Wigner 121 Scientific Symposium

Monday, September 18, 2023 - Wednesday, September 20, 2023

Program

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Monday, September 18, 2023

Wigner RCP: 10 years in E.P. Wigner's footsteps. (8:30 AM - 9:00 AM)

- Presenter: LÉVAI, Péter

Wigner functions in quantum optics (9:00 AM - 9:40 AM)

- Presenter: SCHLEICH, Wolfgang

The Wigner function [1] is a quantum mechanical distribution function and lives in phase space. It allows us to evaluate the expectation values of symmetrically ordered operators. Moreover, it is an extremely useful tool [2] to analyze phenomena at the interface of classical and quantum physics. In the present talk, we focus on three such topics: (i) The equivalence principle of general relativity viewed from quantum phase space [3], (ii) the Kasevich-Chu interferometer described by the Wigner function [4], and (iii) the connection between a logarithmic phase singularity, tunneling through a quadratic barrier [5], and Hawking radiation [6]. References: [1] E.P. Wigner, Phys Rev. 40, 749 (1932). [2] W.P. Schleich, Quantum Optics in Phase Space (Wiley-VCH, Weinheim, 2001). [3] E. Kajari et al., Appl. Phys. B 100, 43 (2010). [4] E. Giese et al., Proceedings of the International School of Physics ''Enrico Fermi'' 188, 171 (2014). [5] D.M. Heim et al., Phys. Lett. A 377, 1822 (2013). [6] F. Ullinger et al., AVS Quantum Science, 4 (2022).

Some problems of integrable Quantum Field Theories (9:40 AM - 10:20 AM)

- Presenter: ARUTYUNOV, Gleb

Coffee break & Poster Session (10:20 AM - 11:00 AM)

Testing General Relativity with gravitational waves (11:00 AM - 11:40 AM)

- Presenter: CARDOSO, Vitor

One of the most remarkable possibilities of General Relativity concerns gravitational collapse to black holes, leaving behind a geometry with light rings, ergoregions and horizons. These peculiarities are responsible for uniqueness properties and energy extraction mechanisms that turn black holes into ideal laboratories of strong gravity, of particle physics (yes!) and of possible quantum-gravity effects. I will review the status of black holes, in light of gravitational-wave observations in the last few years.

Attosecond science - future directions (11:40 AM - 12:20 PM)

- Presenter: KRAUSZ, Ferenc

Attosecond metrology emerged on the turn of the milleneum and enabled scientists to observe fundamental electronic processes in atoms, molecules, or solids in real time. Attosecond techniques now permit measurement of the oscillating electric field of light from the infrared to the ultraviolet. We will discuss how this unprecedented technical capability may help advance electronic signal processing towards its ultimate speed limit and allows sensing changes in the molecular composition of human blood, for health monitoring.

Lunch break (12:20 PM - 1:50 PM)

Particle Physics (1:50 PM - 3:10 PM)

[8] Understanding the Quark-Gluon Plasma with ALICE at the LHC (1:50 PM, 40 minutes)

Presenter: VAN LEEUWEN, Marco

Collisions of lead nuclei at high energy in the Large Hadron Collider (LHC) at CERN provide a unique opprotunity to study the 'condensed matter physics' of quarks and gluons, the fundamental particles of the strong interaction, which are normally bound in hadrons. In these collisions, temperatures of around 10^12 K are reached, and a plasma of quarks and gluons is formed, under conditions that are comparable to those of the universe briefly after the Big Bang. I will present highlights of the experimental study of the Quark-Gluon Plasma by ALICE at the LHC, showing how we use experimental results to determine the temperature and flow fields in the collisions, as well as the transport properties of the plasma. I will briefly outline our plans for new studies of the Quark-Gluon Plasma with the recently installed detector upgrades in the ongoing Run 3 of the LHC, as well as our future plans beyond Run 3.

