and Computing Complex (CICC) provides the largest share to the Russian Data Intensive Grid (RDIG) contribution to the global WLCG/EGEE/EGI Grid-infrastructure which provides virtual organization support within international projects, the LHC experiments included. During 2012, CICC has run more than 7.4 million jobs, the overall CPU time spent exceeding 152 million hours (in HEPSpec06 units). The JINR site is one of the most effective Tier2 level sites in the WLCG (Worldwide LHC Computing Grid) infrastructure. During 2012, JINR secured 45.5% of the overall RDIG computing time contribution to the solution of LHC tasks.

JINR is currently engaged in the creation of a Tier1 level distributed centre in Russia. The centre schedule assumes Tier1 support of the experiments ALICE, ATLAS, and LHCb at the computing complex of the NRC «Kurchatov Institute» and Tier1 support of the CMS experiment at the JINR CICC in the LIT.

NETWORKING, COMPUTING, INFORMATION SUPPORT

During 2012, the provision of reliable operation and development of the JINR networking and informational infrastructure progressed steadily. The key components of this infrastructure comprise telecommunication data links, JINR local area network, CICC and base software responsible for integration of the Institute's information resources in a unified environment accessible to all users and with the use of grid-technologies.

JINR Telecommunication Data Links. In 2012, the reliable operation of the high-speed computer communication channel Dubna–Moscow was supported. In order to provide connection with scientific networks and Internet, the JINR network infrastructure used the following communication links: CERN (10 Gbps), RBnet (10 Gbps), GEANT (2×10 Gbps), Moscow scientific networks (10 Gbps), RASnet (10 Gbps), RadioMSU (10 Gbps), E-arena (10 Gbps). In 2012, the total throughput of the backup channel was increased up to 1 Gbps.

Table 1 shows the distribution of the incoming and outgoing traffics over the JINR subdivisions in 2012 (the incoming traffic of which exceeded 2 TB).

Table 1

Subdivision	Incoming, TB	Outgoing, TB
LIT	64.79	58.26
DLNP	61.4	70.9
VBLHEP	55.3	49.35
FLNP	27.92	81.14
BLTP	19.73	16.02
VPN node	17.62	4.33
Administration	15.13	31.12
HRC	12.1	1.58
LRB	7.25	3.46
FLNR	7.13	2.01
Uni-Dubna	4.86	5.17
SCAR	3.27	0.27
«Dedal»	3.24	0.7
GRID education net	2.74	0.07
«Atom»	2.22	0.75

The total incoming JINR traffic, including the general access servers and CICC, amounted 2642.09 TB (1525.35 TB in 2011). A percentage distribution of the incoming traffic on categories is provided in Table 2.

Table 2

Scientific and educational networks	File exchange (torrent, ftp)	Web-resources	Social net	Software	Multimedia	Dubna net
91.22%	6.84%	1.32%	0.54%	0.04%	0.03%	0.01%

JINR Local Area Network (LAN). In 2012, the work was focused on the further improvement of the JINR LAN capabilities, together with the provision of the users with additional possibilities. Newly added hardware components and software artifacts to the network infrastructure enabled significant enhancement and growth of the fault tolerance of the JINR LAN telecommunication structure kernel as well as of its security level under steady rise of the data flow. In 2012, the Laboratory of Radiation Biology was connected to the JINR Backbone at a rate of 1 Gbps, the JINR Management network was expanded, the wireless connections were deployed in some JINR subdivisions including the hotel «Dubna» and the recreation centre «Ratmino».

In 2012, the possibilities for videoconferencing were significantly extended. A Cisco/Tandberg MCU Codian 4505 exclusive server has been installed which is able to provide a true HD multimedia–enabled environment, allowing the organization of multipoint videoconferencing.

Two main elements for the provision of reliable and safe operation of the whole JINR informational–computational environment are the monitoring system NMIS (Network Management Information System) and the IPDB–JINR network nodes database. The latter is used for the registration and authorization of the network elements and users, the visualization of statistics concerning the network traffic, the support of the remote user database, the electronic library user database, etc.

The JINR LAN includes 7222 network elements and 10128 IP addresses, a number of 3668 users are registered within the network, there are more than 1500 users of the mail.jinr.ru service, a number of 1164 users of digital libraries, and more than 1000 remote VPN users.

JINR Central Information and Computing Complex (CICC). The 2012 year marked a new cornerstone in the growth of the performance and the data storage of the JINR CICC. Presently, the CICC computing farm comprises 2560 64-bit processors and a data storage system of 1800 TB total capacity. The primary CICC network router is connected to the main JINR network router at a rate of 10 GB Ethernet.

Of utmost importance for the development of both the JINR informational-computational infrastructure as a whole and its grid-segment is the collaboration with the NRC «Kurchatov Institute» on the building-up of an automated system for the LHC data processing at the Tier1 level and provision of the grid-services for distributed data analysis. The general plan of this project comprises three basic stages for 2012-2014. A first stage foresees creation of a prototype at the foreseen level of 10% of the scheduled total capacity of the Tier1 centre To this aim, modules consisting of 1200 64-bit processors, 660 TB disk memory, and a 72 TB tape system have been purchased and installed. The second stage to be completed by the end of 2013, foresees the build-up of the full-scale Tier1 centre. During the third, 2014 stage, the subsequent increase of the computing resources is planned.

The computing facilities and storage systems are managed by the basic software (BS) that provides a way for using the CICC resources both by international projects for distributed computing (WLCG, FUSION, BIOMED, HONE, PANDA, CBM, NICA/MPD, etc.) and by local JINR users.

