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I. Main duties of the research unit in 2010

According to the tasks described in the deed of foundation as well as those assigned by the Hungarian Academy of Sciences the Research Institute for Particle and Nuclear Physics (RMKI) has conducted successful experimental and theoretical basic research in the field of particle physics, nuclear physics, plasma physics, the physics of cool atoms, space physics, nuclear solid state physics, nuclear materials science as well as biological applications of physics. The main fields of developments were: laser physics, nuclear analytics, fusion plasma diagnostics, space technology, fast data processing, spectroscopy, special instruments for electronics, mechanical and information technology including software for various operating systems. As the leading institution of the Hungarian Euratom Fusion Society RMKI coordinated the Hungarian R+D activity in controlled fusion energy production research. It has also improved and operated the EG-2R electrostatic accelerator together with the NIK Heavy Ion Implanter facility, the MBE Molecular Beam Epitaxy device as well as the GRID system and other high power computer networks. It has developed and operated the computer network of the KFKI Campus and serves as the regional centre of the National Information and Infrastructure Development Program.

II. Outstanding research and other results in 2010

a) Outstanding research and other results

High-energy experimental particle physics and heavy-ion physics
The LHC collider of CERN in 2010 has reached the record energy of 7 TeV. The collision yield has increased by 5 orders of magnitude (50 pb^{-1} for proton-proton collision at 7 TeV, and 80 million for Pb+Pb heavy-ion collision at 2.76 ATeV energy) and the publication of the experimental results has begun. The work of the Hungarian research groups collaborating in the international particle physics experiments ALICE, ATLAS, CMS, TOTEM, as well as in ASACUSA and NA61 at CERN, FOPI at GSI, CBM at FAIR and PHENIX at RHIC are coordinated by scientists of our Institute.

The main task of the Hungarian CMS group is to guarantee the safe and undisturbed performance of the experiment and data collection. The position monitoring code of the barrel-muon detector developed and operated by the group has been working flawlessly and new software based on a more accurate algorithm has been elaborated and put into operation. The researchers of RMKI had a decisive role in the determination of particle distribution measured in the first 7 TeV p+p collisions. The results are in accordance with the earlier ones obtained at 0.9 TeV and confirm that nearly identical amount of hadrons are produced in proton-antiproton and proton-proton collisions. The density of hadrons obtained from the 2.36 and 7 TeV experiments shows steeper energy dependence than predicted by the models. In recognition of the successful work the collaboration has elected the representative of our Institute as the convener of the CMS QCD research group.

The operation of the „High Momentum Particle Identification Detector" (HMPID) is the responsibility of the Hungarian ALICE team. In the 7 TeV p+p collision data the two- and

three-jet events have been analyzed in HMPID-specific way and the differences between quark and gluon jets have been studied. The results were used in the 2.76 ATeV heavy-ion experiments to study the suppression of particle number. In the course of the development of the new VHMIOPD sub-detector the Hungarian group has built and tested the new prototype of the trigger system and the mirror system of the Cerenkov-module at the beam of the CERN`s PS accelerator.

In the ATLAS experiment the researchers of the RMKI as members of the Liquid Argon group in collaboration with French scientists have studied the spatial form and energy distribution of the electromagnetic showers generated by isolated electrons in the 7 TeV p+p collisions. They proved that with the precise knowledge of the absorbent structure of the closing units of electromagnetic calorimeters the deviation between measurements and simulations can be decreased.

In the TOTEM experiment the internal structure of the proton is studied by the investigation of p+p diffraction scattering. In the TOTEM experiment at 7 TeV energy it was possible to observe the diffractive p+p scattering as well as the first double-Pomeron exchange process. The RMKI researchers played an important role in the finalisation of the Detector Control System (DSC) of the experiment and the totAlarm system that guarantees safe operation was built in.

In the SPS NA61/SHINE experiment the data collection system is a fully Hungarian design and cinstruction so that the continuous development of both hardware and software is a Hungarian task. In 2010 carbon and liquid hydrogen targets have been bombardede with 20-160 GeV energy proton and pion beam and the amount of collected data cloud be increased by an order of magnitude.

At the antiproton decelerator of CERN the accuracy of the experimental check of CTP invariance was further increased. In the two-mode Paul-trap built with the participation of RMKI the monitoring of the antiproton-proton annihilation was further developed.

In the PHENIX experiment of the American BNL RHIC accelerator with the participation of RMKI researchers the distribution of thermal gamma photons emitted by the quark-gluon plasma in Au+Au collisions was determined at the first time and also the temperature of the resulting quark liquid was measured and found to be at least 4 Terakelvin (300 MeV). The value obtained from the measurement of the direct photon spectrum means that at RHIC energies in Au+Au collisions quark-gluon plasma is generated. The contribution of the Hungarian PHENIX group to the results was the calibration of the photon time of flight measurement.

In the frame of the CERN RD51 the REGARD group is developing new types of gas detectors in a collaboration of RMKI and Eötvös University (ELTE). New prototypes have been constructed for the ALICE VHMPID trigger and the NA61/SHINE centrality detector and also a multi-chamber muon-tomograph was built for the mapping of caves which was successfully tested.