[9] Construction of a tracking detector for the future experimental exploration of particle interactions (2:30 PM, 20 minutes)

Presenter: VESZPRÉMI, Viktor

Measurements at the frontier of particle physics performed by the LHC experiments have been a great success when considering the discovery of the Higgs boson. This was an important missing piece in the puzzle of the standard model that governs particle interactions. However, all other measurements have not provided results incompatible with this theory, thus showing no pointer towards potential extensions. The way out is two-fold by exploiting developments in engineering: particle collisions may be generated and observed at an order of magnitude higher rate to gain an increased sensitivity for direct searches, as well as precision measurements may be performed stepping through the door that is presented by the newly discovered particle. Both require the construction of superb measurement devices. A brief status summary of recent measurement results selected with some bias suited to the activities of our group will be provided in the first part of the presentation as motivation for our detector construction project. This will be followed by the description of the new tracking detector at the CMS experiment with details concerning our group's involvement.

[10] Heavy-ion physics: present and future (2:50 PM, 20 minutes)

Presenter: BARNAFÖLDI, Gergely

Shortly, milliseconds after the Big Bang, the Universe was formed of a dense and hot matter, the quark gluon plasma. The properties of this strongly interacting medium set the initial condition of the expansion of the Universe later on. Heavy-ion researchers aim to address the questions: How this matter look like? What are the physical properties of this state? Can we re-create this matter in the ultrarelativistic collisions of nuclei? In this presentation I provide an overview, where we are on the way to answer these questions, indeed what are the future prospects in high-energy heavy ion physics.

Coffee break & Poster Session (3:10 PM - 3:40 PM)

Photonics (3:40 PM - 5:00 PM)

[43] Wigner time delays and the quest to control electron and spin correlations (3:40 PM, 40 minutes)

Presenter: SCHULTZE, Martin

Electrons have little mass and they are strongly interacting with their environment via Coulomb forces which led to their dynamics appearing perfectly synchronized to external stimuli. E.P. Wigner and colleagues anticipated already in the 1950's that in photoionization a time shift between the outgoing electronic wavepacket and the arrival time of the incoming photon is to be expected due to the phase shift derivative associated to this half-scattering event. Nonetheless, it took another half century to develop experiments capable of tracking this time delay in photoemission [1] which laid the ground for the ultrafast control of the electronic&magnetic state of solids [2] and for the development of attosecond spectroscopy into a truly space-time-resolved microscopy technology [3] [1] Science 328, 5986 (2010) [2] Nature 571, 240–244 (2019) [3] Science 380, 6640 (2023)

[44] Ultrafast electron processes is solids (4:20 PM, 20 minutes)

Presenter: DOMBI, Péter

Few-femtosecond laser pulses offer a unique potential to control various electron processes in solid-state media. These include the generation of hot electrons [1], inducing nonadiabatic tunneling photoemission [2] and inducing the transient metallization of dielectric media [3]. In my talk, I will review recent experimental progress of the Wigner Research Centre for Physics in each of these fundamental research fields. In addition, I will also present first real-life applications of these phenomena such as the construction of an optical chip detecting the phase shift in femtosecond laser beams. [1] J. Budai, Z. Pápa, P. Petrik and P. Dombi, Nature Comm. 13, 6695 (2022). [2] B. Lovász et al., Nano Lett. 22, 2303 (2022). [3]. V. Hanus et al., Optica 8, 570 (2021).

[45] Sensitive Raman spectroscopy (4:40 PM, 20 minutes)

Presenter: VERES, Miklós

Being a non-invasive optical spectroscopic tool with high sensitivity to the bonding configuration Raman spectroscopy is widely used to study different materials, including organic and biological systems. Due to its small scattering cross-section, the Raman process is weak, however, it can be enhanced by metallic nanoparticles acting as plasmonic nanoantennas amplifying the Raman signal. This presentation will summarize our recent results in the field of surface-enhanced and high-resolution Raman spectroscopy.