The base CICC operating system (OS) is the OS Scientific Linux — SL5 with architecture x86_64, some important servers for WLCG support have been upgraded to the OS version SL6.

The CICC is supplied with a set of freely distributed compilers for various programming languages (C/C++/Fortran, etc.) which provide the standard compilers for the Unix–like OS. In addition, Intel C/C++/Fortran Compilers have been installed which are the new generation compilers that provide high-performance on the Intel processors. The Intel compilers are enabled with effective means of development of parallel code within the OpenMP standard. For the development of parallel programs with use of the MPI (Message Passing Interface) package, MPI libraries were made available for the programming languages C, C++ and Fortran.

An interactive cluster consisting of 5 machines provides direct interactive access of the JINR users to the computing resources and the disc data storage of the JINR CICC. A special batch server and work nodes provide batch processing of jobs launched from interactive machines by local users or received from the global WLCG environment. Servers for the system of cluster handling control are used for distributed tasks (of local users and WLCG) on various sites of the WLCG project. The X509 PX (ProXy) service stores and updates the users' certificates aimed at protecting the resources and the user tasks within grid-systems. This is the main method of monitoring the registered users in the WLCG project. On the cluster there is maintained the distributed file system CVMFS (CernVM File System) which provides the access to the program support of the ATLAS, CMS, LHCb, and BES Collaborations installed and stored on the CERN servers. Two VOboxes (Virtual Organization box) are used by the ALICE and CMS Collaborations to do their work on the WLCG sites.

The data storage and access systems dCache and XROOTD ensure the data handling both for the local JINR users and for the external users. Two dCache installations are supported: dCache-1 for the experiments CMS and ATLAS; dCache-2 for the local users as well as the international projects NICA/MPD, HONE, FUSION, BIOMED, COMPASS. Three implementations of the XROOTD data access systems supply the access to data of three international collaborations: ALICE, PANDA, and CBM. All the storage systems use the hardware safety mechanism RAID6.

In the CICC there are a few specialized machines devoted to the user support in frames of local and international collaborations: the projects NICA/MPD, PANDA-GRID, and CBM.

Table 3 summarizes the distribution of the batch jobs (other than the tasks within grid-projects and provided their number exceeding 300) in 2012, over the JINR subdivisions and user groups.

Table 3

Laboratory/ Group	Number of jobs	CPU time, kSi2K · h	Astronomical time, kSi2K · h
MPD	27346	194656.04	205650.00
PANDA	26266	49550.08	92931.83
DLNP	21323	1353695.19	401150.82
COMPASS	17182	186303.33	189458.43
VBLHEP	16782	453440.61	464766.41
KLOD	15894	136267.78	136967.64
BES	6217	49043.03	50794.43
BLTP	1698	260697.83	254593.52
LIT	1566	852901.18	66902.14
FLNP	678	99630.53	99825.76
CIMSRVR	420	8524.20	8559.42
LRB	370	186664.84	44115.51

JINR Grid-Environment. During 2012, active JINR involvement continued within two large-scale grid-projects: «Worldwide LHC Computing Grid» (WLCG, http://lcg.web.cern.ch/LCG/) and «European Grid-Infrastructure» (EGI-InSPIRE — Integrated Sustainable Pan-European Infrastructure for Researchers in Europe, http://www.egi.eu/projects/egi-inspire/). The JINR CICC, labeled as the JINR-LCG2 of the global grid-infrastructure provide computing support to ten virtual organizations (alice, atlas, biomed, cms, dteam, fusion, hone, lhcb, bes, and ops). It also provides possibilities for using grid-resources by the experiments CBM and PANDA. The main users of the JINR grid-resources are the virtual organizations of all the large-scale experiments at LHC.

The maintenance of the JINR-LCG2 grid-site is done by 22 servers operating under the WLCG middleware gLite/EMI. Besides supporting the operation of the JINR-LCG2 site itself, part of the servers provide important services and functions for the support of the Russian segment of the WLCG project. From the point of view of its reliability and availability, the JINR-LCG2 site is one of the most effective Tier2 sites in the world.

In 2012, a large amount of work was done on data acquisition and processing for the experiments ALICE, ATLAS, and CMS at JINR. Table 4 presents the use of the JINR CICC grid-infrastructure by the virtual organizations (VO) within RDIG/WLCG/EGI.

Table 4

VO	CPU time, HEPspec06 · h	Jobs
cms	56 601 508	1 082 540
atlas	51 290 108	4 453 229
alice	29 965 312	1 256 509
lhcb	14 549 848	425 068
biomed	1 037 172	97 483
fusion	698 528	3 940
hone	630 420	20 074
bes	239 408	8 335
ops	1 068	66 578
dteam	0	194
Total	155 013 372	7 413 950

Presently, the JINR grid-site is the best among the RDIG sites. Our 2012 comparative contribution to the job processing for RDIG and for the experiments ALICE, ATLAS, and CMS is shown in the diagrams of Fig. 1.

The design and development of software for large-scale distributed data management may be of critical importance in distributed computing A striking example is the data deletion service for the ATLAS experiment [1]. The data of the ATLAS experiment are distributed over 100 gridsites covering a total volume of disk space of almost 150 PB where hundreds of millions files are stored. The weekly rate of deleted data is 2 PB (20 00 000 files).