The RMKI Detector Group has improved the Detector Data Link (DDL) network card for the ALICE and NA61 experiments. The PCI Express version of the RORC (Read-out Receiver Card) cards needed for reading the DDL cards has also been developed. The group also participated in the EDICAM project of the Plasma Physics Division of RMKI, and the

directions of product development have been specified for the subcontractor designing the circuits.

An RMKI research group has joined in 2009 the VIRGO experiment in Italy designed to detect gravitational waves. They have solved the harmonization of the computational infrastructure of the VIRGO and LIGO experiments and have built GPU units into the GRID-based data collecting system.

Materials science by nuclear methods
RMKI operates the 5-MV EG-2R accelerator and the NIK heavy-ion implanter, as well as the Molecular Beam Epitaxy (MBE) laboratory as parts of the Hungarian Ion-beam Physics Platform (HIPP) consortium. The GINA polarized neutron reflectometer – a major magnetic thin film analytical instrument within the Budapest Neutron Centre (BNC) consortium – is offered in user operation and is partly applied by external users. Researchers of the Materials Sciences Division regularly use large European facilities in their experimental research.

In the $LiCoO_2$ the Co 1s x-ray absorption pre-edge has been studied to reveal changes in the lowest-lying unoccupied electronic states. The observed anomalous peak in the pre-edge spectrum was successfully reproduced by the theory in the core-hole approximation in terms of the 4p-3d hybridization of neighbouring cobalt ions. By studying the dielectric function of $YBa_2Cu_3O_{7-\delta}$ in the earlier unravelled large-wave-number region by non-resonant inelastic x-ray scattering – assisted by theoretical calculations – it was shown that Ba 5p and Y 4p core-electrons have a profound effect on the Cu 3d and O 2p valence excitations.

In collaboration with 9 institutes in the EU consortium SPIRIT, the implanted arsenic fluence in silicon was determined to a high accuracy (1.2 %) by means of Rutherford backscattering spectrometry performed with two detectors at two tilt angles.

Hydrogen-containing a-Si samples were synthesized by pulsed lased deposition in a chamber with various H pressures. The hydrogen content was determined by ion-beam analysis and ellipsometry as a function of the hydrogen pressure. The implantation of H into the a-Si layer was found to be limited, however, with increased H pressure, the amount of implanted oxygen increased. The gradient of the refraction index of the film correlates with that of the oxygen concentration.

Indications for the presence of crypto-ferromagnetism were found in $Ni_{55}Cu_{45}$/V ferromagnetic/superconducting double layers by waveguide enhanced polarized neutron reflectometry. By making use of earlier results, a new procedure for stress relaxation by ion-beam irradiation of neutron mirrors was developed. Special magnetizers, radiofrequency flippers and other devices were designed and fabricated for testing neutron mirrors and polarizes.

Guided by their earlier theoretical predictions researchers of RMKI experimentally verified reciprocity violation in nuclear resonance scattering of photons at the European Synchrotron Radiation Facility. It was shown that the shape of synchrotron Mössbauer time spectra can fundamentally change upon a mere 180^o rotation around an axis perpendicular to the beam.

Phases and phase boundaries in the Fe-Si system have been determined by Mössbauer and electron spectroscopy in MBE-deposited Fe and Fe/2Si layers on silicon substrates.

The formation of latent crystalline structure was found by positron annihilation spectroscopy in course of production of LTA and MFI zeolites from synthesis blends well before the crystallization becomes observable by X-ray diffraction. This finding is of high importance for catalytic applications. By investigating the free volume in cyclodextrins the radiation damage by the positron source was found to lead to irreversible changes in as short as a few days time, a result which should be taken into account in studying biological samples.

The RMKI Van de Graaff generator as part of the BNC platform of the CHARISMA EU FP7 project became available for applicants from the EU for non-destructive study of artefacts of cultural heritage. Performing external-beam PIXE analyses in collaboration with a successful applicant from Germany various lapis lazuli semiprecious stones were classified according to their origin.

Theoretical Physics

The researchers of the Theoretical Physics Division are studying fundamental questions in particle - and nuclear physics, and in connection with these they are looking for solutions of problems in quantum field theory, in general relativity and in statistical physics. A brand new multidisciplinary subject is the experimental and theoretical research of gravitational waves.

Numerical works have indicated that spatially well localized lumps form when a massive, real scalar field is coupled to gravity. Such localized scalar lumps are not static, they are oscillating in time. In the literature such objects go under the name of oscillatons. Their very existence is rather surprising as oscillatons are coupled to the radiation field and they are not stabilized by conserved charges, moreover once formed they appear to be very stable.

As it turns out, their oscillation frequency changes slowly in time and in fact they do radiate scalar waves albeit at a very low rate. As a consequence oscillatons are continuously losing mass. Since current physical theories need various massive scalar fields (inflaton, axion, Higgs...) such oscillatons appear as natural candidates for dark matter. The amplitude of the outgoing scalar wave-tail has been reliably computed nonperturbatively and a very good estimate for mass loss has been obtained. For an extremely large range of scalar field masses oscillatons lose only a small fraction of their total mass on timescales comparable to the current lifetime of the Universe. Therefore such objects merit serious studies as possible dark matter candidates. It has been also shown that in a de Sitter-type inflationary universe the effect of the expansion of the universe leads to a mass loss of both boson stars and oscillatons. This mass loss is exponentially suppressed when the expansion rate is slow.