Poster Session (5:00 PM - 6:00 PM)

Tuesday, September 19, 2023

Statistical Physics (9:00 AM - 10:20 AM)

[15] Examining the Nonlinear Response of Quantum Electrons with the Assistance of Wigner Distribution Function (9:00 AM, 40 minutes)

Presenter: MOLDABEKOV, Zhandos

A linear response of quantum electrons is well studied and for that well developed theoretical and computational methods computing the linear response properties are available. However, recent introduction of THz lasers and the novel seeding technique to reach high intensities [1] allow us to generate nonlinear response of quantum electrons in extended systems. Therefore, in this talk the results will be presented for the non-linear density response of quantum electrons and the applicability of various approximations and methods for extended systems will be discussed [3-5]. The utility of the quantum Wigner distribution function for the analytic solution of the non-linear response problem of arbitrary order will be presented [5]. [1] B.K. Ofori-Okai, et al., J. Inst13, P06014 (2018). [2] T Kluge, et al., Phys. Rev. X 8, 031068 (2018). [3] Z. Moldabekov, Jan Vorberger, and Tobias Dornheim, Journal of Chemical Theory and Computation 18, 2900–2912 (2022). [4] T.Dornheim, M. Boehme, Z. Moldabekov, J. Vorberger, and M. Bonitz, Phys. Rev. Research 3, 033231 (2021). [5] P. Tolias, T. Dornheim, Z. Moldabekov, and J. Vorberger, EPL 142 , 44001 (2023).

[16] Microfluidic flow in single-layer dusty plasmas (9:40 AM, 20 minutes)

Presenter: HARTMANN, Péter

Experiments on strongly coupled dusty plasmas provide unique access to the microscopic details of macroscopic condensed matter processes. Since the early years of this field, the application to hydrodynamic processes has been one of the main motivations. In most cases, however, the complexity of the experiments prevented the drawing of general conclusions. In our experiment, using the control provided by a plane-parallel radio frequency (RF) discharge, two metal discs are used to form an electrostatic potential channel. The flow of the electrically charged dust particles through the channel was induced by indirect laser manipulation, which is essential to keep the external effects acting on the particles under control. By adjusting the argon gas pressure and RF power, the channel was tuned to allow the formation of single or multiple lanes of passing dust particles. We use this system to address fundamental details of microfluidic flows, such as particle acceleration and deceleration, lane formation and ordering in the channel, etc.

[17] Flow of elongated particles (10:00 AM, 20 minutes)

Presenter: BÖRZSÖNYI, Tamás

When a granular material or a suspension containing elongated particles is flowing we observe that the particles get aligned. This is due to the non-trivial rotation of the grains in a shear flow. How long does it take for the grains to get ordered? In which direction do they align? What is the consequence of ordering on the rheology? Do elongated particles flow easier than spherical ones? In this presentation we overview the dynamics of such systems, focusing on the above questions.

Coffee break & Poster Session (10:20 AM - 10:50 AM)

Fundamental Interactions and Gravitation (10:50 AM - 12:10 PM)

[18] N-Body Simulations and Cosmological Statistics. (10:50 AM, 40 minutes)

Presenter: SZAPUDI, István

I will review two recent techniques for cosmological N-body simulations. The StePS simulations use a stereographic projection to compactify the universe and fit it into a finite computer. The resulting multiresolution technique is more efficient than standard zoom-in simulations and has isotropic gravity. Complementary simulations augment an existing simulation by minimizing cosmic variance by orders of magnitude without running thousands of additional realizations. These advanced non-linear dynamical models pair with novel statistical techniques such as sufficient statistics and indicator power spectra to extract more information from cosmological surveys, such as the recently launched Euclid.

[19] Symmetries of spacetimes with a compact Cauchy horizon and the cosmic censor (11:30 AM, 20 minutes)

Presenter: RÁCZ, István

We outline an argument proving that any smooth vacuum spacetime containing a compact Cauchy horizon with surface gravity that can be normalized to a nonzero constant admits a Killing vector field. This proves a conjecture of Moncrief and Isenberg from 1983 under the assumption on the surface gravity and generalizes previous results due to Moncrief–Isenberg and Friedrich–Rácz–Wald, where the generators of the Cauchy horizon were closed or densely filled a 2-torus. This result implies that the maximal globally hyperbolic vacuum development of generic initial data cannot be extended across a compact Cauchy horizon with surface gravity that can be normalized to a nonzero constant. Our result thus supports the validity of Penrose's strong cosmic censorship conjecture in the class of spacetimes considered.