During the last few years, the system of distributed data processing of LHC experiments has been augmented with an additional infrastructural layer consisting of the Tier3 level centres which bring a sizable contribution to the physical analysis of experimental data. This level involves various computing resources (servers, clusters, supercomputers) which are outside the WLCG centralized management and planning and which do not obey any of the standard technical criteria for site infrastructure. To keep evidence of the activity of the Tier3 level centres, the architecture of a test infrastructure (Fig. 2) has been developed at JINR, which allows the definition of prototypes of the various Tier3 centre configurations. This infrastructure nests on the concept of virtual cluster for which it is possible to build-up or to implement procedures for the local monitoring and to elaborate exhaustive recommendations concerning the acquisition of information enabling the global monitoring of the Tier3 centres [2].

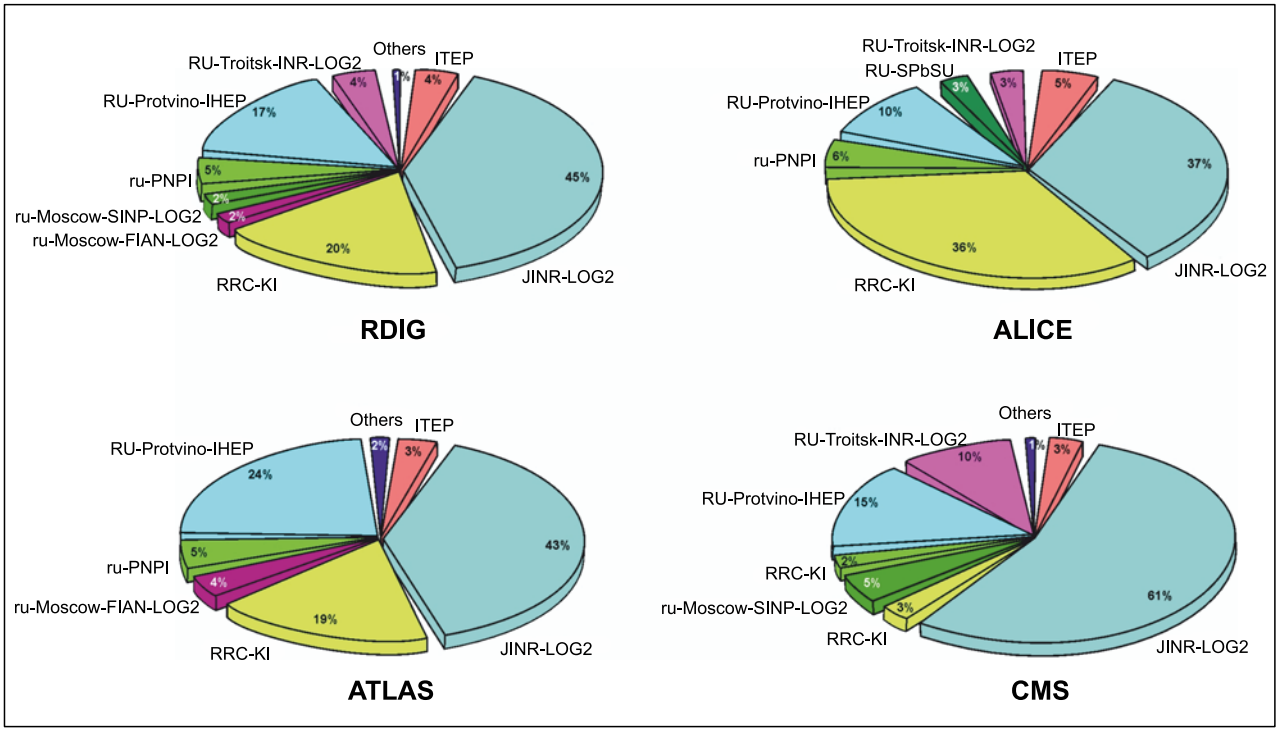

Fig. 1. JINR 2012 contribution to the job processing for RDIG and for experiments ALICE, ATLAS, and CMS