In non-abelian fields in the case of formation of very short time and very intensive chromo-electric field strength the probability of producing quark-antiquark pairs was studied and the density of the newly produced particles was determined. In a time dependent pair creation process the production probability of light and heavy quarks and antiquarks depends mainly on the time gradient of the change of field strength. In case of strong but very short lifespan fields the yield of large mass charmed and bottom quarks was found to be larger than that predicted by the widely used Schwinger-mechanism applied to stationary fields. The characteristic energy scale of particle production is determined not by the mass of the particle but by the width of the field strength pulse. The numerical calculations showed that even in the heavy-ion collisions at LHC energies as a result of the presence of strong non-abelian field the yield of heavy quarks will be close to that of strange and light quarks. This results contradict all earlier expectations, thus its experimental study will be an important task in the future heavy-ion experiments at the LHC.

In matter the spectrum of hadron resonances may change. Since the density and temperature of the matter are also varying in heavy-ion collisions the observation of the spectrum and its change is also one of the important tasks of experimental heavy-ion physics especially at the GSI FAIR/CBM and PANDA collaborations. The account of change is very important since also the measurable signal in the detectors is changed. The RMKI researchers have elaborated a transport model into which they built in the equation describing the time variation of the spectral function that can be deduced from the Kadanoff-Bayn equation. The model was applied to vector mesons, which were created with a modified spectral function corresponding to the local state. It was shown that the result obtained this way satisfied the conservation theorems and at the end of collision the vector mesons recover their vacuum properties, In the collisions investigated by the GSI HADES spectrometer good agreement with experimental data was obtained for dileptons. It was found that in a light system the modification of vector mesons in a the medium produces negligible change in the experimental spectrum.

Plasma physics and the physics of cooled atoms

In 2010 RMKI researchers have built a two-dimensional beam emission spectroscopy (BES) diagnostic equipment at the MAST spherical tokamak (Culham, UK). This is the first BES device in Europe with microsecond time resolution and designed for heating the beam and is the result of a close English-Hungarian collaboration. This new device has been developed primarily for the study of plasma turbulence and plasma flow as well as their interaction. The main advantage of the device is that the observation domain can be varied in a wide region by the motion of the mirror in the vacuum chamber. The most important part of the diagnostics is a camera unit optimized for a low-noise light level with small spatial but high time resolution, developed by one of the spin-off firms of RMKI.

At the TEXTOR tokamak (Jülich, Germany) a lithium beam device was built and in 2010 in collaboration with a number of German groups a detailed study of plasma turbulence and zonal flows was performed. By the processing of data of three different measurement methods it was found that the periodic zonal flows (Geodesic Acoustic Mode, GAM) are asymmetric in both angle directions of the tokamak, and along the smaller radius show a characteristic phase variation. At the edge of the plasma outgoing flow modulations can be seen. The dependence of the tilt of the turbulent whirls as a function of the magnetic field strength and direction was also studied in detail.

The ten-channel video diagnostic unit of the Greifwald Wendelstein W7X stellarator is also developed by the RMKI researchers. The thermal and mechanical test of the prototype was successfully completed. The special objective lenses and the prototype of the EDICAM (Event Detection Intelligent Camera) using 16 Gbit link were also built. This camera (in addition to the COMPASS tokamak) was successfully installed also at the ASDEX Upgrade tokamak and with the help of the diagnostic device cryogen pellets were traced.

The lithium beam diagnostic system developed with several years work by the physicists and engineers of RMKI for the COMPASS tokamak in Prague was delivered at the end of the year according to the plans to the partner institute in Prague.

In several projects continuing also in 2011 the tasks planned for 2010 have been fulfilled. Such a milestone was the development of the prototype of the camera system for the W7X stellarator, the diode covering mechanics of the AXUV camera system of the TCV tokamak in Zürich, the modification of the periscope head of the JET tokamak (Culham, UK) as well as

the development of the opening-closing mechanics of the camera system for the ASDEX device in Garching.

The most important of the various tasks under development for the experimental fusion reactor ITER in France is the conceptual design of the service unit of the „tritium breeding module" (TBM), which is being built in the frame of a tender by the Fusion for Energy agency (Barcelona).

The researchers of the RMKI in collaboration with a Polish group at the High Intensity Laser Laboratory of Szeged University performed measurements in argon gas at the wavelength 83 nm for the resonant third KrF harmonic using a diamond detector insensitive to the fundamental frequency. In addition to the 3ω also signals from 5ω and 7ω were detected. According to preliminary data the conversion factor was found to be 10^{-3}, smaller by one order of magnitude of that described previously in a Hannover experiment but in agreement with their own previous results. With researchers from Prague a complex interferometric diagnostics was jointly developed which makes possible the measurement of plasma density delayed by 10 ps – 6 ns from the main laser beam. In the first experiments the sparks generated in air were studied. The expansion of the long filament and in it the forming of a cavernous structure was observed.

The interaction of multilevel atom with short laser pulses was also studied. With the methods developed previously the metastable states and the coherences between them can be manipulated without significant excitation of the atoms. On the basis of a model with tripod level scheme the possibility of generating deterministic coherence between the three ground states at arbitrary time was considered. The decoherence caused by spontaneous emission from excited states was minimized. The decoherence arising from transverse relaxation has been eliminated by the use of ultra short frequency modulated laser pulses.