[20] Inner structure of neutron stars (11:50 AM, 20 minutes)

Presenter: KOVÁCS, Péter

Neutron stars (NSs) are the most massive known objects in the Universe. Their masses range from 1.2 to 2.3 solar masses, while their radii are in the range of ~10 km. The density increases towards the origin of the star, and can reach 4-6 times the normal nuclear density. The matter in these circumstances is organized by the strong interaction, and it is possible that quark-gluon plasma can be found inside the core. In this talk I will explore how these hybrid stars can be studied using effective models of QCD, and how astrophysical measurements constrain certain parameters of the model. Results from a recent Bayesian analysis will also be presented.

Lunch break (12:10 PM - 1:50 PM)

Functional Materials (1:50 PM - 3:10 PM)

[21] Hard x-ray spectrograph and anomalous soft modes in alpha-iron (1:50 PM, 40 minutes)

Presenter: CHUMAKOV, Aleksandr

For visible light, the concept of spectrographic imaging — dispersion of radiation components with various energies in space — has been known since Newton's time. In this presentation, we report on a hard (14 keV) x-ray spectrograph implemented at the European synchrotron, enabling an observation of anomalous soft modes in alpha-iron [1]. We present new unpublished data on temperature evolution these modes, suggesting an anharmonic nature of the phenomenon, possibly with an additional relation to magnetism. 1. A. I. Chumakov, Y. Shvyd'ko, I. Sergueev, D. Bessas, and R. Rüffer, Phys. Rev. Lett. 123, 097402 (2019).

[22] Advances in the Investigation of FeRh Thin Films (2:30 PM, 20 minutes)

Presenter: MERKEL, Dániel

Recently, FeRh thin films have attracted extensive attention, due to the diversity of their possible applications [[i]]. Their near room temperature metamagnetic transition from antiferromagnetic (AF) to ferromagnetic (FM) order [[ii],] and the interoperability between FM and paramagnetic (PM) states provide an excellent base for energy-saving spintronic devices [[iii]]. Moreover, the outstanding caloric parameters and non-toxic biocompatibility of FeRh give novel alternatives for developing gas-free domestic magnetic refrigerators, or new medical applications [[iv]] In our work, we achieved reversible alteration of the FeRh structural phase between FM B2 and PM A2 phases through the application of Ne+ irradiation and heat treatment. By inducing the FM à PM transition, FM nanopatterns were created within the PM matrix using nanosphere ion-beam lithography. Conversely, the PM à FM transition was utilized to generate magnetic domains through laser irradiation. Based on these results, a tailored magnetic pattern can be implemented in FeRh film, which can be a great step to design modern nano-devices. [[i]] Merkel D G, Lengyel A, Nagy D L, Németh A, Horváth Z E, Bogdán Cs, Gracheva M A, Hegedűs G, Sajti Sz, Radnóczi Gy Z and Szilágyi E 2020 Sci. Rep. 10(1), 13923. [[ii]] Cherifi RO, Ivanovskaya V, Phillips LC, Zobelli A, Infante IC, Jacquet E, Garcia V, Fusil S, Briddon PR, Guiblin N, Mougin A, Ünal AA, Kronast F, Valencia S, Dkhil B, Barthélémy A and Bibes M 2014 Nat. Mater. 13(4), 345 [[iii]] Merkel D G, Hegedűs G, Gracheva M A, Deák A, Illés L, Németh A, Maccari F, Radulov I, Major M, Chumakov A I, Bessas D, Nagy D L, Zolnai Zs, Graning S, Sájerman K, Szilágyi E and Lengyel A 2022 ACS Appl. Nano Mater. 5(4), 5516 [[iv]] Qiao K, Liang Y, Zhang H, Hu F, Yu Z, Long Y, Wang J, Sun J, Zhao T and Shen B 2022 J. Alloys Compd. 907, 164574

[23] Spin state studies with X-ray spectroscopy: From static to ultrafast (2:50 PM, 20 minutes)

Presenter: VANKÓ, György

Coffee break & Poster Session (3:10 PM - 3:40 PM)

Quantum Informatics (3:40 PM - 5:00 PM)