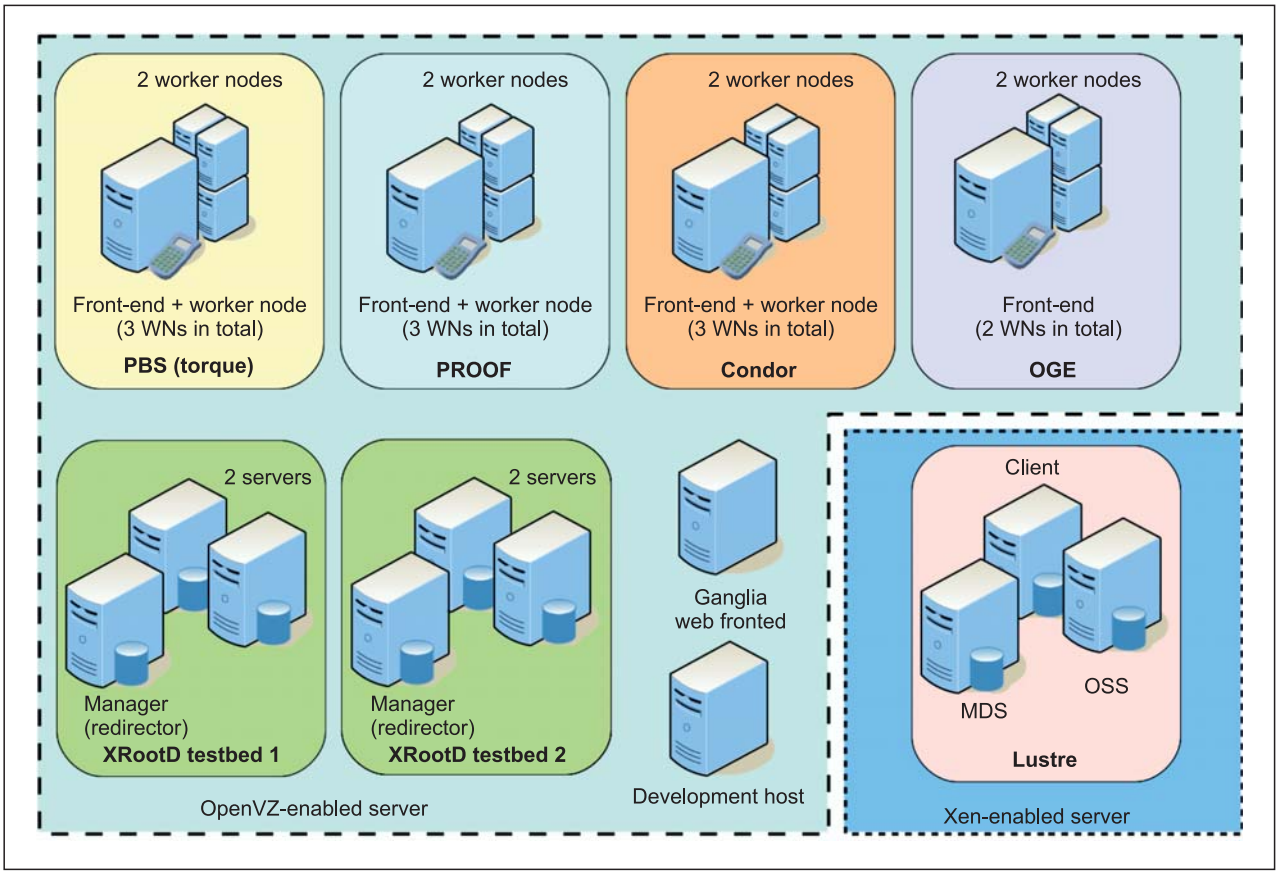

Fig. 2. The architecture of test infrastructure realized on the basis of virtual clusters which has allowed one to investigate different Tier3 configurations

For the ATLAS experiment a software package has been developed within the project T3MON, that allows one to monitor the Tier3 sites not included in the grid-infrastructure [3].

The development of grid-technologies makes the problem of adaptation of existing applications for their use in the grid-infrastructure more and more needed. For the users to work in the GridNNN (Grid National Nanotechnological Network) environment and the Russian Grid Network (RGN), LIT specialists provided the adaptation of a number of software packages to facilitate their use in the grid-environment: Elmer — a package for the analysis of a wide spectrum of physical models by the finite element method; the suite of software Molpro for ab initio high-precision computations of the electronic structure of molecules; the software package Blender for creation and work with 3D models; DL_POLY — a multi-purpose software package for computations in the field of classical molecular dynamics; GEANT4-DNA package for the simulation of the biological damages induced by the ionizing radiation at the cellular and subcellular scale [4]. For the work within RGN, the packages Fire Dynamics Simulator — FDS (modeling of fires and smokes) and ZondGeoStat (processing of geophysical and geochemical data) have been adapted.

In 2012, a model of distributed computing for the NICA project was developed. Based on the software package GridSim, an imitating model of a system for storage and processing data from the NICA accelerator complex has been designed. The use of the simulation approach will allow one to determine parameters of an information processing system at the design stage. Proceeding from the simulation results, one can formulate the requirement to the system architecture for the acquisition, transfer, processing and storage of data coming from installations which generate enormous amounts of data [5].

Information and Software Support. In 2012, the information, software, and algorithmic support of the research-and-production activity of JINR included the development and support of the informational WWW/FTP/DBMS servers of JINR and LIT, the creation and storage of the electronic documents concerning the scientific and administrative activities of the Institute. The administrative databases are regularly maintained and upgraded in cooperation with the Automated Management Information Systems Department of JINR.

Work was constantly done on the design and support of various information websites, sites of conferences, workshops, symposia organized by JINR Laboratories, as well as the organization of website hosting (upon request). Illustrative instances are the web-portal for the FLNP International Seminar on the Interaction of the Neutrons with Nuclei (ISINN), http://isinn.jinr.ru/, for the DLNP B.M.Pontecorvo V International School on Neutrino Physics, http://pontecorvosch.jinr.ru/, for the FLNR VI International Symposium on Exotic Nuclei, http://exon2012.jinr.ru/, the International Youth Conference-School «Modern Problems of Applied Mathematics and Informatics», http://mpamcs2012.jinr.ru/. The maintenance and modernization of the portal of the journals «Physics of Elementary Particles and Atomic Nuclei» and «Part. Nucl., Letters» http://pepan.jinr.ru/ are of permanent concern.

The open access JINR Document Server (JDS) (http://jds.jinr.ru/) electronic archive-repository has been developed and modernized in frames of the international programme Open Access Initiative (OAI) on the basis of the software CDS Invenio. The software support of the electronic access to the JINR Science and Technology Library (STL) was further improved in 2012. It included filling and maintenance of the digital collections of the STL bulletins and digital catalogues, the support and development of its website. An electronic version of bibliographical indices of publications of JINR staff for 2011 has been released (http://lib.jinr.ru).

Another traditional direction of LIT activity includes the development and the support of the program library JINRLIB as well as program libraries developed by other research centres and organizations (CERNLIB, CPC Program Library). Information on recent acquisitions is available in a regular issue of the LIT Information Bulletin at http://lit.jinr.ru/Inf_Bul_6/.

