Report of the External Advisory Board

on the activities of the Wigner Centre for Physics Research

for the period terminating on 1st of September 2013

Part I: **The minutes of the site visit**

The members of the EAB received the Annual Report of the Wigner Centre in April 2013. It was decided that the first meeting of the Board takes place 6-7th of September on the campus of the Centre.

The meeting was attended by Professors László Forró (EPFL, Lausanne), Ferenc Krausz (MPI f. Quantenoptik, Garching), András Patkós (ELTE), Miklós Porkoláb (MIT), Jyrki Räisänen (Univ. of Helsinki) and Tamás Tél (ELTE). Prof. Felicitas Pauss (ETH Zürich) could not attend. The requirement on the minimal number of participating Board members prescribed by the Rules of Procedure was fulfilled.

The members of the Board met on the eve of the visit (5th of September) and discussed the most important quality criteria to be checked in the course of the assessment. They agreed that emphasis will be put on the involvement of young researchers. Moreover, a separate meeting ought to be organized with the graduate students during the next visit.

The first day was introduced by general presentations delivered by the Director General and the Directors of the IPNP (Institute of Particle and Nuclear Physics) and the ISSPO (Institute for Solid State Physics and Optics). By the invitation of the Board, the Heads of the 11 research departments and the leaders of the department of Finances also attended this session. The three talks were followed by a consultation, where the actual situation of the spin-off companies and the renewed efforts towards knowledge transfer were in the focus.

During the lunch break Board members visited the Wigner Data Center. They received information on the circumstances of its construction, the conditions of its sustainable operation and on the advantages Hungarian scientists might draw from its physical proximity.

In the afternoon the Board visited in two groups 6 of the 11 departments of the Centre, where they were briefed on the main directions of research and the most recent scientific achievements of each thematic group. They also visited several experimental laboratories gaining insight into the state of the scientific infrastructure.

A one hour discussion on the financial situation of the Centre closed the workday. In the evening the Director General offered a dinner to the Board in the Club Restaurant of HAS.

On 7th of September (Saturday) the Board held a four-hour closed session where the first version of this report was discussed in depth and the further procedure has been decided. This version was circulated among the Board members electronically, also checked by the Director General to avoid factual errors. Eventually it has been submitted to the leadership of the Centre on 26th of September, 2013.

We wish to express our thanks to the President of the Hungarian Academy of Sciences for inviting us to serve on the Advisory Board and to the whole staff, in particular to the Director General Péter Lévai and the Deputy Director General Ágnes Buka, of the Wigner Centre for providing a very good working atmosphere and informative presentations facilitating the work of the Board.

Budapest, September 26, 2013

András Patkós

for the External Advisory Board

Part II: Consequences of the reorganisation and the actions of the new leadership

The Centre was established officially on 1st of January 2012 upon merging the former Research Institute for Particle and Nuclear Physics (IPNP/RMKI) and the Research Institute for Solid State Physics and Optics (ISSPO/SzFKI) in the framework of a fundamental reorganisation of the research network of the Hungarian Academy of Sciences. The central goal of the management of the Wigner Centre is to maintain the more than 60 years old traditions of the KFKI in world class basic research. The Centre wishes to increase also the efficiency of science-based industrial applications and foster collaborations with industrial partners. Also participation of researchers in finding response to societal needs should be strengthened in agreement with the Horizon 2020 program of the European Union. The Board fully supports the aspiration of the Wigner Centre for the status of an ERA Chair Institute.

The Board would like to congratulate the HAS for the very fortunate choice of name of the research Centre which considerably increased its international image.

The internal structure of the original institutes has changed fundamentally in the process of reorganisation. Moreover, in a single step about 50 senior researchers had to retire as a consequence of the stricter governmental regulations. This led also to considerable changes among the leaders of the Departments. The time since the new system has been introduced is too short to relax all tensions but during the visit of the Advisory Board in 6 of the new Departments no adverse effects were observed in the working conditions of the thematic units.

At the same time 7 new groups were founded under much better conditions as a result of the ”Lendület” programme. Exploiting the preference given to inter-institutional mobility, outstanding young but experienced scientists joined the Centre accompanied by promising post-docs and PhD-students. The establishment of 4 Wigner-groups gives substantial support to some of the already existing groups led by scientists belonging to the young generation.

In an effort to ensure the continuity of the scientific activities the leadership of the Centre has introduced the „external member” status beyond the existing „emeritus research professor” title. Many of the concerned retired senior scientists continue their research and might receive also financial support from the extrabudgetary income (for instance EU-grants, foreign contracts, Industrial collaborations) of their groups.