[24] Detection of typical bipartite quantum correlations by local generalized measurements (3:40 PM, 40 minutes)

Presenter: ALBER, Gernot

Detection of genuine quantum correlations, such as entanglement or steerability, by local quantum measurements, which can possibly be performed by far distant observers, are of particular interest for applications in quantum key distribution and quantum communication. In this context the natural question arises how does the effectiveness of detecting such genuine quantum correlations depend on the nature of local quantum measurements and on the dimensionality of the quantum systems involved for typical, randomly selected quantum states. In this talk recent results are presented which address this question by exploring basic properties of commonly used sufficient conditions for entanglement- and steerability-detection of arbitrary dimensional bipartite quantum systems based on correlation matrices and joint probaility distributions [1]. In order to explore characteristic features of their dependence on the nature of the local quantum measurements, not only orthonormal hermitian operator bases but also generalized quantum measurements based on informationally complete positive operator valued measures(POVMs) of the so called (N,M)-type are discussed. These recently introduced .(N,M)-POVMs [2] are capable of describing various important generalized quantum measurements in a unified way, including mutually unbiased measurements and symmetric informationally complete measurements and their generalizations. Surprisingly, it turns out that inherent symmetry properties of (N,M)-POVMs imply that sufficient conditions for bipartite entanglement- or steerability-detection exhibit characteristic scaling properties which relate different equally efficient local quantum correlation detection scenarios. In order to access the effectiveness of local entanglement- or steerability-detection for bipartite quantum states of different dimensions quantitatively numerical results on Euclidean volume ratios between locally detectable entangled or steerable states and all bipartite quantum states are presented which are based on a recently developed hit-and-run Monte-Carlo algorithm [3,4]. References: [1] O. Gittsovich, O. Gühne, Phys. Rev. A 81, 032333 (2010). [2] K. Siudzinska, Phys. Rev. A 105, 042209 (2022). [3] M. Schumacher, G. Alber, arXiv: 2305.14226 (2023). [4] M. Schumacher, G. Alber, arXiv: 2305.17985 (2023).

[25] Nonlinear quantum dynamics and its potential applications in quantum information (4:20 PM, 20 minutes)

Presenter: KISS, Tamás

Nonlinear evolution is not a usual phenomenon in quantum physics. It is possible to define a time-evolution for an ensemble of equally prepared systems in a somewhat unusual way: take N systems, apply an entangling unitary transformation, measure all but one of the systems and, depending on the measurement results, keep or throw away the remaining system. This procedure applied to the whole ensemble results in a new ensemble, the state of which being a nonlinear transformation of the initial quantum state. We present some properties of the possible dynamics for one- and two-qubit systems without and with noise. We report on the realization of a couple of steps for two of the protocols in optical experiments. Furthermore, we discuss possible applications, e.g. benchmarking quantum computers.

[26] The role of Wigner functions in quantum computing and quantum information theory (4:40 PM, 20 minutes)

Presenter: ZIMBORÁS, Zoltán

Quantum National Laboratory (5:00 PM - 5:40 PM)

[41] Quantum Information National Laboratory (5:00 PM, 40 minutes)

Presenter: DOMOKOS, Péter

The Quantum Information National Laboratory (QNL) boosts the research and development activity of the Hungarian scientific community within the unfolding second quantum revolution which aims at the exploitation of the enormous advancements in our ability to detect and manipulate single quanta for new kinds of applications. We give an overview on the QNL activity via selected outstanding achievements in the research fields of quantum communication, quantum bit architectures and deployment of quantum computation.

Wednesday, September 20, 2023

Solid State Physics (9:40 AM - 10:20 AM)

[28] Near-field infrared microscopy on carbon nanostructures (9:40 AM, 20 minutes)

Presenter: KAMARÁS, Katalin

Scattering near-field optical microscopy (s-SNOM), based on the combination of atomic force microscopy and frequency-dependent light scattering, is an emerging method that combines high spatial resolution with high sensitivity even at long illuminating wavelengths. I will present results in the infrared frequency range obtained on various aspects of carbon nanostructures. The most obvious task, identifying individual molecules, is also the most difficult, due to the weak scattering from molecular vibrations. Free (Drude) electrons in metallic carbon nanotubes or encapsulated metal clusters are more easily detected. The intense field under the tip can also be used to launch and detect the charge distribution inside nanotubes caused by interference of quasiparticles: plasmon-polaritons or phonon-polaritons. The interaction of phonon-polaritons with vibrational modes of molecules confined in the tubes brings the capabilities of the method full circle, enabling to reach a detection threshold of a few hundred molecules and follow their chemical reactions by infrared spectroscopy.