New method was elaborated for producing Zeeman coherence in ^{83}Rb atoms between the magnetic sublevels of the hyperfine magnetic levels of the D2 line. In collaboration with Polish scientists an experimental procedure was proposed for the measurement of artificially produced coherence based on the nonlinear Faraday-effect describing the rotation of the plane of polarization of the light propagating in the medium. A powerful method was for quantum systems with sizeable inhomogeneous widening of transitions (e.g. solid state media) for the mapping of optical information to the position of atomic levels and coherence between quantum states.

By studying multiphoton adiabatic transitions generated by partly overlapping laser pulses in rubidium atoms it was shown that the atomic quantum state can be efficiently controlled even if the energy levels of the atom are degenerated and the transition matrix elements between the magnetic sublevels are different. Such an entanglement of pairs of laser pulses was successfully produced between the internal magnetic states and the external translational state.

In order to experimentally verify the theoretical results a new method was elaborated to produce intense, varying frequency nanosecond laser pulses by using narrow bandwidth semiconductor lasers, integrated electro optic modulator and laser amplifier. The optimal parameters of the source of laser pulses, the applied optical device, the modulator as well as the amplifier were determined. Methods have been worked out for the measurement of the properties of the chirped laser pulses and the processing of the signals of the interferometers and frequency run of pulses were determined. The laser pulses were then used to irradiate

trapped rubidium atoms and the movement of the atomic cloud was measured as a function of the starting frequency and frequency run of the light pulses. It was shown that the laser pulses generated by the new method can be used to coherently generate cooled atom packets.

Space physics and space technology
The faint dust ring in the inner magnetosphere of Jupiter was modelled. It was assumed that the dust particles forming the ring are ejected from the surface of the two innermost moons of Jupiter, Metis and Adrastea, as a result of the bombardments by interplanetary micrometeoroids. The dust particles are electrically charged in the plasma environment of Jupiter and the surface potential of dust particles varies systematically as a function of distance from Jupiter, resulting in surprisingly short dust grains' lifetimes. The spatial density distribution and the optical depth of the dust ring have been calculated. The model reproduces well the results of the Jupiter dust ring region obtained from observations made by telescopes and spacecraft (Voyager, Galileo, Cassini). On the basis of the model an estimate was presented for the dust counts expected to be observed in 2014 by the Juno space probe when crossing that region.

Using the data obtained by the Cluster space probes they determined one dimensional sections of the spatial correlation function of the Interplanetary Magnetic Field; then fitting a function to these sections they determined the three dimensional correlation function itself. The four Cluster probes provide a unique tool for the profound in-situ investigation of the spatial variations of the Interplanetary Magnetic Field; without such an investigation the determination of the correlation function is virtually impossible and suffers from errors. Now, in possession of sufficient data they could produce the most accurate results so far, moreover in all three spatial dimensions simultaneously. They showed that the fluctuations of the magnetic field are essentially anisotropic; the anisotropy can be described by a three axis ellipsoid, the quantitative properties of which were also determined.

Using plasma data obtained by the Cassini space probe the plasma properties around planet Saturn was investigated, with special attention to the moon Titan and the plasma region surrounding its orbit. They classified the first fifty Titan encounters according to the characteristics of the ion component of the plasma. During a more detailed study they also performed a statistical analysis of the plasma properties. They showed that the distance from the so-called magnetodisk of Saturn decisively influences the properties of the plasma. They revealed the fine-structure of the magnetodisk. In the central sheet of the magnetodisk they found a narrow plasma region extraordinarily rich in heavy ions. They showed that this region is colder and denser than its surroundings. They also analyzed the effects of this variable plasma environment on several selected Titan encounters.

The researchers of RMKI have also achieved important results in the field of space technology. New software controlling flight and data collection has been developed for the central computer of the landing unit of Rosette Philae launched in 2004 for cometary research. This new software utilizes all the information obtained since launch of the spacecraft so that it is suitable for all controlling tasks during the approach to the comet, landing as well as at grounding.

The electronic model of the design of the power unit of the PICAM experiment for the BepiColombo spacecraft to be launched in 2016 for the investigation of Mercury has been completed. It will be tested and integrated to the SERENA/PICAM system by researchers in Graz who are responsible for the integration of the experiment.

In collaboration with Swedish researchers a proposal was made for the instrument package PEP (Plasma Environment Package) for the planned ESA space probe to be launched in 2020 for the investigation of the environment of Jupiter. The study of the power supply of the system containing nine detectors was prepared by the engineers of RMKI. The basic task was the optimisation of weight, volume, efficiency as well as reliability. Three presentations were given on the evaluation of more than ten versions and their developers also participated in the preparation of a study submitted to ESA.

Biophysics

In a study of spontaneous and activated neural activity performed in inter-national collaboration it was shown that the activity of the neurons of the visual cortex implies the existence of an internal model which during the onthogeny becomes adapted to the statistics of stimuli from the environment. It was demonstrated that the variability in the responses of neurons to stimuli from the environment which were earlier interpreted as noise can be described by a functional explanation: the variability is just the randomness of patterns in a probability distribution.

In the research dealing with the determination of membrane currents in individual neurons according to measurements by implanted microelectrode systems in the neural tissue the relation between membrane currents and currents generated in the liquid outside the neurons was established. By means of inverse model calculations from the potentials measured outside the neurons the membrane potential was reconstructed which could be measured so far only with implanted electrodes.