The working conditions of the active senior scientists of age above 50 went through a crisis in parallel with the economical situation of the country. Since OTKA and in particular the ERC Advanced Grant scheme became very competitive, the research funds of this age group stagnated or even diminished. The radical changes which occured in the system of the state support to applied research and the lack of cohesion funds in the Central Region of Hungary hurt particularly strongly the researchers of this age group. The Heads of Departments and the leaders of the Centre should monitor the situation closely since any further worsening might endanger the high level of the quantity and the quality of the scientific output of the Centre.

The difficult situation strongly calls for new initiatives and the Director General succeeded to obtain governmental support to the creation of the Wigner Data Center. Its unprecedentedly fast construction was the precondition to the transfer of the Tier-0 data center of CERN to Budapest. The required continuous and high quality operation will guarantee the sustainable existence of the Data Center. It has already increased the options available to the management to finance the administration of the Centre.

The extension of its services both on international and national level holds the perspective to become a leading scientific centre of data intensive complex multidisciplanary (astronomical, environmental, biological etc.) projects. The committee supports the idea of the creation of an Academy Computer Cloud, which will serve the whole academic community with reasonable calculation capability including large flexibility - but avoiding competition with freely accessible large supercomputer-centers.

The reconstruction and modernisation of the scientific equipment was largely supported by the newly established infrastructural reconstruction fund centrally managed by the Secretariate of HAS. This action made a reasonable impact on the degree of availability of the research tools and equipments purchased during last 20 years. It would be desirable to extend the support on purchasing of new infrastructure with the condition that only one equipment for a well defined user group should be purchased in Hungary (including equipment purchased by university laboratories).

The arising new proportions in the distribution of the yearly infrastructural support among the different institutes of HAS reflect better the real needs of their scientific activity. At the same time its central handling substantially diminished the proportion of the stable budgetary sources and is severely compromising the secure planning of the Centre.

Ever since the change in the political system allowed this to happen, the Institute has been successful to stimulate the creation of a number of small and medium-size enterprises (SMEs) in high technologies of great strategic importance in the 21st century, such as laser, photonic, and neutron techniques. Technologies pioneered at the Institute have served as a basis for the foundation of a number of high-tech companies, including *Optilab Ltd* (main activities: design, development and characterization of optical dielectric multilayer coatings tailored primarily for applications in ultrafast laser technology), *Technoorg-Linda Ltd* (optical instruments for environmental monitoring and devices for preparation of surfaces), *Envi-Tech Ltd* (interferometric and light-scattering intruments for medical applications), *Mirrotron Ltd* (devices for guiding neutron beams), *Ultrafast R&D Ltd* (chirped mirrors, ultrafast laser systems and instrumentation), Cerntech Ltd. (data acquision electronics), Fuziotech Ltd. (fast cameras and plasmadiagnostics) and Adimtech Ltd. (plasmadiagnostics and electronics). Thanks to the *state-of-the-art, in several cases even world-leading, technologies and expertise* transferred to them via licencing and recruitment from the Institute, these companies rapidly attained international reputation and have been serving the R&D community, industry and health care in many countries beyond the borders of Hungary. The further development of this activity depends critically on the legal environment and would serve beneficially also the stability of world-class basic research at the Centre.

Part III: Research Profile of the Departments

The EAB could not examine all the scientific activities of Centre. The full picture of the overall performance will be obtained only after reviewing all the research groups and departments. Our general impression is that the groups presented are excellent, highly productive, (reflected also by the bibliometric parameters); many of the researchers have international reputation.

Below we give more detailed evaluation only of departments visited by the Board members. In other cases a short summary is provided, mainly based on the mission reports and list of publications received from the concerned unit.

III A: Insitute of Particle and Nuclear Physics (RMI/IPNP)

<u>High Energy Physics Department</u> (FTE: 12, PhD-students: 6)

The research is focused on participation in three experiments of CERN LHC (ALICE, CMS, TOTEM) which achieved fundamental discoveries very recently. In smaller scale experiments (ASACUSA) and in R&D oriented collaborations at CERN the weight of the Hungarian participation is more visible. The high quality of the work done by the researchers of the Wigner Centre in the research groups is demonstrated by the fact that two of them were elected in the CMS experiment as conveners of the „Heavy ion collisions" and of the „Pixel detector development" group, respectively. Their quick and original analysis of the pp-scattering data of CMS gained wide international attention[1]. Particularly strong is the cooperation with the theoretical heavy ion researchers of the Department of Theoretical Physics of RMI. It is desirable, that beyond the high quality service work, all talented researchers could prove their research capacity in the physical data analysis giving more chance for individual achievements.

The list of the publications in the Annual Report 2012 follows an exemplary practice by putting a distinguishing sign to the publications where the contribution of the Wigner team was decisive.

