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MAGNÓNOVÝ ANALÓG HORIZONTU UDALOSTÍ ČIERNYCH/BIELYCH DIER V SUPRATEKUTOM 3He-B

Marcel Človečko, Emil Gažo, Martin Kupka, **Peter Skyba**

Súčasné technológie neumožňujú experimentálne študovať a overovať naše teoretické modely a predstavy o fundamentálnych fyzikálnych javoch prebiehajúcich v takých astro-fyzikálnych objektoch, akými sú čierne diery. Zatiaľ jediným spôsobom ako experimentálne verifikovať tieto modely (a predstavy) o fyzike čiernych dier je nájsť laboratórny fyzikálny systém, ktorý s istými obmedzeniami umožňuje simuláciu vlastnosti čiernych dier. Cieľom prednášky je prezentovať ako teoretický model, tak aj experimentálne výsledky získané na novom fyzikálnom systéme umožňujúcom simuláciu vlastností horizontu udalostí v čiernych/bielych dierach. Modelový systém je založený na jave spinovej (magnónovej) supratekutosti v supratekutom 3He-B. Ako experimentálny nástroj, ktorý modeluje vlastnosti čiernych/bielych dier sme využili tzv. spinovo precesujúce vlny šíriace sa na pozadí spinového toku medzi dvoma Bose-Einsteinovými kondenzátmi magnónov vo forme homogénne precesujúcich domén. V súhlase s teoretickým modelom sme experimentálne ukázali formovanie a prítomnosť horizontu udalostí pre spinovo precesujúce vlny, vrátane efektu zosilnenia týchto vĺn. Vzhľadom k tomu, že experiment je realizovaný pri teplote blízko absolútnej nuly (600 μK), prezentovaný modelový systém tak umožňuje aj štúdium spontánneho Hawkingovho žiarenia.

QUANTUM WALKS

Martin Štefaňák

Quantum walks represent a generalization of the random walk to the coherent evolution of the quantum particle on a graph or a lattice. We provide an overview of the concept, focusing on the discrete-time quantum walk, and illustrate the applications in quantum simulations and quantum computation. Finally, we introduce a very successful experimental implementation of quantum walks which is based on photonic time-multiplexing, and review the recent experiments.

EXPERIMENT KATRIN LIMITED THE NEUTRINO MASS TO LESS THAN 1 eV

Otokar Dragoun

Neutrinos are together with photons the most abandon particles in the Universe. The knowledge of the neutrino mass is important not only for particle physics but also for cosmology. Oscillation experiments proved that at least two of the known three neutrino mass states have the mass different from zero, while at least one of these states has the mass greater than 0.05 eV. Precision spectroscopy of electrons emitted in the nuclear beta decay offers a principal possibility to determine the neutrino mass directly in a model independent way. However, only upper limits of the neutrino mass were determined until now. The most advanced Karlsruhe

Tritium Neutrino Mass experiment (KATRIN) operates with a windowless gaseous source of molecular tritium. The energy of emitted electrons is analyzed with the electrostatic retarding spectrometer with magnetic adiabatic collimation. Recently, the first four-week science run of the KATRIN limited the neutrino mass to less than 1.1 eV. This is twice better that the previous limit achieved after several years of measurement. The KATRIN aims to the 0.2 neutrino mass sensitivity after 1000 days of measurements. Further on the hypothetical sterile neutrinos in the eV and keV mass ranges will be searched for.

CHARACTERIZATION AND BIOAPPLICATION OF MAGNETIC NANOPARTICLES

Kateřina Poláková

Magnetic nanoparticles (NPs), especially SPIO nanoparticles, have long been used as MRI (Magnetic Resonance Imaging) contrast agents and as advantageous nanoplatforms for drug delivery, taking advantage of their unique magnetic properties and ability to function at the molecular and cellular level. In our centre smart design and development of SPIO nanoparticles in mild conditions with desired physico-chemical properties (size, composition, surface modification, magnetization, relaxivity, biocompatibility, etc.) have been performed to fulfil desired bioapplication. In this lecture the most promising results will be presented and consequently discussed advanced in vitro and in vivo MRI application of such prepared SPIO nanomaterials or nanocomposites
.

The particular attention will be devoted to labeling and MRI detection of stem cells, and potential clinical application of maghemite/bentonite nanocomposite as an per-oral contrast agent.

MAGNETIC FLUIDS AND LIQUID CRYSTALS FOR LOW-FIELD MAGNETIC SENSING

Peter Kopčanský, Milan Timko, Veronika Lacková, Katarína Zakuťanská, Natália Tomašovičová, N. Éber, T. Tóth-Katona, I. P. Studenyak, O. V. Kovalchuk, J. Jadzyn

Liquid crystals (LCs) have been well identified with electro-optical effect that is used in industry dealing with displays and large-screen applications due to the combination of orientational elasticity and fluidity. The successful combination of LC phases with functional inorganic nanodopants allows the development of materials with new structures and functions that open up interesting possibilities for both fundamental investigation as well as technological application. As reported in many studies, several types of nanoparticles (NPs) with semiconducting, ferroelectric, metallic or magnetic characteristic have been investigated that effectively modify electro-optic responses and other physical characteristic of LCs a well.

Conventional LCs are sensitive to magnetic fields but their low magnetic susceptibility makes practical applications difficult as extremely strong magnetic fields are required to enable effective switching of the molecular order. Suspensions of magnetic NPs in nematic LCs, theso-called ferronematics (FNs), have become a promising material with enhancing sensitivity to magnetic

field. Assuming that a stable, optically transparent, and homogeneous FNs are synthetized, it would give a strong push for the development of many kinds of new magnetically controlled LC-devices. As an illustration, this is the way to obtain magnetovision camera with the possibility of mapping the magnetic field in space.

ROLE OF PHOTOVOLTAIC SOLAR CELLS IN THE ONGOING ENERGY SYSTEMS TRANSFORMATION

Antonín Fejfar

Photovoltaic solar energy conversion years has become a decisive part of the electricity generation. The global installed photovoltaic (PV) capacity surpassed 600 GW in 2020 and the terawatt installed capacity is going to be achieved within the following decade. The dramatic fall of costs made PV the cheapest source of new electricity generation (without subsidies) in large part of the world. PV exhibited ~25 % annual growth rate during the last 5 years. PV produces about 3 % of electricity globally, about 5% in the EU and it is expected to reach 15 % share of EU electricity generation by 2030.

PV is dominated by silicon wafer-based cells for which previously unforeseen low system prices have been reached. The advantages of photovoltaics based on silicon thin film (lower consumption of energy-costly silicon and thus shorter energy payback time) have not been sufficient to overcome the disadvantage of lower efficiencies. Thus, the development and production of silicon thin film photovoltaics nearly stopped. The other

types of thin film based PV (CdTe, CIS) as well as concentrated PV approaches struggle as well.

The record efficiency of silicon based cell reached 26.7 % by using the silicon heterojunction (SHJ) with interdigitated back contacts composed of intrinsic and either n or p-type hydrogenated amorphous silicon layers with thicknesses ~ 10 nm. The record SHJ cell has been fabricated by photolithography, unsuitable for mass production. A simpler stencil mask based technology has been developed in the NextBase H2020 project. The tunnel-IBC approach further simplifies the process by eliminating the patterning and aligning the hole collector contacts. These advances offer a chance for a restart of photovoltaic production in Europe.

Innovation goes on to fur¬ther enhance light-to-power conversion efficiency but this is not possible for single junction silicon based cells, as they are close to the fundamental Shockley Queisser limit (~29.6 %). Much higher efficiencies are possible with multijunction designs, but so far they have been demonstrated using III-V semiconductors, which are not suitable to large scale deployment. The next step in PV evolution will be the dual junction (tandem) cells of silicon with a suitable partner. The most perspective is the combination of perovskite – silicon tandem cells, with potential efficiency above 45% and current research results reaching 29%.