In 2012, work was underway on the adaptation of the APT EVM system (Activity Planning Tool Earned Value Management) which is planned to be used for the NICA project management. The system allows one to evaluate the expenses and monitor the activities on the implementation of the project, to perform a financial analysis of the current state of the project as well as to get predictive estimates of the expenses by the project close-out. The system has been installed on a remote site in CERN, initial data were introduced in the system. The software for integrating the APT EVM system and the JINR ADB2 financial system was prepared and tested. A regular data exchange between EVM and ADB2 has been started.

MATHEMATICAL SUPPORT OF EXPERIMENTAL AND THEORETICAL STUDIES

The mathematical, algorithmic, and software support of the experimental and theoretical research underway at JINR is one of the main objectives of the LIT research. In 2012, the obtained results were reported in more than 200 papers, 72 articles being published in referred journals. A number of 37 reports were presented

at Russian and international conferences. Below there is a brief report about a few of the obtained results.

A number of fast and highprecision algorithms has been developed and implemented for electron identification with the help of the Ring Imaging Cherenkov (RICH) detector and the Transition Radiation Detector (TRD) of the CBM experiment at FAIR. A fast RICH ring recognition algorithm based on the Hough Transform was implemented. An efficient algorithm based on the Artificial Neural Network was developed for the RICH electron identification. An algorithm based on the Kalman Filter method was realized for the TRD track reconstruction [6].

The problem of reliable electron identification in conditions of dominating pion background with the help of a multilayered TRD in the CBM experiment is considered. With this aim, various mathematical methods, including methods based on a nonparametric goodness-of-fit ω_n^k criterion, have been elaborated and investigated. The characteristic properties of the distributions of energy losses by electrons and pions in the TRD radiators are considered, and specific features of applying traditional statistical methods, methods based on the ω_n^k criterion, and artificial neural networks to the analyzed problem are discussed. Some results of a comparative analysis on the power of these methods are presented, and recommendations on their usage are given [7].

Different options of the CBM dipole magnet have been studied. A comparative analysis of the resistive and superferric versions of the dipole magnet has been performed. 3D TOSCA models of the window frame and H-type superconducting dipole magnets have been constructed. An optimization analysis of the Lorentz-force distribution on the coils is performed. A field map for H-type magnet is calculated.

The results of the CBM dipole magnet modeling were reported on the 19th CBM Collaboration Meeting (March 26–30, 2012, GSI, Germany), BM Magnet Review Meeting (June 18–19, 2012, GSI, Germany) and CBM Magnet CDR Review (November 5–6, 2012, GSI, Germany).

The SIS100 quadrupole and dipole superconducting magnets have been studied in frames of the FAIR project (GSI). The dynamic effects of the vacuum chamber on the field quality have been analyzed. The design and the development of an insertion to improve the end field quality of the SIS100 dipole have been performed.

A 3D model of the NICA booster bent dipole magnet has been constructed. Field quality analysis has been performed.

A new Asynchronous Differential Evolution (ADE) algorithm is used to determine the parameters of microscopic optical potential of elastic pion scattering on ^{28}Si, ^{58}Ni, and ^{208}Pb nuclei at energy 130, 162, and 180 MeV. This algorithm provides more ample opportunities for paralleling and accelerating the computations. A good agreement with experimental data has been obtained On the one hand, this confirms that the ADE algorithm is capable of solving multiparametric optimization problems with a complex multimodal profile of the objective function. On the other hand, this allows one to draw some conclusions about the mechanism of pion–nuclear scattering and to trace paths for the further development of the model of the microscopic optic potential [8].

The program VSHEC has been developed for the automatic calibration of spectrometric detectors, i.e., transformation of the output channels of a measuring device into physical values such as energy, time, angle, etc. This is essential for the calibration of multidetector systems, where hundreds of registering devices are in operation. The calibration is complicated by the fact that the required pivotal channel numbers should be determined from peak-like distributions so that the pattern recognition procedure is to be employed. The automatic calibration allows one to determine the calibration curve parameters based on the reference quantity list and the data which are partially characterized by these quantities [9].

Local and semilocal convergence domains of the continuous analogue of Newton's method are defined and an optimal choice of the iteration parameter is proposed. A global convergence is proved for the Newton method and error bounds are derived. The proposed strategies allow extension of the convergence domain of the initial iteration parameters. Several comparisons are performed [10].

A computational scheme was developed for the numerical solution of direct and inverse scattering problems on parameter-dependent spherically symmetric potentials. The scattering problem for the radial Schrödinger equation, in contrast to its statement as a Cauchy problem, is formulated as a boundary-value problem for the wave function with a nonlinear asymptotic condition which is free of the unknown phase shift. The phase shift is determined after calculation of the wave function by taking into account its asymptotic behavior and applying the iteration scheme of the continuous analog of Newton's method. The inverse problem for the equation with a parameter-dependent potential is reduced to a minimization problem with respect to the parameters for a functional which is the sum of the squares of the deviations of the calculated values of phase shifts from the corresponding specified values. Basic features of the computational schemes are demonstrated by solving a problem with Morse potential that admits an analytical solution and a problem with Woods–Saxon potential [11].

Properties of the scalar σ meson are investigated in the two–flavor Nambu–Jona-Lasinio model with Polyakov loop. A model analysis of the phase diagram of strong interacting matter is performed. The temperature dependence of the $\sigma \to \pi\pi$ decay width is studied at zero chemical potential and near the critical endpoint. The calculated strong coupling constant $g_{\sigma\pi\pi}$

and the decay width are compared with available experimental data and other model results. Nonthermal enhancement of the total decay width is noted for the σ meson near the critical endpoint when the condition $m_\sigma \geqslant 2m_\pi$ is broken [12].