The new group of detector development established in the framework of the „Lendület" programme focuses its efforts on gaseous detectors by improving classical and micro-structure designs, new technologies. This direction holds the perspective of individual and original research as demonstrated already by a number of recent publications[2]. The scope of this R&D activity realized within a CERN-collaboration goes beyond the horizon of particle physics. Members of the department also contribute to detector upgrades of CERN experiments.

The number of PhD and Master's students is considerably higher than in other departments. This is the result of the constant lecturing activity of the senior and also of younger researchers at the University of Debrecen and the Eötvös University. Through these contacts they systematically attract not only graduate students but also senior members from these Physics Institutes into their research program.

<u>Department of Applied Nuclear Physics</u> (FTE:16, PhD-students: 3)

The Department conducts experimental basic research in the field of analysis and study of physical-chemical phenomena and deliberate modification of the properties of hard or soft condensed matter

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[1] CMS Internal Report: Observation of long range near side angular correlations in proton lead at the LHC, CMS-HIN-12-015

[2] D Varga, G Kiss, G Hamar, Gy Bencédi, Nuclear Instruments and Methods A 698 (2013) 11

by applying nuclear methods. They develop methods and the underlying theories as well as related infrastructures in home laboratories and at large international research facilities.

Ion beam physics

The approval of the CHARISMA follow-up proposal is vital for the ion beam laboratory. This would justify the upkeeping of the E-2R electrostatic accelerator for the time being. The combination of the Budapest Neutron Center housed techniques with the accelerator based techniques has proven to be beneficial for the CHARISMA project[3].

The Board supports the intent to erect a Wigner RCP dedicated beam line at the new Atomki based tandetron accelerator. Also the opening of the planned research related to embedded nanostructures is encouraged by seeking actively proper collaborators (within the Wigner RCP and/or outside).

The engagement of young scientists and students to the group and its activities is recommended to ensure continuity.

Functional nanostructures

The research group is clearly competitive at the international level. They have clear visions how to proceed within the chosen research themes. Recent results on source-detector reciprocity put new light on classic and basic features of physical phenomena.[4]

Improvement of the MBE facility by incorporating e.g. in situ characterisation techniques is highly recommended. This would improve significantly the versatility of the facility and provides opening of new lines of research in materials physics.

X-ray spectroscopy with synchrotron radiation

The research group is highly competitive (ERC and „Lendület" grant holder) and should be supported in all possible ways. The Board encourages the senior scientists of the group to take actively part in teaching at universities. The approach would eventually attract new students to the group to secure a leading position in the field in the future.

<u>Department of Plasma Physics</u> (FTE: 20, PhD-students: 5)

Research under this topic has two important lines of activity, namely "High temperature plasma physics" (HTPP) with relevance to magnetically confined fusion plasmas (MFE), and "Low temperature plasma and atomic physics in strong laser fields " (LTPP).

Low temperature plasma and atomic physics in strong laser fields

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[3] Rehren T, Belgya T, Jambon A, Káli Gy, Kasztovszky Zs, Kis Z, Kovács I, Maróti B, Martinón-Torres M, Miniaci G, Pigott V, Radivojevi M, Rosta L, Szentmiklósi L, Szőkefalvi-Nagy Z: Journal of Archaeological Science (2013) in press

[4] L. Deák, L. Bottyán, T. Fülöp, G. Kertész, D.I. Nagy, R. Rüffner, H. Spiering, F. Tanczikó, G. Vankó: Physical Review Letters 109, 237402 (2012)

The subject has relevance to basic atomic physics as well as potential application to the development of future particle accelerators. The concept is based on the wakefield particle acceleration concept, a growing research activity both in Europe and the US. The group simultaneously conducts experimental and theoretical investigations and is involved in the AWAKE collaboration of CERN. The interest in contributing to the scientific program of ELI appears to be somewhat lower.

Recent results show the emergence of various nonlinear optical phenomena during pulse propagation in a medium of inhomogeneously broadened two-level quantum systems, which have a vibrational degree of freedom with respect to the center-of-mass coordinate[5].

High Temperature Plasma and Fusion Research

The high temperature plasma physics activities of the Centre receive strong financial support from external funding agencies, in particular Euratom and foreign countries with substantial world class fusion facilities, namely Germany, UK, Korea and China. We expect that this activity will be increasing with time as some of the facilities are just coming into operation while the future relies on the startup and operation of ITER in Cadarache, France. New major activity in 2014 is expected to be funded by the Chinese fusion program, based on its world class EAST tokamak facility.

The Hungarian activities are coordinated by the HAS fusion Association led by Wigner RCP and comprising cca. 35 FTE.