[29] Novel approaches in material science and ab initio quantum chemistry via massively parallel tensor network state methods on Hybrid CPU-GPU based HPC architectures (10:00 AM, 20 minutes)

Presenter: LEGEZA, Őrs

Tensor network states algorithms have proven to be a powerful tool for simulating strongly correlated spin and fermionic models. In this contribution, we overview recent developments that can be used for the treatment of high-dimensional optimization tasks used in many-body quantum physics with long range interactions, ab initio quantum chemistry and nuclear structure theory. We will also discuss the controlled manipulation of the entanglement, which is in fact the key ingredient of such methods, and which provides relevant information about correlations. Novel algorithmic solutions together with implementation details to extend current limits of TNS algorithms on HPC infrastructure building on state-of-the-art hardware and software technologies will also be addressed.

Coffee break & Poster Session (10:20 AM - 10:50 AM)

Space Physics (10:50 AM - 12:10 PM)

[30] What is Space Weather and Why Should Hungary Care? (10:50 AM, 40 minutes)

Presenter: GOMBOSI, Tamás

A hundred years ago, the sun-Earth connection was of interest to only a small number of scientists. Solar activity had little effect on daily life. Today, a single strong solar eruption could bring civilization to its knees. Modern society has come to depend on technologies sensitive to solar radiation and geomagnetic storms. Particularly vulnerable are power grids, interplanetary robotic and human exploration, satellite operations and communications, and GPS navigation. These technologies are woven into the fabric of daily life, from health care and finance to basic utilities. This presentation will describe the basic processes controlling space weather together with observational, modeling and forecasting efforts.

[31] Installation of the first Hungarian magnetically shielded room in Nagycenk (11:30 AM, 20 minutes)

Presenter: ERDŐS, Géza

The ELKH Institute of Geophysics and Space Science and the ELKH Wigner Physics Research Centre jointly built a zero magnetic field laboratory in the Széchenyi István Geophysical Observatory, near Nagycenk. The construction of the research infrastructure was completed in the summer of 2023, the commissioning is in progress. The primary purpose of the facility is to build and calibrate magnetometers for space exploration in the environment typical of interplanetary space. Of particular importance is to develop the space-qualified version of a new type of magnetometer, known as SERF magnetometer, which is a rival of superconducting magnetometers in accuracy, but operate in extremely small (less than 10 nT) magnetic field. This was the main motivation for the construction of a magnetically shielded measurement site. Unlike superconducting magnetometers, the SERF magnetometers can be used in space, as they do not require liquid helium cooling. Another application of the zero magnetic field laboratory is the test of the magnetic cleanliness of equipment, before sending it into space. Other interdisciplinary researches can be carried out in the magnetically shielded room as well in the field of materials science, geology, biology and life sciences. The geomagnetic field is reduced by about 5 orders of magnitude in two steps: large compensating electromagnetic coils (active shielding) and a room covered with high permeability plates made of a special metal alloy (passive shielding). The current in the electromagnetic coils is determined by taking into account the geomagnetic field measured in the observatory with one second frequency. The presentation will demonstrate the performance of the magnetically shielded room. Also shown are the potential applications of the installation.

[32] Solar System research with space probes (11:50 AM, 20 minutes)

Presenter: BEBESI, Zsófia

Our department is currently participating in several leading international space research projects to study and analyze in situ measurements taken in the solar wind and in the vicinity of various solar system objects. Our expertise reaches back to the 1980's, when our collaboration with the international space agencies first began. Ever since then we have been active in the scientific data analysis of missions like Ulysses, Cassini-Huygens, Venus Express, Rosetta-Philae, and as of now our team has co-investigators in the STEREO, the Solar Orbiter, the BepiColombo and the recently launched JUICE space missions. The talk will briefly summarize the currently running research projects and scientific objectives of our department.