In collaboration with the Pfitzer Inc. that has just begun, micro-field potentials important from the point of view of schizophrenia have been measured by microelectrode systems in the cerebral cortex and hippocampus of genetically modified mice. By means of their new localization method properties of the measured neurons (e.g. the direction of axons) were exhibited which were possible until now only by microscopic painting technique.

By studying the effect of dendritic information processing at certain regions of hippocampus on the spatial firing pattern of neurons it was found that the large dendritic tree of pyramidal neurons is advantageous for the local plasticity, however, for evoking firing the cooperation of dendritic compartments is needed. By studying the role of nonlinear dendritic trees in neural networks where the neurons perform nonlinear calculations with analogue signals (e.g. membrane potentials) but communicate with digital signals (firings) it was found that for optimal implementation of calculations local nonlinear subunits are needed even if the calculation is globally nonlinear or if the input variables are correlated.

A new method was elaborated which can be applied to any directed information- or signal processing network which can be used to create a connection between the network structure and the functional role of network nodes and edges in signal transfer and processing. The method has been used for fine tuning model networks and the functional classification of real networks.

It was shown that the citations both given and received by patents span a multidimensional space, where - with a classification based on the distance - the hierarchical structure of technological branches can be exhibited and in this structure the appearance of new technological branches can be recognized by studying the changes.

Informatics, e-science

In the frame of Worldwide LHC Computing Grid collaboration the Institute's BUDAPEST grid station was expanded, which now has 500 processors and 170 TB memory. The station is run by an efficiency of 97%, in 2010 it was the second most successful Tier-2 centre out of 120 stations. Since 2009 the Hungarian Grid Competence Centre is led by RMKI, which also entered the EGI-InSPIRE international project. In the frame of this project RMKI has a key role in the creation, running and development of the Hungarian National Grid Initiative (NGI). The major part of the resources of NGI including all the central services, operative tasks and technical co-ordination has been provided by RMKI.

In the frame of the GENAGRID consortium formed together with Hungarian universities and firms the 6.5 teraflop performance SGI ALTIX ICE computer of RMKI with 512 processors, 1 terabyte memory has been operated with full capacity. The computer is specially designed for the solution of problems in genomics and has been used to analyze the structure of human DNS on associative basis. During the year the first scientific publications also appeared.

In 2010 the programming and testing of the user platform of a GPS navigation code for blind people has been completed. The device has been described at the ICCHP Conference and in several papers.

As a continuation of the Mobil SegítőTárs (MOST, Mobile helper) project by using the navigation engine of the company Nav-N-Go Kft the system was adapted for a new type PDA (Airis T483). So far 18 machines were sold to blind people, who were taught the use of the MOST system together with the GPS navigation. The new PDA has also an FM radio, with a convenient user platform for the blind. The Talkpad program for helping the communication of people with autism has been adapted to a new woman voice speech synthesizer and given for testing to an autistic girl.

The researchers have participated in the monitoring of the electronic elimination of barriers in Hungary made under Spanish guidance for the European Union.

b) Relations between science and society

2010 was the year of the Large Hadron Collider (LHC) in the media. The researchers of RMKI have fulfilled the expectations of the media in communication with great ardor, granted interviews regularly to public and commercial TV and radio stations, online newspapers, gave lectures at high schools and institutes of higher education as well as actively helped the work of the CERNBLOG (cernblog.worldpress.com) providing continuously fresh news. Naturally the lectures dealt not only with the field of high energy physics but also with other areas of research. With such an activity the researchers of RMKI made an important contribution to the easy to understand explanation of the scientific goals and the increase of the public acceptance and support and of the scientific research work conducted at the research institutions of the Hungarian Academy of Sciences (HAS).

The researchers of the institute have actively contributed to the increase of the level of education in high schools as well as in institutes of higher education. This is especially important owing to the present lowest point of the level of physics teaching. The International School in Particle Physics for Students has been organized in the RMKI by the seventh time in a row and the researchers were also actively involved in the refresher courses for physics

teachers at CERN. A number of popular science articles were published and lectures given at meetings for teachers and in high schools as well as at the Biennial Conference of Physicists held in this year in the town of Pécs.

Lectures were given as part of the popular science program of the Budapest Neutron Centre (BNC) and also at the symposium on material science R&D with neutrons in the frame of the series of lectures organized on the occasion of the Hungarian Science Festival.

The Simonyi Day organized in 2010 for the sixth time has also evoked great interest. The researchers of RMKI described their research and results to the employees of the institute and a wider audience (120 persons) in an easy to understand language.