List of the research topics at Wigner RCP: Atomic beam diagnostic technologies: Li beam, optics, detectors; Plasma turbulence measurements on the European fusion facilities MAST, COMPASS and JET (UK) , TEXTOR and ASDEX Upgrade (Germany) , KSTAR, (Korea) and future activities on EAST (Hefei, China); Pellet-plasma interaction and diagnostics: JET (UK) and ASDEX U (Germany); Tomography: Bayes and conventional numerical techniques (ITER, TCV, ASDEX Upgrade); ITER diagnostics: Bolometer tomography (with IPP Garching), CXRS (with FZ Jülich).

The ITER tokamak services project is led by Wigner RCP, is key element in ITER.

Overall Assessment: Work is of very high quality, among the top few in the diagnostic area of charge exchange recombination spectroscopy (specifically Beam Emission Spectroscopy, or BES) for the purpose of plasma turbulence measurements; this expertise is based on experiments performed recently by the Hungarian group on existing short pulse copper field coil tokamaks in Europe;

Key recent publications have revealed "common and fundamental feature of the physics of far from equilibrium systems—the ‘‘multiscale’’ physics, i.e., how large-scale structures can be developed by small-scale events”[6,7]. In both of these publications the key diagnostic instrument, “Beam Emission Spectrosopy” was developed and installed by the Hungarian group.

The group was successfully incorporating PhD-students in the past (4 PhD absolved in the period 2007-11). We expect that in the future more students could be attracted to these activities because entering a physics operation phase on foreign machines should be attractive, in particular Wendelstein 7X, in Germany and ultimately in ITER, Cadarache, France where we would expect local

[5] G. Demeter, Z. Kis, U. Hohenester; Phys.Rev A 85, 033819 (2013)

[6] YC Ghim, … D. Dunai, S. Zoletnik, Phys Rev Lett 110, 145002 (2013)

[7] Y. Xu,…S. Zoletnik Phys. Rev. Lett. 110, 265005 (2013)

control room connections.

Short summary remarks on the Departments of RMI/IPNP not visited this time

Department of Theoretical Physics (FTE: 36, PhD-student: 4)

This is the department with the largest number of scientific staff and comparatively very low number of graduate students.

The topics investigated reflect individual research interests and extend over a large variety of subjects in theoretical brain research, mathematical physics, string theory, gravitational physics[8], foundations of thermodynamics, relativistic hydrodynamics and phenomenology of heavy ion collisions[9]. Part of the research is directly related to ongoing experiments of heavy ions, particle physics (LHC, RHIC) and gravitational wave detection (VIRGO).

The new „Lendület" group bringing also a number of graduate students strengthens the research in string related AdS/CFT investigations and in subjects beyond the Standard Model (BSM). The missing expertise in perturbative QCD devoids the necessary support to the high quality experimental research of the Centre.

Space Science and Space Technology Department (FTE: 9, PhD-student: 3)

The continuous collaborative activity of the Department in international space probe missions and the analysis of the data revealing fundamentally new aspects of the structure of our planetary system[10] and the dynamical processes of interplanetary plasma will receive new momentum with Hungary joining ESA.

High priority is devoted to fulfill the duties of the Department imposed by international contracts. This involves contributing to the development of instruments for the BepiColombo (Mercury orbiter), Solar Orbiter, and JUICE (Jupiter orbiter) missions. Data analysis will be extended to the new data expected by the Rosetta mission from 2014.

The necessary reshaping of the age-tree of the senior researchers is expected to bring also the renewal of the scientific plans, preserving the internationally renowned present expertise in the field of the interplanetary magnetic field[11] and the equipment design and manufacturing for space missions.

Specific recommendations at RMI/IPNP level

It would largely facilitate the evaluation of the performance of the Centre in experimental high energy physics if all related activities could be reviewed in a single visit, independently of the accidental organisational separations.

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[8] László B. Szabados. Class.Quant.Grav. 30 (2013) 165013

[9] P. Van, T.S. Biro, Phys.Lett. B709 (2012) 106

[10] Szegő, K., Z. Németh, L. Földy, S. W. H. Cowley, and G. Provan, J. Geophys. Res. Space Physics, 118, 2883, 2013

[11] Balogh, A., Erdős, G., Space Science Reviews, 176, Issue 1-4, 177, 2013

It would help the assessment of the impact of the research groups of the Centre on the results achieved in large (huge) collaborations if in the Annual Report publications with decisive Hungarian contribution would bear specific signal. In particular, this suggestion refers to high energy physics, gravitational wave observations and space physics.