The effects of nonzero photon momentum on the triply differential cross section (TDCS) for $(\gamma, 2e)$ processes have been investigated numerically. Due to the low value of the photon momentum, these effects are weak and manifest themselves only in special kinematical conditions such as the back-to-back emission of electrons with equal energy sharing. Helium and a few light helium-like ions were analyzed in detail. The magnitude of these effects was found to be maximal for relatively small photon energies. However, although this effect on the TDCS remains rather small, of the order of a few $\mathrm{mb} \cdot \mathrm{eV}^{-1}\ \mathrm{sr}^{-2}$, it is sufficient to be observed experimentally [13].

The coupled dynamics of low lying modes (including scissors) and various giant quadrupole resonances are studied with the help of the Wigner Function Moments method generalized to take into account spin degrees of freedom. Equations of motion for collective variables are derived on the basis of Time Dependent Hartree–Fock equations in the model of harmonic oscillator with spin orbital plus quadrupole–quadrupole residual interaction. Enlisting the spin allows one to introduce into consideration a new type of nuclear collective motion [14].

The results of measurements of a single differential cross section of the proton charge exchange on a helium atom at proton energies of 630, 1000, and 1200 keV/u are presented. In this case both the helium ion and the oxygen atom in the final state remain in their ground states. Theoretical computations in the first and the second plane-wave Born approximations (SPBA) with regard to the interaction potentials and in the approximation of distorted waves are given. SPBA is calculated in the contact approximation and gives a good agreement with experiment at small angles of dispersion at all energies under study [15].

A new type of relativistic force exerted by an electro-scalar field on an electrically charged particle and the relativistic law of superposition of electromagnetic transverse and electro-scalar longitudinal fields are established in [16]. Also, a relativistically invariant form of a Lagrangian describing the interaction between an electroscalar field and a massive electrically charged particle is defined.

In the floating point computation of an integral by means of an interpolatory quadrature sum, the algebraic degree of precision, d, of the quadrature sum is to be abandoned in the favour of its floating point degree of precision, d_{fp}, the value of which significantly varies with the extent and localization of the integration domain over the real axis. The use of d_{fp} instead of d drastically sharpens the admissible bounds of variation of the integrand in the Bayesian automatic adaptive quadrature [17].

Finite difference approximations to systems of polynomially-nonlinear partial differential equations, the coefficients of which are rational functions over rationals in the independent variables, are considered. The concept of strong consistency (s-consistency) of such systems is determined for uniform and orthogonal grids, an algorithmic procedure for the verification of the strong consistency is described based on the computation of difference standard bases [18].

Symbolic algorithms transforming systems of nonlinear algebraic, differential and difference equations into the Gröbner basis form were improved and implemented in *Maple* and C [19].

The symbolic–numeric algorithms to simulate dynamics of ensembles of nonspherical quantum dots and other low-dimensional hydrogen-like quantum nanostructures in strong magnetic fields have been developed and implemented in *Maple* and *Fortran* [20]. Figure 3 shows the profile of the wave function in the xz-plane computed for one of the resonant highly exited (Rydberg) states of Hydrogen atom for the magnetic quantum number $m = -200$ and z parity $\sigma = 1$.

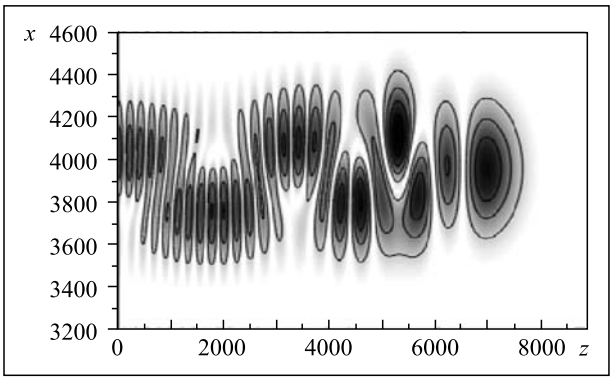

Fig. 3. The profile of the wave function in the xz plane computed for one of the resonant highly excited (Rydberg) states of hydrogen atom for the magnetic quantum number $m = -200$ and z parity $\sigma = 1$

In the framework of finite quantum mechanics it is shown [21] that any quantum-mechanical problem can be formulated in terms of permutations. In this case quantum interferences arise as phenomena occurring in the invariant subspaces of permutation representations of the symmetry group of a system, and observable quantities can be expressed in terms of the permutation invariants. In such an approach for description of quantum phenomena it is sufficient to employ the fields of cyclotomic numbers — minimal extensions of the natural numbers suitable for quantum-mechanical formalism.

The fate of entanglement of spins for two heavy constituents of a bound state moving in a strong laser

field is analyzed within the semiclassical approach [22] when the spin density matrix is determined as a solution to the von Neumann equation with an effective Hamiltonian describing spin-laser interaction along the bound state classical trajectory. Based on the solution, the dynamics of concurrence of spins is calculated for the maximally entangled Werner states as well as for the initially uncorrelated state.

A *Maple* package for calculating two-loop propagator type integrals with all massive propagators and arbitrary momentum was developed and optimized [23]. The procedure for calculating appropriate high rank tensor integrals (up to rank 8) was developed and implemented in *Maple* and *FORM* languages. At the present time, with this software the calculations of the two-loop mixed propagator for quarks are finalized.