III. Presentation of national and international relations

National connections

The RMKI maintains active professional relations with several research institutes of the HAS, primarily with those sharing the site at the KFKI Campus and the Institute of Atomic Research of the HAS (ATOMKI) in Debrecen. The RMKI together with the Research Institute for Solid State Physics and Optics (SZFKI), the KFKI Atomic Energy Research Institute (AEKI) and the Research Institute for Technical Physics and Material Science (MFA) forms the KFKI Condensed Matter Research Centre (CMRC) consortium moreover together with the AEKI, the SZFKI and the Institute of Isotopes (IKI) the BNC consortium. Inside BNC the SZFKI-IKI-RMKI collaboration forms one of the FIXLAB platforms of the CHARISMA (Cultural Heritage Advanced Research Infrastructures: Synergy for a Multidisciplinary Approach to Conservation/Restoration) EU FP7 project, whose versatility is increased by the possibility of external beam PIXE measurements offered by the RMKI. The traditionally strong RMKI-ATOMKI relations are characterized by the joint projects in the field of high energy physics, the Hungarian Ion-Beam Physics Platform (HIPP, http://hipp.atomki.hu/) established for the more efficient operation and development of the domestic ion-beam facilities, and the "ECT-Hungary" consortium organized for the joint participation in the work of the European Centre for Theoretical Studies in Nuclear Physics and Related Areas (ECT, Trento, Italy). The RMKI has active working relations with the researchers of the Chemical Research Center (KKK), the Computer and Automation Research Institute (SZTAKI), the Konkoly Thege Miklós Astronomical Institute as well as the Biological Research Centre, Szeged. The RMKI Computer Networking Center (SZHK) is the regional centre of the National Information Infrastructure Development (NIIF) Program. The RMKI is also a member of the Hungarian Grid Competence Centre together with the Budapest University of Technology and Economics (BME), the Eötvös Loránd University (ELTE), the NIIF and SZTAKI.

A researcher of the RMKI each is the chairman of the International Workshop for Theoretical Physics (NEFIM) available for the Hungarian science community, the Synchrotron Committee and the Dubna Committee. The financial and administrative tasks of these bodies are fulfilled by RMKI.

A considerable success of the year 2010 is that Szeged, Hungary is selected as the site of one of the large infrastructural investment of the EU Extreme Light Infrastructure (ELI), the Attosecond Facility. The research groups of RMKI are in close collaboration with other

Hungarian institutes taking part in the project, as the Universities of Szeged and Pécs, the BME as well as SZFKI.

RMKI researchers organized a symposium in Budapest on the recent position of Hungarian nuclear physics research, on the domestic and European research opportunities in the near future (30 participants) as well as the applicability of graphic processors in scientific research (25 participants) with the participation of Hungarian experts of the field.

The researchers of RMKI are functionaries or members of several committees and bodies of the HAS, governmental R&D committees, the Roland Eötvös Physical Society, various professional advisory boards, the governing bodies of the Hungarian space research, etc.

Higher education

In order to assure the reinforcement of research groups of the institute the RMKI attributes utmost importance to the close connection with the institutions of higher education. It is important to take part in the university education, on BSc level with the offer of research problems, as well as suggesting subjects for MSc and PhD theses and supervising the selected works. The RMKI has developed especially close connections with the Faculties of Science of the ELTE and BME in the education of physicists and engineering physicists as well as with the Universities of Debrecen, Gödöllő, Szeged and Pécs in the field of teaching in the Physics Institutes. In 2010 about 1400 hours of lectures were delivered in addition to high level laboratory exercises in the field of nuclear physics and biophysics. At the Faculty of Veterinary Science of the Szent István University the biophysics lectures of the curriculum are given both in Hungarian and English by a researcher of RMKI. As a result of the activity of RMKI researchers 8 student essays, 10 BSc and 12 MSc theses were submitted by students connected to the RMKI as well as 3 PhD dissertations were defended. Presently 17 PhD theses are being prepared in the institute. The researchers also take part in the work of various university committees.

International connections

In the RMKI almost all research activity is conducted in international collaboration, the most important ties being those with CERN, ESA and EURATOM, moreover the RMKI is the coordinator of the PHENIX-HUNGARY experimental collaboration with the participation of ELTE and the University of Debrecen at the Relativistic Heavy Ion Collider (RHIC) of the Brookhaven National Laboratory, USA. With the active participation of RMKI researchers important results are expected in the coming years at the PHENIX, ALICE and TOTEM high energy nuclear physics experiments aiming the production of quark-gluon plasma. It should be emphasized that in the LHC CMS collaboration in 2010 an RMKI researcher was elected the coordinator of the QCD working group for two years. Our researchers continue to play an important role in the KATRIN particle physics experiment in Germany to measure the mass of the neutrino, and the preparatory steps to join the GS/FAIR medium energy nuclear physics experiment have been continued. The RMKI has joined with the active participation of its researchers the VIRGO experiment in Italy to measure gravitational waves. Research performed at large European facilities (synchrotrons, ion accelerators, neutron sources, tokamaks, stallarators) or contributing to their development (e.g. ITER, ELI) has gained an increasing importance. The bilateral or multilateral collaborations with other research institutions play also important role. In nuclear materials science and in space physics about 35 foreign institutes, whereas in particle physics more than 100 ones including the most prestigious institutes in their field are involved in these collaborations, but they are too numerous to list them here. The bilateral agreements of the HAS, the Science and Technology

(TéT) collaborations as well as he HAS-Dubna projects help the successful work a lot. The renewal of these agreements is among the priorities of the institute. The RMKI is coordinating the Hungarian fusion program as the leader of the Hungarian EURATOM Fusion Association with the participation of all the other Hungarian institutions (AEKI, Széchenyi University, ATOMKI, BME, ELTE, College of Dunaújváros). In this field the researchers of RMKI are active in a number of international committees, and joined already in the present phase of the design of ITER, the world's first fusion reactor. As a sign of international reputation the 31th ECLIM Conference was held in Hungary in 2010 and the chairman of the Organizing Committee was researcher of RMKI.