A closer collaboration of the Department of Experimental High Energy Physics with the Department of Theoretical Physics is desirable in the topics related to the exploration of the physics beyond the Standard Model. This would require the establishment of a specific position in the Department of Theoretical Physics and its advertisement worldwide.

The board supports the plans for purchasing and installing at RMI a Medium Energy Ion Scattering (MEIS) equipment as a unique user machine serving not only material science research in Hungary but also in the Central European region. The experimental technique is a refinement of the Rutherford back scattering method and given that the energy and the angle of the scattered ions is being analysed simultaneously, MEIS is able to measure the atomic mass, depth, and the surface structure. A complete solution of the surface structure requires a comparison between experiment and simulation for several scattering geometries. By appropriate choice of the scattering geometry atomic displacements as small as 0.05 angstroms can be measured. The gradual development of this diagnostic would require cca. HUF 400 million.

III B: Institute for Solid State Physics and Optics (SzFI/ISSPO)

The EAB did not examine all the activities of ISSPO. The performances of the selected groups compare favourably with groups of similar scientific scopes and size in the world and, furthermore, they are well integrated in the international scientific community. The majority of the research topics do not need necessarily a large scale facility; it can successfully be carried out in small groups and with small scale or even table-top experiments. This type of approach fits naturally into the profile of the Institute and should remain supported in the future.

The Departments are focusing on basic research activities. Experimental and theoretical activities are not strictly separated, the constitution of the staff of a given department is determined also by personal relations and the readiness for everyday cooperation.

There are successful trials to bridge fundamental research and advanced technology in emerging research fields like (i) the engineering of new nanomaterials with controlled functionalities e.g. in biology and health (ii) the information and communication technologies, (iii) solar cells and hydrogen production (iv) the study of quantum effects in micro and nanostructures. The EAB is encouraging research groups to further address topics from the basic research side like energy conversion (solar, thermoelectrics, fuel cells) which respond to national and international priorities.

Department of Experimental Solid State Physics (ETF: 25, PhD-students:6)

The experimental Department consists of 3 groups/laboratories: Non-equilibrium alloys, Radiofrequency spectroscopy and the Laboratory for advanced structural studies. The latter is subdivided into Chemical and structural studies (CSS), x-ray techniques (XRT) and Computational material science (CMS) laboratories. The research themes are very broad, ranging from biomolecules, through carbon nanostructures to metals and alloys; despite the name of the department, they have a strong theoretical, computational activity. Their excellent research directions can be illustrated by a few highlights:

In recent years, one of the most productive groups is the CMS[12]. Their quantitative phase-field modelling of pattern formation, crystal nucleation, and solidification of real materials, alloys is very successful, which may have even metallurgical applications.

Other significant recent developments in the CSS group include the synthesis of organic compounds. After the discovery of low-dimensional fullerene compounds and that of fullerenes/cubane co-crystals[13], the completely freshly made single crystals of metal-organic frameworks (MOFs) will offer a large tunability of magnetic interactions. The group's expertise in transparent conducting carbon nanotube films has an international visibility.

A further strong point of CSS is the high level optical studies of novel carbon-based materials. The latest success is the identification of a Jahn-Teller distortion in Cs_3C_{60} compound[14]. Due to their continuous highly visible performance they were granted by a near-field optical spectrometer, quite unique instrument of its kind.

In recent years, the greatest achievement of the XRT group is the charge flipping algorithm which has a high strength in structural refinements[15]. This work won the Széchenyi Prize in 2013. Recently, they work on the reconstruction of a molecular structure (e.g. of a protein) from single molecule fragments obtained by diffraction measurements on a free electron laser. For the time being they establish their expertise testified by few papers[16], but when the real experiments will come this visionary strategy will pay off. The XRT group has been granted recently by an outstanding single crystal x-ray diffractometer.

<u>Department of Theoretical Solid State Physics</u> (ETF: 16, PhD-students: 4)

Theory is traditionally strong, the only department with two „Lendület" Awards. A novel feature is the appearance of research in semiconductor nanostructures. It contains the potential of several applications which has recently been extended to even in vivo biomarker applications[17]. This direction is evolving dynamically which calls for close experimental collaborations. This is, however, not necessarily possible in other areas of theoretical investigations where excellent research is going on. Notable examples are:

1. the development and applications of the density-matrix renormalization group method to a broad range of phenomena including quantum chemistry,
2. the investigation of magnetic properties and spin-fluid phases,
3. the study of interacting disordered and quantum systems,
4. the *ab initio* investigations of various alloys.
5. the study of BREM (Beyond Rear Earth Magnet) materials.