ORGANIC SEMICONDUCTORS

Martin Weis

Organic semiconductors are a broad family of organic molecular materials that exhibit certain properties similar to inorganic semiconductors. Interestingly, molecular materials show only weak forces between the

molecules which gives an opportunity of new deposition methods. The low-temperature evaporation in a vacuum is applicable for various small molecules, whereas “wet technologies” using organic material solubility in solvents are famous of large molecules and polymers. The thin-film fabrication technology is not only unique property of these materials; organic semiconductors exhibit semiconducting properties even without any doping. Hence, the organic semiconductors do not represent only alternative semiconducting materials, but it is also an exciting challenge for electronics and device physics. It has been found that the semiconducting properties have different microscopic origin than the inorganic materials even though the macroscopic behaviour is sometimes almost identical. Interestingly, in contrast with very first ideas researcher commented that “organic semiconductors” can be misleading term and suggests to call these materials “organic semi-insulators” but it is too late for such a correction. Actually, it is fascinating to state “Yes, it works, but we are still not sure why”.

TIME-RESOLVED OPTICAL AND TERAHERTZ STUDIES OF THIN-FILM FERROMAGNETS AND ANTIFERROMAGNETS

L. Nádvorník

Recent breakthroughs in electrical detection and manipulation of antiferromagnets have opened a new avenue in the research of non-volatile spintronic devices. Antiparallel spin sublattices in antiferromagnets lead to the insensitivity to magnetic field perturbations, multi-level stability and ultra-fast spin dynamics. However, these features also make the characterization of

antiferromagnetic materials, in particular of thin metallic films suitable for spintronics, a major challenge [1]. In this contribution we show how the know-how, which we achieved in the pump-probe study of diluted ferromagnetic semiconductor (Ga,Mn)As [2,3], can be transferred to the research of thin films of compensated antiferromagnetic metal CuMnAs. In particular, we show how pump-probe experiments can be used to study magnetic anisotropy [4], dynamics of heat dissipation [5] and even to achieve switching in memory devices by single femtosecond laser pulse due to nano-fragmentation of magnetic domains [6].

[1] P. Němec, M. Fiebig, T. Kampfrath, and A. V. Kimel, Nature Physics 14, 229 (2018)
[2] P. Němec et al., Nature Physics 8, 411 (2012)
[3] N. Tesařová, et al., Nature Photonics 7, 492 (2013)
[4] V. Saidl, et al., Nature Photonics 11, 91 (2017)
[5] M. Surýnek et al., arXiv 2004.05360
[6] Z. Kašpar et al., arXiv 1909.09071

ELECTROMAGNETIC STRUCTURE OF MESONS AND BARYONS

C. Adamuščín, E. Bartoš, **S. Dubnička**, A. Liptaj, A. Z. Dubničková

Present state of elementary particles to be specified by a set of quantum numbers is summarized. An existence of four types of interactions between elementary particles is reminded with an emphasis that not all particles are able of all four interactions. Those to be able of strong interactions are named “hadrons”-compound of “quarks”. Compound from quark-antiquark are “mesons” and compound from three quarks are baryons. Recently four, even five quarks hadrons are confirmed experimentally, not to be in contradiction with QCD. Nevertheless X,Y,Z particles are out of any classification into multiplets to be known for standard mesons and baryons. Hadrons in interaction with charged leptons manifest space structure to be called electromagnetic (EM) structure, first time revealed for protons before the quark model of hadrons was established. It is described by “EM form factors (FFs)” the number of which depends on spin of hadron. The Unitary and Analytic model of FFs is presented to be based on analyticity and existence of vector-meson-resonances with quantum numbers of photon. Model depends on some unknown coupling constant ratios. Therefore, it is applicable only to hadrons for which some experimental data exist. As a result only, the EM structure of the nonet of pseudoscalar mesons and the ½^+ octet baryons is completely described in the framework of this model up to now.

SELECTED RESUTS OF THE ATLAS EXPERIMENT WITH SIGNIFICANT CONTRIBUTION OF CZECH AND SLOVAK PHYSICISTS

Tomáš Davídek

The ATLAS experiment is the largest particle physics detector installed at the Large Hadron Collider at CERN, which measures the proton-proton (or lead-lead) collisions at the world-highest energies. The precision measurements of the physics processes and particles' properties probe our current theory of elementary particles, the so-called Standard Model (SM). The discovery of the Higgs boson in 2012 opened a new territory to be explored - its detailed properties and interactions. Another exciting goal for now and the future is the search for new physics phenomena behind the SM.

The ATLAS Collaboration produces plenty of physics results every year. This talk concentrates on recent analyses with significant contribution of Czech and Slovak physicist participating in this experiment, for instance the measurement of selected Higgs boson decays, top-quark physics, rare decays of B-mesons and heavy-ion physics.

EXPLOSIONS IN THE UNIVERSE AND THE ORIGIN OF CHEMICAL ELEMENTS

Ondřej Pejcha

Recent detection of gravitational waves from merging black holes and neutron stars opened a new window for studying the Universe and further accelerated

the tremendous progress in multiwavelength time-domain astronomy. This talk will review exciting new developments in the quest for uncovering the origin of chemical elements in the Universe and understanding the birth of neutron stars and black holes. These major unsolved astrophysical problems are associated with some of the most luminous explosions and involve a wide range of physics such as nuclear matter at high densities, neutrinos, strong magnetic fields, and formation of dust and molecules.

TEN YEARS OF COMPASS TOKAMAK OPERATION

M. Komm on behalf of the COMPASS team

The COMPASS tokamak, originally constructed and operated at UKAEA in UK, has been reinstalled at the Institute of Plasma Physics of the CAS in 2009 and experienced a fruitful decade of scientific exploration. In this contribution, we will summarize the main achievements, which have contributed to the physics understanding of tokamak plasmas and development of nuclear fusion related technologies. These include: (i) investigation of the power decay lengths in limited plasmas, which directly impacted the design of the ITER inner wall plasma-facing components, (ii) error field (EF) experiments using the unique set of the tokamak high-field-side error field coils, (iii) power exhaust studies, (iv) runaway electron characterization and mitigation programme, and others.

COMPASS tokamak will be shut down before the end of 2020 to make space for a completely new

machine: COMPASS Upgrade. Characteristics of this challenging device will be presented.

CZECH PARTICIPATION IN NEW EUROPEAN LARGE RESEARCH INFRASTRUCTURE FAIR

Andrej Kugler, coordinator FAIR-CZ

Czech Republic is aspirant member of the Facility for Antiproton and Ion Research (FAIR) since March 2019. Unique new European Large Research Infrastructure FAIR is currently built up at the campus of German national laboratory for heavy ion research GSI Darmstadt. It will cover research in nuclear and hadron physics as well as in associated fields. It is included in the European Strategy Forum on Research Infrastructures (ESFRI). The current status of FAIR construction will be discussed as well as current status and future enlargement of Czech participation in all four pillars of FAIR, i.e. in CBM, NuSTAR, PANDA a APPA. Now days Czech scientist from NPI CAS, Silesian University at Opava and Czech Technical University are involved in studies of compressed baryonic matter (HADES, CBM); team from Silesian University is involved in studies related to nuclear astrophysics (NuSTAR); teams from Charles University and Czech Technical University participate in R&D and construction of detectors for PANDA pillar devoted to particle physics. APPA pillar is devoted to application of nuclear and hadronic physics in further fields, like plasma physics, radiobiology, testing of detectors for European Space Agency (ESA) etc. Small group from NPI CAS interested in radiobiology participates now in APPA, further Czech groups involved in other fields covered by APPA as well as by other pillars, are welcomed.

Investments of Czech groups in experiments planned to be carried out in FAIR are currently covered mainly by Large Research Infrastructure FAIR-CZ.