Some burning problems of modern cosmology were analyzed. The most popular models dealing with dark energy are also discussed in short. We specially stretch on the spinor model of fluid and dark energy. It is shown that the model with a spinor field can resolve a number of standing problems of modern cosmology. It is noted that the nontrivial nondiagonal components of energy momentum tensor of spinor fields impose some severe restrictions on the metric functions [24].

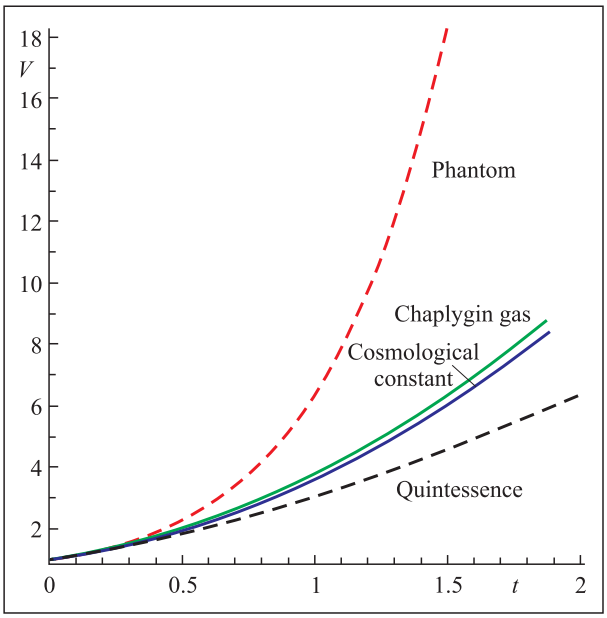

Fig. 4. Evolution of the Universe filled with dark energy

The issues of the Universe evolution were studied taking spinor models of fluids and dark matter into account (Fig. 4) [25].

INTERNATIONAL COOPERATION

The research work at the Laboratory is carried out in close cooperation with scientists and specialists of the JINR Member States as well as a number of research centres of other countries. Some instances of such a cooperation should be particularly stressed.

The training of users and system administrators in the grid-environment uses the educational infrastructure installed and under extension at LIT (http://gridedu.jinr.ru). On the base of OpenNebula software with a driver for the OpenVZ hypervisor, a local cloud infrastructure has been deployed. The services of the educational–research and test grid-infrastructure were transferred to this platform. Based on the educational–research grid infrastructure, polygons were created for the development of a prototype of the subsystem for data storage of the Russian Grid Network as well as for the participation in research work on ATLAS XRootD federation. The grid-site of the Institute of Physics (Baku, Azerbaijan) was integrated into the educational–research grid-infrastructure. At present, this infrastructure comprises 8 grid-sites in the JINR-participating countries and three sites located at JINR. In frames of training users and system administrators for the JINR Member States, tutorials were organized in 2012 for the employees of the Institute of Theoretical Physics (ITP, Kiev, Ukraine), the National Technical University of the Ukraine «Kiev Polytechnic Institute» (KPI, Kiev, Ukraine) and the Institute of Scintillation Materials of the Ukrainian Academy of Sciences dedicated to the installation of grid-services EMI2, XRootD, and AliEn; training courses were provided for system administrators from Egypt, Mongolia, and Azerbaijan on the base set of EMI2 grid-services; practice on grid-technologies was secured for students from the Republic of South Africa.

In frames of collaboration with BLTP and the University of Plovdiv (Bulgaria), the critical regimes in the long Josephson junction (LJJ) model are studied on the basis of numerical solution of the double sine-Gordon equation [26]. The numerical approach is based on the consideration of the stationary sine-Gordon equation and the respective Sturm–Liouville problem as a unique system that is numerically solved by means of the modified Newtonian iteration in combination with a numerical continuation algorithm. It is shown that the second harmonic contribution to the current-phase relation changes the properties of the static magnetic flux distributions in the LJJ and inspires new homogeneous and fluxon static states. The interconnection

of the coexisting (stable and unstable) magnetic flux distributions has been analyzed.

In cooperation with Bulgarian colleagues, a microscopic optical potential is used to calculate cross sections for elastic $^{11}\mathrm{Li} + p$ scattering at the energies of 62, 68.4, and 75 MeV per nucleon, and the results are compared with available experimental data. The potential used does not involve free parameters, but the depths of its real and imaginary parts are renormalized. The known trend in the energy dependence of the volume integrals of the optical potential is taken into account in analyzing experimental data. The role of spin-orbit interaction is studied, and the total reaction cross sections that are proposed to be measured in future experiments are calculated (Fig. 5) [27].

The evolution of the Universe has been studied in the presence of fluid and dark energy, where the role of dark energy is played by the parameter of the equation of state (EoS parameter) ω. In doing so, both constant and time varying EoS parameters have been considered. The consideration of time varying EoS parameter was determined by the fact that according to the observational data the Universe entered into an accelerating mode of expansion from the decelerating one, which means the EoS parameter has changed its value from positive to a negative one. The obtained results were compared with those found experimentally. It has been shown that the predictions of those models are in good agreement with the observational data [28].

In cooperation with our Romanian colleagues, the evolution of the Universe within the scope of a Bianchi type-I model in presence of cosmic string and magnetic fluid was studied. The problem was analyzed in the framework of both classical and loop quantum cosmology. A thorough comparison of the obtained results was carried out [29].