Lunch break (12:10 PM - 1:50 PM)

Quantum Optics (1:50 PM - 3:10 PM)

[36] Ultracold Bose Gases in Driven-Dissipative Environments (1:50 PM, 40 minutes)

Presenter: OTT, Herwig

Driven-dissipative systems are characterized by the appearance of steady-states. Upon parameter change, they can undergo dissipative phase transitions between different types of steady-states. One of the paradigmatic examples for a first order dissipative phase transition is the driven nonlinear single-mode optical resonator. I will report on the corresponding realization within an ultracold bosonic gas, which generalizes the single-mode system to many modes and stronger interactions [1]. We measure the effective Liouvillian gap of the system and find evidence for a first order dissipative phase transition. Due to the multi-mode nature of the system, the microscopic dynamics is much richer and allows us to identify a non-equilibrium condensation process. References: [1] J. Benary et al., New J. Phys. 24, 103034 (2022)

[37] Photon-blockade breakdown as a first-order dissipative phase transition in zero dimension (2:30 PM, 20 minutes)

Presenter: VUKICS, András

I present the relatively recent concept of first-order dissipative phase transitions that can occur in meso- and even microscopic quantum systems. One of the first examples of this phenomenology was the photon-blockade breakdown (PBB) effect, that occurs most simply in a coupled system of a bosonic mode and a qubit. For PBB, an abstract thermodynamic limit has been identified [1], where the coupling between the subsystems goes to infinity without affecting the system size (hence the designation zero-dimensional), and this limit was studied in a finite-size scaling approach [2], with scaling exponents determined numerically. Upon discussing the microscopic mechanism and the fully quantum solution, I will assess the neo- and semiclassical models, and the connection with optical bistability. I describe the experimental studies: PBB was first observed in a circuit QED system [3], and the thermodynamic limit could also be modeled on this platform with a bespoke device [4]. The numerical modelling of this latter set of experiments highlighted the role of the higher lying transmon levels and the phase noise. On the computational front, I present the extensive numerical studies (taking cca. 100 CPU years) performed with the C++QED simulation framework [5] in an OpenStack cloud environment. [1] H. J. Carmichael, Phys. Rev. X 5, 031028 (2015). [2] A. Vukics, A. Dombi, J. M. Fink, P. Domokos, Quantum 3, 150 (2019). [3] J. M. Fink, A. Dombi, A. Vukics, A. Wallraff, and P. Domokos, Phys. Rev. X 7, 011012 (2017). [4] R. Sett, F. Hassani, D. Phan, Sh. Barzanjeh, A. Vukics, and J. M. Fink, arXiv:2210.14182 (2022). [5] https://github.com/vukics/cppqed

[38] New approaches for quantum sensing with nitrogen-vacancy centers in diamond (2:50 PM, 20 minutes)

Presenter: PERSHIN, Anton

Nitrogen-vacancy (NV) centers in diamond enable a variety of sensing applications ranging from measuring basic properties, such as temperature, pressure, strain, and external fields, down to detecting single cells, single molecules, or even single nuclear spins. Here, we present new opportunities for quantum sensing with shallow NV centers, i.e. located within 10 nm from the surface. First, we show that the presence of an adsorbed water layer improves the stability of negative charge state of NV [1]. This allows for quantum sensing at ultra-low temperature. Second, we demonstrate the possibility of manipulating the coherence time of shallow NV centers by controlling electric noses via interfacial band bending. This property enables sensing diamagnetic electrolytes from a solution on top of diamond surface [2]. Finally, we also discuss a new approach to accurately resolve the hyperfine structure based on the measurements of dephasing time (T2*). [1] JN Neethirajan, T Hache, D Paone, D Pinto, A Denisenko, R Stöhr, P Udvarhelyi, A Pershin, A Gali, J Wrachtrup, K Kern, and A Singha. Nano Lett. 2023, 23, 7, 2563–2569 [2] FA Freire-Moschovitis, R Rizzato, A Pershin, MR Schepp, RD Allert, LM Todenhagen, MS Brandt, A Gali, and DB Bucher. ACS Nano 2023