NUCLEAR METHODS FOR ASTROPHYSICAL PURPOSES

Giuseppe Ferdinando D'Agata, Jaromir Mrazek, Vaclav Burjan[1], Anastasia Cassisa

It is widely known that nucleosynthesis takes place into stars. Element lighter than Iron and heavier than Lithium (partially produced in primordial nucleosynthesis) are in fact produced during stellar evolution by means of the interaction between charged and neutral particles. About charged particles its interactions is strongly hampered by the presence of the Coulomb barrier – usually around some MeV – that is much higher than the typical energies of thermal agitation of particles inside a star (between tenth and thousands of keV). This fact generates the strong, exponential fall of the cross-section that can be observed in many experiments that have been conducted through the years. This often makes really hard – when not virtually impossible – the study of this reactions in our laboratories around the world. Regarding the reactions involving neutrons in the entrance channel, experiments are complicated by the many difficulties involved in produce a suitable neutron beam. To overcome these problems many indirect methods have been developed through the last decades, and in particular the Asymptotic Normalization Coefficient (ANC) method and the Trojan Horse Method (THM) have proven to be quite useful to study reactions involving charged particles and neutrons in the entrance channel.

THE PROTON AND DEUTERON ACTIVATION AT NPI CAS AND SPIRAL2/NFS FRANCE

E. Šimečková, R. Běhal, V. Glagolev, J. Mrázek, J. Novák, M. Štefánik

Knowledge of experimental activation cross sections is important for creation and evaluation of evaluated libraries (TENDL) used by various programs for design accelerators, their components, reactors, but also for nuclear structure study. The proton and deuteron activation cross sections have been studied at NPI CAS (Nuclear Physics Institute) for many years at variable energy cyclotron U120M. Deuteron energy is limited to 20 MeV. For this reason, we took advantage of the opportunity to extend this research to the new facility SPIRAL2/NFS (Neutrons For Science) constructed at GANIL/SPIRAL2 in France. Charge-particle irradiation chamber was developed and constructed at NPI CAS. The chamber is equipped with a pneumatic transfer system that allows measurement of activated isotopes with halflives in minute region. The first test with protons was made at the end of 2019.

The proton induced reaction cross sections on iron were investigated by stacked-foil activation technique with initial proton beam of energy 20 MeV from the cyclotron U-120M of the NPI CAS, Řež and the measurements confirmed the data of previous authors. We determined production cross sections for 58mCo a 58gCo for the first time. We also determined the production cross sections for 51Mn which were incorrectly ascribed to 51Cr. The investigation will continue for higher proton energy interval up to 33 MeV at SPIRAL2/ NFS with the equipment allowing measurement of products with halflives in minute

region (e.g. 54mCo, 53mFe) and using isotopically enriched targets.

DETECTION FOR (N,G*) REACTIONS BY FAST NEUTRONS

Daniil Koliadko, Martin Ansorge, Mitja Majerle, Jan Novák

Precise nuclear data are of great importance in the design of fusion and ADS devices. The studies of prompt and delayed gamma rays from (n,g*) reactions bring important knowledge as it is one of the main sources of nuclear data such as cross-section, nuclear energy levels, etc.

A central part of the capability is the Cyclotron U-120 and neutron converter coupled to the collimator. The collimated neutron beam of fast neutrons (with energies up to 33 MeV) was recently acquired at the Laboratory of Fast Neutrons of the NPI CAS. The detection system for the prompt gammas irradiated in the reaction of studied material with fast neutrons is being constructed. The setup consists of an array of HpGe detectors. The first experiments performed have shown that the setup was able to detect delayed gammas with decay times of a few ms. Future tests will focus on detecting prompt gammas.

NUCLEAR DATA MEASUREMENTS WITH COLLIMATED FAST NEUTRON BEAMS PRODUCED BY CYCLOTRON-DRIVEN NEUTRON GENERATORS

Martin Ansorge, Mitja Majerle, Jan Novák, Daniil Koliadko

At the Nuclear Physics Institute at the laboratory of Fast Neutron Generators, a new neutron collimator was recently constructed. Simultaneously a new neutron converter coupled to the collimator was constructed and successfully tested last year. Collimated beams of fast neutrons bringing new experimental possibilities especially for on-beam measurements with semiconductor detectors. Motivated by the development of future fission and fusion energy projects the nuclear data measurements of cross-sections for nuclear reactions induced by fast neutrons are under preparation (or were already conducted) at the Department of Nuclear Reactions at the NPI CAS. A new vacuum chamber with silicon detector composed telescopes will allow us to perform precise measurements of double-differential cross-sections for interaction (n, cp) induced by fast neutrons with kinetic energies from 5 to 33 MeV. The current status of development and preparations for experiments with the new vacuum chamber will be given.

Moreover already measured experimental total cross-section data for reaction natO(n,tot) will be shown and a particular experimental approach to transmission experiments will be described.

EFFECTS OF HIGH PRESSURE ON THE RADIOACTIVE DECAY

Anastasia Cassisa, Jaromir Mrazek, Giuseppe D'Agata, Francois de Oliveira Santos

It is well known that the radioctive decay can be influenced from external environment [1][2]. However, we still don't have a univocal picture that describes these effects. Understanding how the radioctive decay is

influenced in high density environments is useful for different fields like, for example, the relevant fusion processes in stellar environment [3] or for isotope-cycling and fractionation on Earth [4]. Therefore, we prepare a test at the Nuclear Physics Institute of the Czech Academy of Science. We will use three large HPGe detectors to measure gamma-rates from a solid target of 22Na under high pressure. The source of 22Na decays by β+ that presents a strong gamma line, it has reasonably long half-life (T1/2 = 2.6 yr) and it is commercially avaible. This simple system may provide an optimal test-bench. Hereby we will present and discuss our preparations for the test.

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[3] C. Nociforo et al. - Phys. Scr. T 150, 014028 (2012)
[4] M.B. Andersen, et. al - Nature 517, 356 (2015)

TRENDY VO FYZIKÁLNOM VZDELÁVANÍ, OČAKÁVANIA A REALIZÁCIA

Marián Kireš

Vzdelávanie je procesom sprístupňovania nadobudnutých poznatkov a overených postupov z vybranej oblasti ľudskej činnosti, ponúkajúcim využívanie a nadväznosť na existujúcu úroveň vedy, techniky či spoločenských zvyklostí. Kvalitným vzdelávaním nie iba informujeme o minulosti, ale najmä iniciujeme smerom k budúcnosti. Fyzika, ako veda, má obrovský vzdelávací potenciál z pohľadu rozvoja vedeckej gramotnosti, štúdia novodobých vedeckých tém, prepájania základného a aplikovaného výskumu, interdisciplinarity a silnej väzby na informatiku. Fyzika, ako vyučovací predmet, je unikátnym priestorom pre aktívne poznávanie, bádateľskú výučbu, formatívne hodnotenie, kolaboratívne učenie, rozvoj zručností a spôsobilostí, vyšších poznávacích procesov. Náročnosť sprístupňovania vzdelávacieho obsahu vo fyzike si vyžaduje spoluprácu vedcov, didaktikov a učiteľov v oblastiach tvorby kurikula, aplikácie vyučovacích metód, popularizácie a neformálneho vzdelávania. Vysoké očakávania z pohľadu profilu absolventa, kladú požiadavky na vzdelávanie, ktoré položí silné základy pre neustálu adaptáciu, inováciu, kreativitu, či riešenie globálnych výziev, o ktorých dnes iba uvažujeme. Vďaka národným a medzinárodným projektom sa už dnes realizujú vzdelávacie koncepty, ktoré veríme, že naplnia naše očakávania. Koncept gymnaziálnych tried so zameraním na informatiku, prírodné vedy a matematiku, ako jeden z produktov

národného projektu IT Akadémia, je v príspevku predstavený s dôrazom na inováciu obsahu a metód fyzikálneho vzdelávania, profiláciu absolventa, jeho orientáciu a pripravenosť na vysokoškolské štúdium STEM odborov.