Their results can be illustrated by a few highlights:

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[12] G. Toth et al. Phys. Rev.Lett. 108, 025502 (2012) ; H. Emmerich et al., Adv. Phys. 61, 665 (2012).
[13] G. Bortel, et al., Crystal Growth & Design 11, 865 (2011).
[14] G. Klupp et al., Nature Communications 3, 912, (2012).
[15] G. Oszlanyi and A. Suto, Acta Crystallographica Section A 64, 123 (2008).
[16] Z. Jurek and G. Faigel, EPL, 101 (2013)
[17] B. Somogyi, V. Zolyomi, A. Gali, Nanoscale 4, 7720 (2012).

- They built a novel theoretical model within the Density Matrix Renormalization Group (DMRG) method to calculate the excitation spectra of polydiacetylene threads. For this 20 year old problem they published a parametrization which, for the very first time, was able to reproduce the full measured excitation spectrum and the geometrical structure. They were also able to show the existence of the so-called “optically dark states”[18].

- In a study of nonequilibrium quantum relaxations they pointed out the decisive role of quasiparticles that are reflected at the surfaces. For sites at or near the surface nonthermal behavior was observed. For bulk sites a crossover to thermal behavior is present, with exponentially decaying correlations, and this was shown to define a relaxation time and a correlation length that is identical in semi-infinite and in infinite systems[19].

- Concerning the interactions of magnetic impurities on metal surfaces, they showed that the details of the electronic structure of the semi-infinite host are responsible for the existence or lack of interaction. They were the first to show how the transition between surface and bulk interactions occurs[20].

- They demonstrated that ab initio theory is able to describe the available experimental data with high accuracy in the important class of engineered alloys. They were the first to predict that some of the alloys are more anisotropic regarding some mechanical properties than the others and did this for a broad range of concentrations**.**[21]

The leading researchers of the Department are traditionally participating in education, teaching solid state physics at various levels.

<u>Department of Applied and Nonlinear Optics</u> (FTE: 21, PhD-students: 5)

The department covers a broad range of activities in the general fields of *laser physics, nonlinear optics, quantum optics and ultrafast science, as well as the development of lasers and optical systems for a number of applications,* including (but not limited to) the generation of squeezed light, ultrashort laser pulses, electron pulses, high-order harmonics, attosecond extreme ultraviolet light, and their applications for a wide range of fundamental light-matter interactions, ultrafast microscopic processes, optical characterization of materials and optical components, studies of nonlinear phenomena.[22] Several research activities are at the forefront of international efforts and give rise regularly to first-rate, internationally recognized results.

The *optical coating laboratory* became world-famous in the 90’s with the first proposal and demonstration of chirped multilayer mirrors, which are now being used in hundreds of laser laboratories all over the world, in particular for the generation and manipulation of extremely short, few-cycle, few-femtosecond laser pulses. Ever since then, SZFI remains one of the world-leading centers in the innovation of special multilayer optics tailored for a number of applications in ultrafast science.

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[18] G. Barcza, W. Barford, F. Gebhard, and Ö. Legeza, Phys. Rev. B 87, 245116 (2013).
[19] F. Igloi and H. Rieger, Phys. Rev. Lett. 106, 035701 (2011).
[20] E. Simon, B. Ujfalussy, B. Lazarovits, et al., Phys. Rev. B 83, 224416 (2011)
[21] F. Tian, L. K. Varga, N. Chen, L. Delczeg and L. Vitos, Phys. Rev. B 87, 075144 (2013)
[22] P. Dombi et al., Nano Lett. 13, 674 (2013).

Another area of great tradition is the development of new *laser-based devices for environment monitoring and health care,* including the development of laser particle counters and sizers, nonlinear laser-scanning microscopy, Laser Doppler velocimeters (LDV), aerosol analysers and their application in monitoring of the air contamination within big cities, study of the dynamics of atmospheric pollution, measurement of red mud,[23] monitoring of the air quality in and surrounding big industrial firms, and the study of aerosol deposition in lungs. The SZFI has accumulated a unique range of expertise and know-how and is among the leading institutes in Europe in these fields.

Manufacturing crystals and nanostructures and characterizing them with a broad range of diagnostic and spectroscopic techniques is another important domain of activities. The crystals are aimed at nonlinear frequency conversion of laser light, whilst the nanostructures are being considered for applications in electronic devices (e.g. ultracapacitors) or medical instrumentation (e.g. as coating of stents for bypass heart surgery).[24] The availability of a broad range of modern optical characterization techniques in addition to the in-house manufacturing and engineering of these components puts the institute into a unique position in the international competition.