Coffee break & Poster Session (3:10 PM - 3:40 PM)

Computational Sciences (3:40 PM - 4:20 PM)

[34] Physics Ideas in Artificial Intelligence (3:40 PM, 20 minutes)

Presenter: JAKOVÁC, Antal

Although artificial intelligence (AI) methods are developing rapidly, there are fields, where the improvement seems to be less dynamic. It is crucial to understand the reason of this difference, and try to work out methods which can help to overcome the obstacles. To achieve this goal we shall use the approach of the generalized scientific method, in particular which is used in understanding physics. We shall recognize the central importance of laws, even if they are not exact. Based on this generalization we developed a new approach to the general AI (AGI) which is applied for timer series exploration as a first application.

[35] NeuroAI – How to harness Artificial Intelligence Research for understanding the brain (4:00 PM, 20 minutes)

Presenter: ORBÁN, Gergő

Recently, ambitious goals have been phrased on how technology can boost or heal brain function, focussing on concerted hardware developments. In this talk I will present how developments in Artificial Intelligence research enables us to gain deeper insight into how neurons contribute to cognitive functions.

NAnoPlasmonic Laser Ignited Fusion Experiment: NAnoPlasmonic Laser Ignited Fusion Experiment (4:20 PM - 5:00 PM)

[42] NAnoPlasmonic Laser Ignited Fusion Experiment: a status report (4:20 PM, 40 minutes)

Presenter: BÍRÓ, Tamás

The recent revolution of lasers with increased power and shorter pulse length opens new possibilities for fusion energy research. The existence of detonations with time-like normal on space-time hyper-surfaces [1] combined with absorption adjustment using nanoantennas, allows for igniting the target in an opposing laser beam setup [2,3], avoiding instabilities. We describe both theoretical aspects and how the collaboration aims to investigate this novel idea experimentally by exploiting nano-technologies and knowledge from the field of high intensity plasmonics [4]. We summarize our latest achievements by briefly presenting theoretical comparative studies on possible energy deposition via optimized plasmonic nanoresonators [5], as well as results of kinetic studies analyzing the resilience of plasmonic nanoantennas [6]. We show results from experiments exploring the interaction between high-intensity femtosecond laser irradiation and UDMA-TEGDMA copolymer target doped with plasmonic gold nanorods. We present LIBS analysis of pure and doped mixture [7], along with intriguing morphological and structural changes during crater formation [8]. Additionally we analyze volume growth during crater formation to understand the impact of embedded plasmonic gold nanorods [9]. Finally, we present Raman spectroscopic study results on structural transformations in the copolymer upon irradiation [10]. [1] L.P. Csernai and D.D. Strottman, Laser and Particle Beams, 33, 279-282 (2015) [2] L.P. Csernai, N. Kroo, and I. Papp, Laser and Particle Beams, 36 (2), 171-178 (2018)[3] L.P. Csernai, M. Csete, I.N. Mishustin et al. Physics and Wave Phenomena, 28 (3) 187-199 (2020) [4] A. Bonyár, M. Szalóki, A. Borók et al. Int. J. Mol. Sciences 23 (21), (2022) [5] M. Csete, A. Szenes, E. Tóth et al. Plasmonics, 17 (2), 775-787 (2022) [6]I. Papp, L. Bravina, M. Csete et al. PRX Energy 1, 023001 (2022) [7] A. Kumari talk at the 11th Int. Conf. on New Frontiers in Physics 2022 Kolymbari, Crete (2022). [8] J. Kámán talk at the 11th Int. Conf. on New Frontiers in Physics 2022 Kolymbari, Crete (2022). [9] Á. N. Szokol talk at the 11th Int. Conf. on New Frontiers in Physics 2022 Kolymbari, Crete (2022). [10] I. Rigó, J. Kámán, Á. N. Szokol et al. arXiv - https://doi.org/10.48550/arXiv.2210.00619