ŠKOLSKÝ MERACÍ SYSTÉM S VYUŽITÍM MIKROKONTROLÉRA

Sergej Iľkovič**, Michal Choma**

Zvyšovanie výpočtového výkonu počítačových komponentov, ktoré je sprevádzané znižovaním ich cien je predpokladom vzniku nových progresívnych oblastí, ktoré postupne získavajú na popularite, vďaka čomu získavajú masový rozmer. Tieto nové technológie rýchlo prenikajú do rôznych oblastí nášho života a školstvo nie je výnimkou. V čase, keď väčšina žiakov vlastní digitálne zariadenie sa využitie týchto zariadení aj na vzdelávacie účely javí ako dobré riešenie. Predpokladom takéhoto riešenia je existencia systému, ktoré umožňuje okrem plnenia edukačných úloh aj zabezpečovať komunikáciu so zariadeniami učiteľov a študentov. Školský elektronický merací systém predstavuje technický prostriedok pre realizáciu merania, ktorý následne poskytuje namerané údaje užívateľovi pre ich ďalšie spracovanie. Elektronické meracie systémy predstavujú zaujímavý nástroj pre zefektívnenie výučby fyziky na základných a stredných školách. V príspevku autori predstavujú vlastný vyvinutý školský merací systém základom ktorého je mikrokontrolér ESP32. Veľkou výhodou systému je jeho univerzálnosť a škálovateľnosť, vďaka čomu môže systém plniť aj špecifické požiadavky užívateľa. Modulárnosť systému zase zjednodušuje prácu

s jednotlivými komponentmi a sprehľadňuje jeho štruktúru aj pri jeho pomerne vysokej komplexnosti. Vďaka bezdrôtovej technológii a použitiu kompatibilných komunikačných protokolov je možné sa k systému pripájať pomocou zariadení bez ohľadu na ich operačný systém. Súčasťou návrhu systému je aj návrh plošného spoja elektroniky a zapuzdrenia komponentov.

MODELOVANIE ZMENY TIAŽOVÉHO ZRÝCHLENIA A JEHO VPLYVU NA TLAK V KVAPALINE

Milan Kováč

Cieľom príspevku je ponúknuť učiteľom fyziky spôsob ako rozvinúť žiacke predstavy o tlaku v kvapalinách, o jeho príčine a dôsledkoch. Zaoberáme sa preto chápaním pojmov tiaž, tiažová sila, gravitačná sila. Venujeme sa tiež pokusu s kvapalinou v beztiažovom stave, kedy na telesá ponorené v kvapaline nepôsobí vztlaková sila. V príspevku navrhujeme experiment zameraný na overenie lineárnej závislosti tlaku v kvapaline od tiažového zrýchlenia. Zmenu tiažového zrýchlenia modelujeme využitím princípu Atwoodovho pádostroja. Experiment odporúčame realizovať so žiakmi vyšších ročníkov strených škôl a gymnázií.

FAKTORY OVLIVŇUJÍCÍ VNÍMÁNÍ DEMONSTRAČNÍCH EXPERIMENTŮ STUDENTY: VIDEOSTUDIE

Alexandr Nikitin, Marie Snětinová, **Petr Kácovský**

TUESDAY

Experiment je základním prvkem nejen ve fyzice jako vědě, ale také ve výuce fyziky. Ačkoliv je v poslední době více výzkumné pozornosti věnováno samostatnému experimentování žáků v rámci badatelské výuky, významnou roli stále ve školách hraje demonstrační experiment. Na katedře didaktiky fyziky MFF UK má projekt předvádění demonstračních experimentů pro studenty středních škol tradici více než 30 let a v současné době nabízí celkem sedm tematických celků.

Výzkum provedený ve školním roce 2017/18 na vzorku cca 5100 studentů však ukázal, že tyto tematické celky jsou studenty vnímány poměrně odlišně zejména z hlediska jejich zájmu, vnitřní motivace a subjektivně vnímané užitečnosti a hodnoty. Nabízí se tedy otázka, zda existují parametry, které předurčují pozitivní vnímání demonstračních pokusů studenty – ať už by mělo jít o požadavky na performera, o způsob práce s publikem či o výběr jednotlivých experimentů.

Cílem tohoto příspěvku je představit výsledky videostudie, které byly podrobeny videozáznamy všech sedmi tematicky odlišných vystoupení, a interpretovat tyto výsledky ve spojení s tím, jak pozitivně či negativně studenti daná vystoupení vnímali.

FYZIKA PRO NEJMENŠÍ A JEJICH UČITELE

Jitka Houfková

Co zajímá nejmenší "fyziky" z mateřských škol a prvního stupně základních škol, co se jim líbí a co všechno dokáží, a co na to jejich učitelé? Co vše lze prostřednictvím jednoduchých fyzikálních pokusů u dětí rozvíjet? Jak fyzika pomáhá spolupráci učitelů z různých typů škol?

Při odpovídání na předchozí otázky vychází autorka ze své mnohaleté zkušenosti se zprostředkováváním fyziky předškolním a mladším školním dětem a jejich učitelům v rámci vlastního autorského programu Pohádková fyzika i v rámci Elixíru do škol.

SMÍCHOVSKÁ PRŮMYSLOVKA TŘETÍHO VĚKU

Věra Krajčová

Smíchovská střední průmyslová škola se dlouhodobě snaží o zavádění nových forem výuky, se kterými souvisí také snaha o status otevřené instituce přístupné všem generacím. Centrem všeho dění jsou samozřejmě studenti školy, kteří mají možnost se všeobecně rozvíjet, a to nejen klasicky v hodinách, ale i jako asistenti či vedoucí workshopů pro mateřské a základní školy a od roku 2015 také pro seniory. Smíchovská průmyslovka třetího věku je dlouhodobý projekt podpořen grantem magistrátu hl. města Praha, který formou pravidelných přednášek a workshopů

pomáhá k rozvíjení technických schopností seniorů ale i sociálních vazeb mezi mladou generací a seniory.

STRASTI A SLASTI UČITEĽA FYZIKY V ROKU 2020

Jozef Beňuška

Vyučovací proces, nielen predmetu fyzika, má svoje viac či menej zaužívané pravidlá. Zvyčajne sa ich adepti na učiteľstvo dozvedajú na pri štúdiu na vysokej škole. V tomto príspevku chceme odpovedať na niekoľko otázok a podať informácie, ktoré sa možno pri štúdiu nedozvedia. Napríklad:

Je vyučovanie fyziky iné oproti iným predmetom? Ako sa mení úloha učiteľa fyziky v posledných rokoch? Sú vytvorené podmienky na kvalitné vyučovanie fyziky na základných a stredných školách? Ako môže vyzerať „dobrá“ vyučovacia hodina fyziky? Čo sa zmenilo na metodickej pomoci organizácii nazvanej Metodicko-pedagogické centrum v posledných desaťročiach? Kde sú IT technológie rozumné využiteľné a kde ich pomoc je skôr prekážkou? Je 3D tlač pre obyčajného učiteľa fyziky prínosom? Boli sme pripravení na online vyučovanie fyziky a zvládli sme ho?

KULATÝ STŮL K OTÁZKÁM ČESKÉ TERMINOLOGIE VE FYZICE (MÁ JEŠTĚ SMYSL PSÁT O FYZICE ČESKY?)