In order to help the participation in the program of the GSI/FAIR Nuclear Physics Research Centre an international conference was organized (50 participants) entitled „Hot and Cold Baryonic Matter".The „Zimányi Winter School on Heavy Ion Physics" was organized at the 10th time and became one of the most important international meeting of the field (30 participants). The Cluster Hungarian Data Centre supplying orbital and other data for the data system of the four identically equipped Cluster spacecrafts of ESA is operated by the RMKI. In the field of biophysics (computational brain science) a successful collaboration supported by international grants is continuing including the exchange of professors as well as students with the Kalamazoo College (Michigan University, USA), but also the joint research with scientists of Brandeis University, Waltham, MA, USA and the University of Cambridge, UK should be mentioned. A collaboration agreement was signed with the Pfitzer Inc. in the frame of which they will be supplied with experimental data of neurophysiologial measurements for scientific analyses.

The RMKI researchers are active participants of the international professional community in many fields. The most important of the institutions of long term task where RMKI members represent the Hungarian interests are the CERN Council and its committees, the EURATOM Scientific and Technical Committee, EFDA Science and Technology Advisory Committee (vice-chair), the expert committees of the IAEA, Joint Undertaking for ITER Governing Board, EFDA Steering Committee, the EPS International Astronautical Academy (Board of Trustees, International Space Science Committee), COSPAR, European Science Forum on Research Infrastructures, the FP7 Research Infrastructures Program Committee of the European Comission, the IUPAP, COST DC MPNS (Domain Committee for Materials, Physcial and Nanosciences), COST TDP SAB (Trans-Domain Proposals Standing Assesment Body), ESF Standing Committee for Physics and Engineering (PESC) és NUPECC, European Neural Network Society Executive Committee, EuGridPMA (European Policy Management Authority for Grid Authentication), and the international research group working on the development of Linux kernel Netfilter/IPtables component.

Numerous researchers of RMKI are referees, members of the Editorial Board or Advisory Board of international scientific journals, Advisory or Program Committees of international conferences, scientific councils of foreign research institutes. Their international recognition is shown not only by the large number of invitations but also requests to participate in various panels (e.g. ERC Advanced Grant Evaluation Panel, ERC Starting Grant remote evaluation, COST Proposal Evaluation Board, CNRS, etc.).

IV. Brief summary of national and international research proposals, winning in 2010

The financial support of research conducted in RMKI has been provided also in 2010 by the budget of HAS and the various grants obtained from external sources. This latter support decreased in 2010 since no applications were invited during the year, all the successful projects mentioned were announced in 2009.

One of the researchers has won the European Research Council Starting Independent Research Grant of 1.1 million euro for a period of 5 years. The grant supports the study of transition metal compounds with "switchable" electronic structure by means of X-ray spectroscopic methods based on synchrotron radiation as well as other physical, chemical and biological transitions on an ultrafast timescale.

In the frame of the EU FP7 program the EGI InSPIRE project has obtained support for developing the international grid technology with the participation of members of the Hungarian Grid Technology Centre as well as there was a winning application for a Marie Curie Intra-European Fellowship in the field of biophysics. The financial support of the CHARISMA EU FP7 project became available in 2010 allowing the start of the factual work.
In the frame of the Plan for European Cooperating States (PECS) the institute has won a „Participation in the Assessment Study for the Jupiter Ganimede Orbiter" grant for 1.5 year.
A research group working in field theory has obtained an OTKA grant as well as the Hungarian LHC CMS group has received funds from OTKA-NKTH. This latter project is coordinating the work of 32 researchers from 4 Hungarian institutions in the CMS collaboration.

The complications in connection with the reorganization of National Research and Technology Office (NKTH) were seriously detrimental for the institute, since in 2010 practically no financial support due to transfer was obtained for the running projects inducing serious liquidity difficulties. In addition, for example, in the spring of 2010 the institute has won several grants in the field of cosmic physics and space technology, however half a year later the winning application were cancelled with reference to an administrative error and no funds were transferred. A similar problem occurred in connection with an NKTH application facilitating mobility. The application received support for two years, but no funds were transferred until now. A similar fate happened to the successful TéT Hungarian-South African project application declared winning by NKTH. On the other hand the Hungarian-Serbian as well as the Hungarian-Vietnamese projects began earlier run successfully.

V. List of important publications in 2010

1. Lévai P, Skokov V.V.:
   Nonperturbative enhancement of heavy quark-pair production in a strong SU(2) color field,
   Phys. Rev. D82 074014, 2010.

2. Csörgő T, Vértesi R, Sziklai J,
   Indirect observation of an in-medium eta' mass reduction in $\sqrt{s_{NN}}$=200 GeV Au+Au collisions,
   Phys. Rev. Lett. 105, 182301, 2010.

3. Khachatryan V, Aranyi A, Bencze G, Boldizsár L, Debreczeni G, Hajdu C, Horváth D.,Krajczár K, László A, Siklér F, Vesztergombi, CMS Collaboration, 1967 szerző,
Transverse momentum and pseudorapidity distributions of charged hadrons in pp collisions at $\sqrt{s}$= 0.9 and 2.36 TeV.
J. High Energy Physics 1002, 041, 2010.