Short summary remarks on the Departments of SzFI/ISSPO not visited this time

Department of Quantum Optics and Quantum Physics (FTE: 14, PhD-students: 4)

The group conducts theoretical research in quantum optics and quantum information processing. Fundamental questions of quantum theory, such as, for example, the measurement theory and mesoscopic systems are investigated in collaboration with experimental groups. The aim is to extend the high-precision coherent quantum manipulation from single atoms, ions, photons, and ultracold quantum gases, to composite objects[25] or to networks of elementary quantum optical objects[26].
The senior staff has regular courses at master's and doctoral leve lat ELTE, BME and University of Pécs.

Department of Neutron Spectroscopy (FTE: 6, PhD-student: 2)

The department intensively contributes to the development of national and international neutron-based R&D infrastructures (Budapest Neutron Centre, access to the EU neutron facilities (ILL membership, NMI3 Access, JRA's). At the BNC a New Focussing Small Angle Neutron Scattering Spectrometer is ready to be commissioned. They conduct collaborative research on the structure and dynamics of condensed matter[27].

Symbiotic, mutually advantageous cooperation is functioning with Mirrotron Ltd., a spin-off company established by the researchers of the Department.

Department of Complex Fluids (FTE: 23, PhD-students: 4)

Complex fluids (multicomponent fluids, non-thermal plasmas, electrochemical solutions, liquids composed of molecules with anisotropic shape, nanoparticle suspensions) are investigated with

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[23] A. Gelencsér et al., Environmental Science and Technology 45, 1608 (2011).
[24] A. I. Gopalan et al., Rad. Phys. Chem. 81, 1407 (2012).
[25] Kálmán O, Kiss T, Fortágh J, Domokos P, Nano Letters; 12, 435, 2012
[26] Kollár B, Kiss T, Novotny J, Jex Phys Rev Lett; 108, 230505, 2012
[27] Posselt D, Nagy G, Kirkensgaard J J K, Holm J K, Aagaard T H, Timmins P, Rétfalvi E, Rosta L, Kovács L, Garab G: BIOCHIMICA ET BIOPHYSICA ACTA-BIOENERGETICS 1817**:**(8*)* 1220 *(2012*)

modern experimental and advanced simulation tools. The research is motivated by the aim of fundamental understanding of principal physical properties and advanced applications in nanoscience and biomedicine.

A dusty plasma experimental setup was individually designed and built, realizing a unique apparatus in Central Europe with parameters significantly different form other “standard” experiments[28].

Ordering and alignment of elongated objects in shear flows was observed at all length scales and found that for simple dry granular materials in steady shear flow the time and ensemble averaged direction of the main axis of the particles encloses a small angle with the streamlines[29].

Summary conclusion: We are convinced that in this institute optical studies, nanoscale science and interdisciplinary approaches will flourish in the future which means that the scientific output of the ISSPO will continue to stay at a high level, the international visibility will raise in the future. The most important reason for this optimistic vision is that we met many young and talented PhD students, researchers who will continue the outstanding research tradition of KFKI.

Specific recommendations at the SzFI/ISSPO level

The CSS and the XRT groups who have obtained the two highly performing machines, the near-field optical spectrometer and the single crystal diffractometer should consider them as user facility. This could strengthen their position and visibility in the country**.**

Making use of their expertise in electronic structure calculations - especially regarding surfaces and interfaces - they could try to develop a new theory and computer code to describe the electronic structure of superconductor-normal metal interfaces and heterostructures of both conventional (like Nb) and high Tc superconductors. The resulting theory could be the first of this kind, and its importance lies in the application of superconductor magnets where such problems inevitably occur.

The unparalleled synthesis of expertise and instrumentation in laser, optical, and nanofabrication techiques available at SZFI puts the institute into a unique position to tackle a number of highly topical areas of basic and applied research at the forefront of international activities as well as to create a strong link and synergies between the RMI and SZFI (e.g. in the area of femtosecond spectroscopy). Based on their existing and dynamically expanding know-how in several relevant fields (ultrafast laser technology, femtosecond multilayer optics, high-order harmonic and attosecond pulse generation, etc.) and their well-established links to leading European laser laboratories such as MPQ, SZMI is predestined and strongly encouraged to make major contributions to the development of the basic infrastructure of ELI-ALPS in Szeged. In order to exploit these potentials the leadership of the Institute and the Academy is advised to further strengthen strategic collaborations with leading European partners and to make all possible efforts to be able to continue the modernization of the SZMI scientific infrastructure, in particular in the areas of ELI-relevant ultrafast laser technologies (OPCPA, HHG). This requires investment on the order of several hundred million HUF in the coming years and the leadership of the Institute and the Academy is strongly recommended to make all efforts to find resources for these investments.