J. Valenta

STRUCTURAL AND MAGNETIC PHASE DIAGRAMS OF $RMn_{1-x}Fe_xO_3$ SYSTEM WITH PEROVSKITE CRYSTAL STRUCTURE

Marian Mihalik, Matúš Mihalik, Mária Zentková

The transition metal oxides, with perovskite structure, have been largely studied because these materials exhibit strong coupling between orbital, electronic, spin and lattice degrees of freedom. The atomic substitution at the dodecahedral sites in stoichiometric compounds has been extensively studied and recently, interest has turned on to the effect of the substitution at the octahedral sites, where the experimental studies have been mainly focused on the magnetic behaviour, and few on the multiferroic properties. In our paper we focus on construction of structural and magnetic phase diagrams of RMn1-xFexO3 system with perovskite crystal structure (R = Nd, Pr, Tb and Dy). Our study was performed on single crystals prepared by optical floating zone method. We studied creation of the substitutional solid solutions in whole concentration range, evolution of Jahn-Teller (JT) effect and orbital ordering with substitution at the octahedral sites with non-active JT ion Fe3+. Construction of magnetic phase diagrams was undertaken with particular emphasis to determination of magnetic structure by means of magnetization, heat capacity and neutron diffraction measurements. We paid special attention to tuning of magneto-electric (ME) coupling in multiferroic compounds ($RMnO_3$, R = Tb, Dy) with magnetically

induced ferroelectricity by low concentration doping with Fe.

EXPERIMENTAL STUDY OF EMERGENT GROUND STATE BEHAVIOUR IN $RENi_5$ (RE = Ce, Yb, Gd) SYSTEM

Andrea Dzubinska, M. Reiffers, M. Giovannini, J. R. Fernandez, R. Varga, J. I. Espeso, J. C. Gomez Sal

The study of intermetallic compounds has a long history. Rare earth intermetallic compounds are systematically investigated more than 3 decades already. Polycrystalline samples (Ce, Gd, Yb)Ni_5 were prepared by different ways, where interesting physical problems were studied.

In this work we focused on competition between the effect of spin fluctuations and the possible existence of quantum criticality, a dimension response of physical properties and the response of chemical pressure on the physical properties.

First of all, structural analysis confirms required crystal structure and scanning electron microscopy shows the chemical compositions. After that, magnetic and thermal properties were performed by using several experimental techniques. The results will be displayed.
Collected experimental data show, that substitution of rare earth atoms in a compound has very important role. An interesting physical property can be observed due to acquired information.

THE SEARCH FOR MULTIFERROELECTRICITY: THE CASE OF NICKEL TELLURIDES

Ch. Kadlec, S. Skiadopoulou, M. Reteuerto F. Kadlec, F. Borodavka, M. Míšek, M. Greenblatt, S. Kamba

Multiferroic materials exhibiting coupled magnetic and electric orderings are intensely studied due to an interest in both their fundamental properties and potential applications based on the magnetoelectric coupling. In general, magnons are collective spin excitations of various types. In multiferroics, the electric component of the electromagnetic radiation can excite magnons via the dynamic magnetoelectric coupling. These excitations are then called electromagnons; they can be difficult to distinguish from classical magnons. One possible method consists in comparing terahertz or infrared spectra with Raman spectra. In fact, the electromagnons, unlike magnons, must follow the same selection rules as polar phonons—they must be active in both kinds of spectra. In this presentation, we will illustrate our approach by the study of nickel tellurides [1,2,3]. Indeed, a colossal magnetoelectric coupling has been found in Ni 3 TeO 6 . For the first time, we managed to synthetise its isostructural compounds by substitution of Ni with Mn or Co. Low- temperature spectra revealed electromagnons sensitive to magnetic field, which proves the multiferroic character of the compounds.

FRUSTRATED SHASTRY-SUTHERLAND METALLIC SYSTEMS TmB_4 and ErB_4

Slavomír Gabáni, Mat. Orendáč, G. Pristáš, J. Bačkai, E. Gažo, K. Siemensmeyer, N. Shitsevalova, K. Flachbart

Geometrically frustrated lattices play an important role in emergent quantum mechanical phases, which have been rather well investigated in electronic insulators. A system that exhibits both lattice frustration and metallic behaviour are the rare-earth (*RE*) tetraborides REB_4. They have a tetragonal structure with magnetic *RE* ions embedded in boron network and forming a lattice topologically equivalent to the frustrated Shastry-Sutherland lattice with the strong Ising single-ion anisotropy.

In our contribution we compare the behaviour of TmB_4 and ErB_4 by investigating the angular dependencies of their thermal and magnetic properties in a wide range of temperatures (*T*) and magnetic fields (*H*) as well as transport properties under pressure up to 3 GPa. Compared are also the rotating magneto-caloric effects (R-MCE) of both compounds. Spin-electron model was suggested to explain the complex behaviour of R-MCE, which is based on the idea of two interacting systems: the localized spins of *RE* ions and the itinerant electrons in conduction band. The received results from Monte Carlo approach successfully reproduce the observed heating and cooling regions in *H* - *T* phase diagrams of TmB_4. Thus, our study shows that measurements of R-MCE can be an effective tool for investigating the microscopic properties of magnetization processes.

SKÚMANIE MIKROŠTRUKTÚRY OCELÍ POMOCOU MÖSSBAUEROVEJ SPEKTROMETRIE

Dávid Košovský, Tomáš Kmječ, Marcel Miglierini

Mikroštruktúra materiálov determinuje aj ich makroskopické fyzikálne vlastnosti. Tie je nevyhnutné poznať hlavne v prípade ocelí, ktoré sa používajú ako základný materiál pre konštrukčné prvky jadrových zariadení. Ukazuje sa, že chróm v rôznych zliatinách má antikorózne vlastnosti kvôli povrchovej segregácii a tvorbe pasivačnej vrstvy. Práve preto sú ocele s prímesou chrómu vhodným kandidátom pre tlakové nádoby jadrových reaktorov.

Pre výskum mikroštruktúry ocelí je mimoriadne vhodná Mössbauerova spektroskopia, ktorá pomocou hyperjemných interakcií medzi jadrami ^{57}Fe a príslušným elektrónovým obalom citlivo popisuje ich lokálne usporiadanie. Poskytuje informáciu o štruktúrnom usporiadaní (typ kryštalických fáz) a aj magnetickom stave. V prezentácii budú diskutované rôzne spôsoby vyhodnocovania Mössbauerových spektier modelových zliatin typu Fe-Cr s obsahom Cr v rozsahu 1-50 at. %. Pre nízke koncentrácie Cr (do 15 at. %) je vhodná metóda binomického rozdelenia, u vyšších zas distribúcie hyperjemných magnetických polí. Zloženie modelových vzoriek bolo overené metódou röntgenovskej fluorescencie, ich povrch bol skúmaný pomocou rastrovacej elektrónovej mikroskopie. Získané výsledky budú použité pri skúmaní mikroštruktúry reálnych typov konštrukčných ocelí.

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CURRENT DEVELOPMENT IN THE STUDY OF MAGNETICALLY INDUCED CRYSTAL REORIENTATION OF Ni-Mn-Ga FERROMAGNETIC SHAPE MEMORY ALLOY

Šimon Sukup, Samuel Heczko, **Oleg Heczko**

In the past two decades Ni-Mn-Ga Heusler alloys have received great attention as these exhibit magnetic shape memory effects, first described in 1999. Modulated Ni_2MnGa martensite has exceptionally low stress for pseudoplastic deformation or structural reorientation by twinning mediated by highly mobile twinning boundaries [1]. Owing to large magnetic anisotropy and low twinning stress the large pseudoplastic deformation can be induced by a magnetic field. Thus, these materials can replace giant magnetostrictive materials with fast external actuation control and strain exceeding 10 % [1].