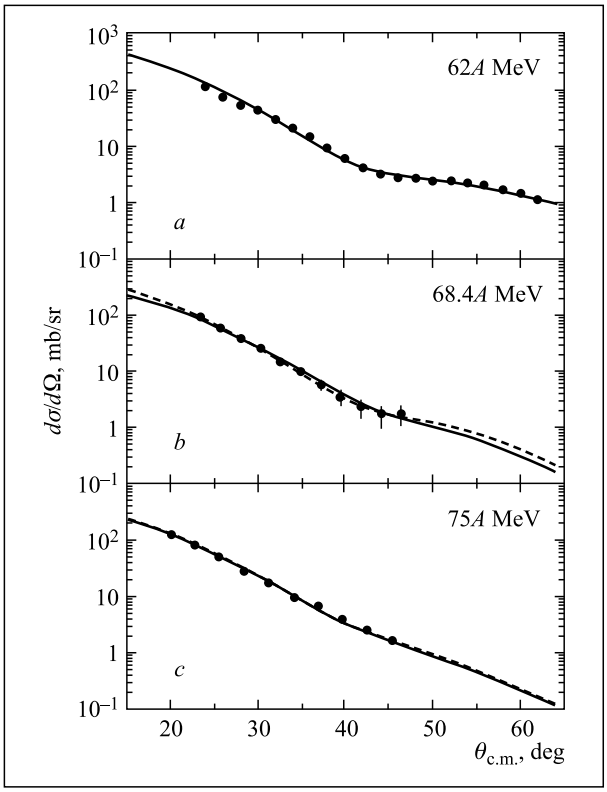

Fig. 5. Elastic scattering $^{11}\mathrm{Li} + p$ at 62 (*a*), 68.4 (*b*) and 75 MeV/nucleon (*c*) for OP with calculated renormalizing factors of the depths of real and imaginary parts of the potential. Solid and dashed curves are the calculations without and taking into account the ls interaction, accordingly

CONFERENCES AND MEETINGS

On January 31 – February 3, 2012, LIT hosted the nineteenth interdisciplinary conference «Mathematics. Computer. Education». Special features of these conferences are their scientific–educational and interdisciplinary character. They give the opportunity of a professional scientific dialogue during the conference sessions and enable young scientists to discuss their results with prominent researchers and lecturers. The 19th conference was attended by more than 380 participants, most of them being young people.

The traditional two-day workshop on computer algebra was held at LIT on May 23–24, 2012. More than 30 scientists representing universities and research centres of Bucharest (Romania), Moscow, Saint Petersburg, Omsk, Petrozavodsk, Pereslavl-Zalessky, Saratov, Tambov and Dubna attended the event and presented 28 reports.

On July 16–21, 2012, the Laboratory of Information Technologies hosted the fifth international conference «Distributed Computing and Grid-Technologies in Science and Education».

This event is held at LIT every two years under support of the Russian Foundation for Basic Research and involving more and more specialists from year to year. The programme of the Conference included not only questions related to the creation and operation of grid-infrastructures and grid-applications, but also some theoretical and practical aspects of utilizing distributed computing environments, distributed data processing, etc. This time the heightened interest to the Conference was aroused by the creation in Russia of a Tier1 level data-processing centre at JINR and at NRC «Kurchatov Institute» as well as by vigorous activity in applying cloud computing.

The Conference was attended by 256 participants from 22 countries: Azerbaijan, Belarus, Bulgaria, Great Britain, Germany, Georgia, Italy, Kazakhstan, China, Cuba, Moldova, Mongolia, Myanmar, Russia, Romania, USA, Uzbekistan, Ukraine, France, Czech Republic, Switzerland, Sweden as well as CERN and JINR. Russia was presented by participants from 40 universities and research centres.

The Conference programme included daily plenary sessions and 8 sections: grid-infrastructures, clouds and grid, grid-applications, desktop grids, systems of distributed information resources, WLCG (Worldwide LHC Computing Grid), GridNNN (Grid of the National Nanotechnology Network), Distributed computing: methods and algorithms, as well as poster presentations. A workshop on computing for ATLAS experiment on LHC chaired by the leader of computing for ATLAS experiment A. Klimentov (BNL, USA/CERN) was organized in frames of the Conference. The International Desktop Grid Federation (IDGF) Tutorial was held in frames of the Conference in combination with a practical part on this direction as well as introduction into grid-technologies which was continued after the conference for students, post-graduate students and conference participants from Mongolia and Azerbaijan.

A round-table discussion devoted to the creation of a Tier1 level data processing centre for LHC experiments in Russia became a very important event of the Conference. The developmental work on this centre is carried out by NRC «Kurchatov Institute» and JINR on the basis of the state contract No. 07.524.12.4008.

The International Conference-School for Young Scientists «Modern Problems of Applied Mathematics & Computer Science» was held at the JINR Recreation Centre «Ratmino» on August 22–27, 2012 under the auspices of the Russian National Committee of the Society for Industrial and Applied Mathematics (SIAM) and the International Coordination Committee for Computational Mathematics of the CIS Academies of Sciences. The Conference-School was organized by the Keldysh Institute of Applied Mathematics RAS, JINR Laboratory of Information Technologies, Institute of Numerical Mathematics RAS and the Research Computer Centre, MSU. The Conference-School was organized with the purpose of reviving the traditions of schools in the field of applied mathematics and mathematical simulation. The main goal of this Conference-School was the acquaintance of young scientists, students and post-graduate students with modern computational methods, tools and methods of programming, computing platforms as well as with the results of mathematical modeling of various systems in science and technology. The Conference-School was attended by more than 120 participants from Russia, Bulgaria, Belarus, Vietnam, Germany, Mongolia, Slovakia, Tajikistan, Ukraine, South Africa. Russia was represented by participants from Dubna, Moscow, Voronezh, Yaroslavl, Sarov, Novosibirsk.

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