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[28] Hartmann P, Donkó I, Donkó Z, Rev. Sci. Instrum., 84 (2013) 023501

[29] T. Börzsönyi, B. Szabó, G. Törös, S. Wegner, J. Török, E. Somfai, T. Bien, and R. Stannarius, Phys. Rev. Lett. 108, 228302 (2012)

Part IV: SWOT assessment of the Centre

Strengths

- Outstanding, internationally renown scientists (now dominantly below age 45) with highly individual research profile and with at least two decades of carreer perspective ahead
- Strong participation in international cooperation and global projects
- Active presence in research related university curricula in Physics Institutes of Hungarian universities
- Efficient use of the existing instrumentation, agreed plans for modernisation
- Successfull project funding through the „Lendület" scheme, complemented by the Wigner-group support realized with the own resources of the Centre.

Weaknesses

- Low intensity of knowledge transfer (small number of patents)
- Low public relation activity (e.g. appealing web-site, public lectures, open days)
- Annual report booklet is not appealing to interested scientists, graduate students
- Sharply unequal distribution of young researchers among different groups and problems of leadership in some historically well performing groups (examples: space physics, non-equilibrium alloys)
- Missing institute level measures supporting excellent scientific activities for researchers of age beyond 50. In certain departments this is accompanied with an age dip between 40 and 50.

Opportunities

- Participation in and project funding through Horizon2020
- Central program for gradual modernization of the local experimental infrastructure, collaboration on newly installed large scale intruments on national level
- The data handling competences of the Wigner Data Center as „in kind" membership fee for entering global projects in astronomy, genetics, brain research, environmental research, high energy physics, etc.

Threats

- Continuation of low government funding in basic research endanger the sustainability of high quality basic research.
- Brain drain might outweight the attractive effect of the „Lendület" programme.
- Several of the formerly successful thematic groups might get marginalized without attracting young researchers and without increased (balanced) access to research funding of the active but not-so-young generation.
- Without regained confidence in the eyes of the state administration spin-off companies created by the researchers of the institute cannot contribute to the stabilisation of the project financing and maintaining competitive combined income with those of the industry.
- Lack of stable medium term financing of participation in international co-operations considerably diminishes the impact of the Hungarian teams within the concerned projects.

Part V: Recommendations at the Centre level

In addition to the specific recommendations concluding Sections IIIA and IIIB, here we make a few more referring to the Centre as a whole.

- The capability of the individual research teams to attract young researchers, in particular MSc- and PhD-students should be an important criterion for the evaluation of the scientific performance of the teams. Improved teaching commitment and PR-activity aimed at this group should be a top priority.
- The leadership of the Centre should ensure the necessary strategic support making attractive the ERC Advanced Grant applications for outstanding senior scientists.
- With the help of specific criteria applicable to researchers of different age group the Wigner group scheme should be advertized without age restrictions.
- The leadership of the Centre and the Academy is encouraged to make all efforts to continue the Institute's highly successful tradition in fostering collaboration with existing industrial partners and the creation of new high-tech enterprises. This is not only beneficial to the competitiveness of the small but growing number of high-tech industry groups of Hungary but also benefits the Centre in several ways, in particular by keeping highly-qualified experts trained at the Centre in the neighbourhood and hence available for continued collaborations.
- A merger of two research institutes should ideally result in significant synergies at the scientific level. The Leadership of the Centre is strongly encouraged to take specific measures for fostering and intensifying such synergies among the respective groups belonging to different Departments/Institutes of the Centre (examples: laser-matter interactions, medical applications, spectroscopy) .
- The Board recommends the Leadership of the Centre to establish a platform (similar to the existing ELI virtual unit) for the large variety of research and development related to applications in life sciences. This would enhance both the communication between RMI and SzFI and the external visibility of the whole Wigner Centre.

Part VI: Plans and requests concerning future meetings of the EAB

- The Board and the Leadership of the Centre has agreed on arranging the next evaluation meeting of the EAB in form of a video-conference. Its probable date will be May or June 2014.
- A tentative agreement was made also on the 2015 meeting of the EAB which again will be organized in form of a site visit. It will precede the expiration of the term of the Director and the Deputy Director of the Centre. During this session the EAB will meet graduate students at a separate meeting.
- The Annual Report of the Centre will be made available to the EAB every year by the end of April. The EAB requests to refer in all highlighted scientific results to at least one item of the selected list of publication/intellectual products/science based services appearing in the Report.
- It has been accepted that the 5 Departments not visited during the first EAB meeting will prepare for the 2014 meeting a computer presentation of similar style as was presented this time. It will be made accessible to the EAB on the web site of the Wigner Centre in advance and will be discussed in form of separate video conferences with the leaders of the concerned departments as integral part of the second meeting.