In this study, the energy needed for the deformation by a magnetic field and by mechanical force was measured and compared in monocrystalline $Ni_{50}Mn_{28}Ga_{22}$ modulated martensite. Measurements were conducted on five samples by vibration sample magnetometer and stress-strain device to compare directly different modes of loading. In contrast with the phenomenological model [2] the calculated energy of magnetically induced reorientation or pseudoplastic deformation were considerably higher compared to the energy needed using mechanical force. The switching field of samples with nucleated twinning boundaries was also measured and compared to single variant crystals. Results only partly support modelling of the twinning stress and switching field [1-3]. The model-data

discrepancies are an unresolved issue suggesting a need for modification of the model.

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[3] O. Heczko, D. Vokoun, V. Kopecky a M. Beleggia, Effect of Magnetostatic Interactions on Twin Boundary Motion in NiMnGa Magnetic Shape Memory Alloy, *IEEE Magnetics Letters* 6 (2015) 1-4.

TAJOMSTVÁ FUJARY A PÍŠŤALIEK

František Kundracik

Píšťalky a najmä fujara sú neodmysliteľnou súčasťou slovenskej kultúry a svetového kultúrneho dedičstva. Najviac osobitými slovenskými píšťalami sú fujara (najdlhší nástroj tohto typu na svete) a koncovka (píšťala bez dierok). Fujara si získala celosvetovú pozornosť najmä špecifickou farbou zvuku, koncovka zasa svojou jednoduchou konštrukciou a spôsobom hry na ňu. Oba tieto nástroje však môžu slúžiť aj ako učebné pomôcky pri výučbe viacerých oblastí fyziky, napríklad šírenie zvuku a stojace vlny, hydrodynamika tekutín, alebo základy harmónie z pohľadu frekvencie zvuku.

Na koncovke a fujare možno pekne ilustrovať (počuť) rôzne typy stojacich vĺn (vyššie harmonické kmitočty) za okrajovej podmienky ako otvoreného, tak aj uzavretého konca. Vybudením vyšších harmonických kmitočtov sa dajú vysvetliť tradičné hudobné ozdoby hráčov na fujaru, ako sú rozfuk a prefuk. Prúdenie plynu za vzniku vírov je kľúčovým faktorom pri vzniku kladnej spätnej väzby a trvalého tónu. Pytagorejská teória harmónie spolu so štruktúrou vyšších harmonických tónov generovaných v píšťale umožňuje vysvetliť spôsob hry na koncovku a tiež to, prečo minimálny počet dierok na píšťale sú tri (ako má aj fujara) a prečo majú píšťaly najčastejšie 6 dierok.

Ukážky rôznych (aj primitívnych) nástrojov a hry na ne môže spestriť výučbu fyziky a tiež zvýrazniť väzbu fyziky na iné odbory.

VODÍK – PALIVO PRO UDRŽITELNOU ENERGETIKU

Vladimír Matolín

Odklon od využívání fosilních paliv vyžaduje hledání nových nosičů energie, které budou nezbytné pro dosažení ambiciózního cíle uhlíkově neutrální energetiky. Přestože podíl výroby elektrické energie z obnovitelných zdrojů, především solární a větrné, neustále roste, významnější závislost na těchto zdrojích bude spojena s řešením různých problémů, spojených především s vlivy počasí a geografického umístění na jejich efektivitu. Obtížná regulace produkce elektrické energie z obnovitelných zdrojů vyžaduje hledání způsobu reverzibilního ukládání energie a nových chemických nosičů energie. Zatím se jako nejperspektivnější jeví využití vodíku, a je zřejmé, že vodík bude důležitou součástí energetického mixu budoucnosti. Pokles ceny solární a větrné energie vede k rozvoji výroby „čistého“ vodíku elektrolýzou vody a umožňuje tak ukládání přebytků energie. Energii z vodíku lze zpětně přeměnit ve vodíkovém cyklu na energii elektrickou v palivových článcích, které mohou být jak stacionární, tak mobilní. Mobilní prostředky jsou v podstatě elektrické hybridní systémy, kde je baterie doplněna vodíkovou nabíječkou. Vodík se uplatňuje v manipulační technice, bude využit v elektrickém letectví, kamionové a lodní dopravě. Vodík jako nosič energie má výhodu rychlého čerpání a rovněž delšího dojezdu.

Vodíková budoucnost je neoddělitelně spojena s využitím baterií a hybridní systémy budou tím víc nezbytné, čím větší spotřebu bude mít dané zařízení.

MEASUREMENTS OF OPEN CHARM HADRONS IN Au+Au COLLISIONS AT SQRT(S_NN) = 200 GeV BY THE STAR EXPERIMENT

Jan Vaněk

At RHIC energies, charm quarks are primarily produced in hard partonic scatterings at early stages of ultra-relativistic heavy-ion collisions. This makes them an ideal probe of the Quark-Gluon Plasma (QGP) produced in these collisions, since they experience the whole evolution of the hot and dense medium. STAR is able to study the interactions of charm quarks with the QGP through direct reconstruction of hadronic decays of D±, D0, Ds, and Λc± hadrons. This is possible thanks to an excellent pointing resolution provided by the Heavy Flavor Tracker.

In this talk, we will present the most recent results on open charm hadron production from the STAR experiment. In particular, we will discuss the nuclear modification factors of D± and D0 mesons which give access to the charm quark energy loss in the QGP. We will also discuss Ds/ D0 and Λc±/D0 yield ratios as functions of transverse momentum and collision centrality which help us understand better the charm quark hadronization process in heavy-ion collisions. In addition, we will present the rapidity-odd directed flow of D0 mesons, which can be used to probe the initial tilt of the QGP bulk and effects of early-time magnetic field.

RECENT RESULTS OF INCLUSIVE JET PRODUCTION IN Au+Au COLLISIONS AT √sNN = 200 GeV BY THE STAR EXPERIMENT

Robert Licenik for the STAR Collaboration

It has been established that the Quark-Gluon Plasma (QGP), an exotic state of deconfined matter, is created in high-energy heavy-ion collisions. Jets are a very important probe of this hot and dense nuclear matter, since they emerge from the fragmentation of hard-scattered partons (quarks and gluons) that are created during the early stages of the collisions. Therefore, measurements of modifications to jet properties in heavy-ion collisions relative to those in proton-proton collisions can provide insight into understanding interactions between hard-scattered partons and the QGP.

This talk aims to present recent results of jet production in Au+Au collisions at √sNN = 200 GeV by the STAR Collaboration at the Relativistic Heavy Ion Collider. We will focus on the measurement of inclusive jet production as a function of transverse momentum (pT) of jets and collision centrality. Jets are reconstructed using charged tracks from the Time-Projection Chamber and neutral energy from the Barrel Electromagnetic Calorimeter towers, using the anti-kT algorithm with jet resolution parameter R = 0.2, 0.3, and 0.4. The large combinatorial background is suppressed by requiring a high-pT leading hadron in accepted jet candidates. Jet yield suppression is observed for central relative to peripheral Au+Au collisions, which is attributed to medium-induced parton energy loss. The measured distributions are compared to theoretical calculations incorporating jet quenching, which will improve our

understanding of medium-induced energy loss of jets at RHIC energies.

SEARCH FOR JET QUENCHING EFFECTS IN HIGH-MULTIPLICITY PROTON-PROTON COLLISIONS AT $\sqrt{s}$ = 13 TeV

Filip Křížek for the ALICE Collaboration

QCD jets are modified ("quenched") by their interactions with the quark-gluon plasma (QGP) formed in high-energy nuclear collisions. The measurement of jet quenching in small collision systems can tell us about the limits of QGP formation and the nature of equilibration in QCD, but to date no significant jet quenching has been observed in small systems. In this talk, the ALICE Collaboration reports results of a novel approach to jet-quenching measurements in high-multiplicity pp collisions at $\sqrt{s}$ = 13 TeV, searching for modification of di-jet azimuthal acoplanarity measured by the semi-inclusive distribution of jets recoiling from a high-p_T hadron. Charged-jet reconstruction is carried out using the anti-k_T algorithm with R = 0.4 and a data-driven statistical method is used to correct the measured jet yield for uncorrelated background, which includes multi-partonic interactions. High-multiplicity (HM) pp events are selected based on charged-particle multiplicity registered in forward scintillator detectors and their acoplanarity distributions are compared to that for Minimum Bias (MB) events. Significant azimuthal broadening is observed in HM collisions, consistent with jet quenching.