4. Khachatryan V, Aranyi A, Bencze G, Boldizsár L, Debreczeni G, Hajdu C, Horváth D., Krajczár K, László A, Siklér F, Vesztergombi G, Pásztor G, CMS Collaboration, 2322 szerző,
First Measurement of Bose-Einstein Correlations in Proton-Proton Collisions at $\sqrt{s}$=0.9 and 2.36 TeV at the LHC.
Phys. Rev. Lett. 105, 032001, 2010.

5. Khachatryan V, Aranyi A, Bencze G, Boldizsár L, Debreczeni G, Hajdu C, Horváth D., Krajczár K, László A, Siklér F, Vesztergombi G, Pásztor G, CMS Collaboration, 2324 szerző,
Transverse momentum and pseudorapidity distributions of charged hadrons in pp collisions at $\sqrt{s}$= 7 TeV.
Phys. Rev. Lett. 105, 022002, 2010.

6. Aamondt K, Agócs AG, Barnaföldi GG, Boldizsár L, Dénes E, Fodor Z, Hamar G, Lévai P, Molnár L, Pochybova S, Tölyhi T, ALICE Collaboration, 1056 szerző,
Charged-particle multiplicity measurement in proton-proton collisions at $\sqrt{s}$ = 0.9 and 2.36 TeV with ALICE at LHC.
Europ. Phys. J. , C68, 89, 2010.

7. Aamondt K, Agócs AG, Barnaföldi GG, Boldizsár L, Dénes E, Fodor Z, Hamar G, Lévai P, Molnár L, Pochybova S, Tölyhi T, ALICE Collaboration, 1056 szerző,
Midrapidity antiproton-to-proton ratio in pp collisions at $\sqrt{s}$ = 0.9 and 7 TeV measured by the ALICE experiment
Phys. Rev. Lett. , 105, 072002, 2010.

8. Adare A., Csörgő T, Ster A., Sziklai J., Vértesi R. Zimányi J., PHENIX Collaboration, 428 szerző
Enhanced production of direct photons in Au+Au collisions at at $\sqrt{s_{NN}}$ = 200 GeV and impications for the initial temperature
Phys. Rev. Lett. 104, 132301, 2010

9. Fodor G, Forgács P, Mezei M;
Mass loss and longevity of gravitationally bound oscillating scalar lumps (oscillatons) in D-dimensions;
Phys. Rev. D81, 064029, 2010.

10. Fodor G, Forgács P, Mezei M;
Boson stars and Oscillatons in an inflationary universe;
Phys. Rev. D82, 044043, 2010.

11. Barz H.W., Kämpfer B, Wolf Gy, and Zétényi M.:
Propagation of Vector-Meson Spectral-Functions in a BUU Type Transport Model: Application to Di-Electron Production,
The Open Nuclear & Particle Physics Journal , 3, 1, 2010.

12. Bíró T. S., Ván P.,
About the temperature of moving bodies
Europhysics Letters 89: 30001 2010.

13. Vankó G, Glatzel P, Pham V-T, Abela R, Grolimund D, Borca CN, Johnson SL, Milne CJ, Bressler C
Picosecond Time-Resolved X-Ray Emission Spectroscopy: Ultrafast Spin-State Determination in an Iron Complex
Angew Chem - Int Ed, 49, 5910, 2010.

14. Szilágyi E:
Energy and depth resolution in elastic recoil coincidence spectrometry.
Nucl. Instr. Meth. B268, 1731, 2010.

15. Solano ER, Kocsis G, et al., JET EFDA Collaboration (31 szerző):
Observation of confined current ribbon in JET plasmas,
Phys. Rev. Letters, 104, 185003, 2010.

16. Dunai D, Zoletnik S, Sárközi J, and Field AR,
Avalanche photodiode based detector for beam emission spectroscopy,
Rev. Sci. Instrum*,* 81, 103503, 2010.

17. Demeter G:
Quantum control of multilevel atoms with rotational degeneracy using short laser pulses
Phys. Rev. A82, 043404, 2010.

18. Dzsotjan D, Sorensen AS, and Fleischhauer M:
Quantum emitters coupled to surface plasmons of a nanowire: a Green's function approach,
Phys. Rev. B82, 075427, 2010.

19. Földes IB, Csáti D, Szűcs FL, Szatmári S:
Plasma mirror and temperature evolution for short pulse KrF lasers,
Radiation Effects and Defects in Solids 165, 429, 2010.

20. Erdős G, Balogh A
North-South asymmetry of the location of the heliospheric current sheet revisited,
J. Geophys. Res. 115, A01105 doi:10.1029/2009JA014620, 2010.

21. Horányi M, Juhász A
Plasma conditions and the structure of the Jovian ring.
J. Geophys. Res. 115, A09202, doi:10.1029/2010JA015472, 2010.

22. Németh Z, Facskó G, Lucek EA
Correlation Functions of Small-Scale Fluctuations of the Interplanetary Magnetic Field.
Solar Physics, Volume 266, 149, 2010.

23. Fischer J, Berkes P, Orbán G, Lengyel M.
Statistically optimal perception and learning: from behavior to neural representations.
Trends in Cognitive Sciences, 14, 119, 2010.

24. Dézsi I, Fetzer Cs, Bujdosó L, Brötz J, Balogh AG
Mechanical alloying of Fe–Si and milling of α- and β-$FeSi_2$ bulk phases
J Alloy Compd. 508, 51, 2010.