However, qualitatively similar features are also seen in pp collisions generated by the PYTHIA Monte

Carlo event generator which does not include the simulation of jet quenching
or any other QGP effects. We will discuss the current status of this analysis and prospects to understand the origin of this striking phenomenon.

IDENTIFYING HEAVY-FLAVOR JETS USING VECTORS OF LOCALLY AGGREGATED DESCRIPTORS

Georgy Ponimakin, Raghav Kunnawalkam Elayavalli, Josef Šivicd, Jana Bielčíková, Jörn H. Putschke

Jets of collimated particles arising from hard scattered partons have been studied extensively in hadron collisions. Jets serve a multitude of purposes as they are utilized in fundamental studies of the Standard Model (SM) and in searches for new particles. Recently, studies of jet interaction with the quark-gluon plasma (QGP) created in high energy heavy ion collisions are of growing interest, particularly towards understanding partonic energy loss in the QGP medium and its related modifications of the jet shower and fragmentation. Since the QGP is a colored medium, the extent of jet quenching and consequently, the transport properties of the medium are expected to be sensitive to fundamental properties of the jets such as the flavor of the parton that initiates the jet. Identifying the jet flavor enables an extraction of the mass dependence in jet-QGP interactions. We present a novel approach to tagging heavy-flavor jets at collider experiments utilizing the information contained within jet constituents via the JetVLAD model architecture. We show the performance of this model as characterized by common metrics and showcase its ability to extract high

purity heavy-flavor jet sample at various realistic jet momenta and production cross-sections.

RECENT RESULTS OF UPSILON PRODUCTION MEASURED WITH THE STAR EXPERIMENT

Leszek Kosarzewski for the STAR Collaboration

Heavy-ion collisions allow to recreate conditions present in the universe shortly after the Big Bang when the quark-gluon plasma can be formed. The properties of such plasma can be studied using Upsilon mesons. Each of Upsilon states is expected to dissociate at a different temperature reached in the plasma, through Debye-like screening of color charges. Thus, their production yields are suppressed to different levels with respect to the yield in p+p collisions. Additional cold nuclear matter effects can be studied in p+A or d+A collisions. Furthermore, the production mechanism of these heavy mesons is not fully understood and this can be studied in p+p collisions as well.

In this talk, we will present an overview of recent measurements on the production of Upsilon states by the STAR experiment. These include a comprehensive study performed in Au+Au, p+p, and p+Au collisions at p $\sqrt{s_{NN}}$ = 200 GeV as well as p+p collisions at $\sqrt{s}$ = 500 GeV.

STUDENTS' SOLVING OF MULTIPLE-CHOICE TASKS FOCUSED ON GRAPH SLOPE INTERPRETATION OBSERVED BY THE EYE-TRACKING METHOD

Martina Kekule

We employed the eye-tracking method (Eyetracker by Tobii, 300 Hz) in order to observe students' strategies of choosing an option when they solved multiple-choice tasks focused on graph slope interpretation. Each student solved 7 multiple-choice tasks focused on graphs in kinematics. Most tasks were adopted from Beichner's TUG-K test (Beichner, 1994). Particularly, they were focused on position-time graphs and determining velocity from the graphs as it is stated in the Objective 1 of the Beichner's original test. Altogether 23 high school students participated in the study (8 women, 15 men). Each stem-text, stem-graph and each option was marked as a separate Area Of Interest for every task. We provide comparison of attention allocation between two students group: those, who solved a test task correctly and those who not. Based on the data analysis, we observed and described different students understanding of the graph slope concept. Moreover, we applied the cluster analysis in order to divide students into groups according to their attention spent on each option. We obtained very similar results as in the previous case.

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DOPLŇKOVÉ KURZY (BRIDGING COURSES) PRO STUDENTY 1. ROČNÍKŮ NA VYSOKÝCH ŠKOLÁCH

Renata Holubová

Cílem příspěvku je prezentovat výsledky mezinárodního šetření o existenci a obsahu překlenovacích kurzů pro absolventy středních škol, kteří nastupují do 1. ročníku studia přírodovědných předmětů na vysokých školách. Byli dotazováni jak studenti, tak i vysokoškolští pedagogové, zda jsou takovéto kurzy na vysokých školách nabízeny, zda studenti tyto kurzy navštěvují, popř. zda by byl o takovéto průpravné kurzy zájem a jaký by měl být jejich obsah (kritická místa kurikula středních škol). Je známo, že v ČR je diskutována úroveň znalostí matematiky absolventů středních škol, zda mají potřebné kompetence pro studium technických oborů, popř. fyziky na technických vysokých školách a přírodovědeckých fakultách (aktuálně také zrušení povinné maturity z matematiky). Je zajímavé porovnat tuto situaci s tím, zda podobné problémy řeší zahraniční vysoké školy a popř. jaké kurzy jsou na vysokých školách nabízeny, na jaké učivo je kladen důraz. Uvedeme příklady nabídky doplňkových kurzů na Přírodovědecké fakultě v Olomouci a příklady z Rakouska, Itálie a Litvy.

STRATÉGIE ZVOLENÉ ŠTUDENTMI PRI TVORBE KOMENTÁROV K TICHÝM VIDEÁM

Simona Gorčáková, Klára Velmovská

Konštruktivistické prístupy, ktoré sa v súčasnosti uplatňujú vo vzdelávaní v podobe bádateľsky orientovanej výučby, zdôrazňujú okrem rozvíjania porozumenia aj rozvoj zručností a spôsobilostí súvisiacich s činnosťami, ktoré vedú ku konštrukcii poznatkov. Počas prípravy študentov učiteľstva fyziky sa však často stretávame so situáciou, kedy študent uprednostňuje vyučovacie stratégie, ktorými si počas svojho vzdelávania prešiel on sám, a má tendenciu ich napodobňovať. Preto považujeme za dôležité poskytovať študentom učiteľstva neustálu spätnú väzbu a vzor v konštruktivistickom sprístupňovaní poznatkov. Jednou z viacerých príležitostí, kedy môžeme takúto spätnú väzbu našim študentom poskytnúť, je aj realizácia aktivít s tichým videom. Tiché video je typ úlohy, v ktorej študenti nahrávajú komentár k videu trvajúcemu spravidla jednu až dve minúty, zobrazujúcemu nejaký fyzikálny jav, pokus, experiment. Príspevok obsahuje javovú analýzu, na základe ktorej sme určili stratégie zvolené študentmi učiteľstva fyziky pri tvorbe komentárov k trom tichým videám.

VYUŽITÍ KONCEPTUÁLNÍCH ÚLOH A GRAFICKÉHO ZNÁZORŇOVÁNÍ V ÚVODNÍM KURZU KVANTOVÉ FYZIKY

Zdeňka Koupilová, Petr Kácovský

V poslední době se i ve vysokoškolské výuce, zejména v úvodních kurzech během prvních let studia, objevuje posun od tradičně pojaté výuky k aktivizujícím výukovým formám. Jejich prostřednictvím se prohlubuje konceptuální pochopení základních myšlenek, které se tak vzájemně doplňuje s řemeslným zvládnutím

konkrétních technik řešení úloh typických pro dané fyzikální téma. Výzkumy prováděné v zahraničí ukazují, že tento přístup má pozitivní efekt jak na pochopení probírané látky, tak na schopnost řešit tyto úlohy.

Konceptuální a aktivizující přístup využíváme ve výuce úvodního kurzu kvantové fyziky pro budoucí učitele již několik let. Velkou výzvou zůstává shánění vhodných materiálů – konceptuálních úloh, otázek do diskuze, námětů na skupinovou práci či vhodných nástrojů pro vizualizaci jednotlivých problémů. V našem případě je navíc velmi vhodné používat materiály v češtině, aby si budoucí učitelé dostatečně zažili terminologii i způsoby diskutování, protože ve své praxi se budou muset obejít bez matematického aparátu, který tvoří přirozenou a jedinou dostatečně výstižnou „řeč“ kvantové fyziky.

V příspěvku představíme ucelenou kolekci konceptuálních úloh i vhodných nástrojů a vizualizací vytvořených jak na základě zahraničních zdrojů, tak vyvinutých přímo ve zmíněném kurzu. Tyto materiály jsou volně dostupné všem zájemcům a mohou tak obohatit výuku úvodních kurzů kvantové fyziky i na dalších školách a oborech.

SMART BIOMETRIC RECORDING SYSTEM FOR REAL-TIME EVALUATION OF MOTILITY ON ORGANISM WITH KNEE PATHOLOGY

Amir Enikeev, **Josef Skopalík**, Tomáš Parák, Karol Švík, Jana Kolářová, Vratislav Čmiel, Josef Mašek

Lab rats and rabbits are irrepleceable models for study of the ortopedic pathologies. Traditional analysis of these pathologies is based on postmortem histological

analysis or X-ray or invasive sampling, however modern monitoring of orthopedic pathology and regeneration needs the smart and noninvasive methods for quantification of the motility of the limbs and organism. Advances in imaging technologies have enhanced our posibilities to quantify the typical movement of the organism.

Lab animals were hold in typical lab cage. We developed an autonomous optical setup which recorded animal position and displayed the trajectory and typical characteristic of the movement (speed, acceleration, shading of the walls of cage, rocognition of biorhytmic period).

The system was based on the HD 10 fps camera. Export of the frames was commited to OpenCV and mathematical conversion of motion to x-y coodinates was curbed by set of Python utlilities.

Comparison of animals with deffects and healthy animals gives basic criterion for automatic recognition of patholgical state and basic criterion for evaluation of regeneration process. Upgrade of these biometric system should be used also for clinical and home rehabilitation in the future.

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MAGNETICKY MÄKKÉ KOMPOZITY: PRÍPRAVA, VLASTNOSTI A APLIKÁCIE

Ján Füzer, Peter Kollár, Samuel Dobák, Magdaléna Strečková, Zuzana Birčáková, Radovan Bureš, Mária Fáberová

Nepretržitý pokrok v oblasti magneticky mäkkých materiálov prináša nové možnosti ich využitia v modernej elektrotechnike a elektronike. Cieľom hľadania progresívnych materiálov je snaha o zníženie ekonomických nákladov na ich výrobu a prevádzku z nich zhotovených výrobkov v priemyselných aplikáciách. Magneticky mäkké kompozity (MMK) vyrobené práškovou metalurgiou otvárajú nové možnosti pri navrhovaní a výrobe dielov aj pre nové typy elektromotorov. Vďaka vysokému elektrickému odporu majú MMK v aplikáciách s vysokofrekvenčným premagnetovaním nižšie celkové magnetické straty v porovnaní s klasickými materiálmi. Za magnetické vlastnosti feromagnetík je zodpovedná ich štruktúra, fyzikálne vlastnosti, doménová štruktúra a jej reakcie na magnetické pole. Tieto vlastnosti je možné zlepšiť alebo optimalizovať správnou voľbou a vhodným spracovaním magneticky mäkkého materiálu. MMK sa skladajú z jednotlivo obalených feromagnetických častíc prášku, ktoré sú pokryté elektricky izolačnou vrstvou. Súčasný výrobný postup zahŕňa lisovanie prášku do konečného tvaru a tepelné spracovanie, ktorého cieľom je uvoľnenie napätí indukovaných v priebehu lisovania. Základné metodiky skúmania magnetických vlastností sú meranie hysteréznych slučiek v širokom pásme frekvencií a použitie impedančnej spektroskopie. Koncept MMK

založený na využití izolačných vlastností povrchovej vrstvy častíc môže priniesť výrazné výsledky v oblasti prípravy feromagnetík rôznorodých tvarov s optimalizovanými vlastnosťami pre konkrétne aplikácie.

NOVEL DIRECTIONS IN STUDIES OF ELECTRON-HOLE LIQUID IN SEMICONDUCTORS: WIDE GAP AND 2D MATERIALS

Jan Valenta

The low-temperature electron-hole plasma may undergo phase transition to the liquid state: the *electron-hole liquid* (EHL). The transition is allowed in dense plasma below critical temperature T_C and it exists only in the thermodynamic limit, i.e. when the lifetime of the electron-hole system is long enough to reach the thermal equilibrium. For that reason, the macroscopic and relatively long-lived EHL is exclusively observed in the indirect semiconductors. This liquid phase is the *two component degenerate Fermi liquid*. EHL has a form of spatially separated "droplets" within a cloud of EHP or excitons. In close analogy with conventional liquids EHL has constant density at given temperature – it is related to the quasiparticle distance for which their energy is minimized. Decay of EHL droplets via electron-hole recombination is faster than decay of free excitons - fortunately, this decay includes radiative recombination processes giving rise to photoluminescence (PL) which is the most important messenger bringing information on EHL. The investigation of the intriguing new "matter" was conducted mostly in 1970ies in Si and Ge. EHL was later observed also in low-dimensional semiconductor

structures. Here we present recent results on wide-gap semiconductors (especially 4H-SiC) and the graphene-like materials like MoS_2.

NITRIDE MULTIPLE QUANTUM WELL CHALLENGE

Jiří Oswald, František Hájek, Alice Hospodková, Tomáš Hubáček, Vítězslav Jarý, Karla Kuldová, Jiří Pangrác

Nitride semiconductor heterostructures are widely used for light-emitting, high-power and high-frequency applications. But InGaN/GaN multiple quantum well (QW) structures are also potential candidates for scintillation detectors. This application needs completely different design of the heterostructure in comparison with LED one. It opens new problems that have not been solved yet. Main technological challenge for scintillator structure design is the demand for thick active regions with a higher number of QWs compared to that for LED structures due to the high penetration depth like high energy electrons or X-ray radiation. Another challenge is usually extremely low excitation intensity of ionizing radiation. Under such conditions, the excitonic QW luminescence can have even lower intensity than different kinds of defect bands originating either in GaN or in InGaN QWs. Our ability to realize scintillators on an InGaN/GaN base will be presented and influence of number of QWs in the structure on luminescence properties will described and discussed.

NITRIDE SEMICONDUCTORS – PROPERTIES AND APPLICATIONS

Alice Hospodková, Tomáš Hubáček, Jiří Oswald, František Hájek, Karla Kuldová, and Eduard Hulicius

Why are the III-nitride semiconductors so unique that they became the second most important semiconductor material after silicon? Why it was so difficult to prepare high quality nitride layers? It was so difficult that scientist, which have partly solved this problem were five years ago awarded by Nobel Prize. What are the most perspective applications for nitrides? What problems have to be solved in nitride technology? Answers to these four questions concerning nitride properties, applications, technology and open problems will be presented in our contribution. We will show how the piezoelectric field in nitride heterostructures can be utilized in transistors with high electron mobility, but on the other how it can complicate the carrier confinement in quantum wells and design of optoelectronic applications. Application in lasers and light emitting diodes, in high electron mobility transistors (HEMTs) and in scintillators will be discussed with their advantages and limitations. We will touch also the most important technological problems and challenges, such as high dislocation density and possible ways to suppress it, the p-type doping of AlGaN layers, problems with limited indium atom incorporation. Results of scintillator structure development in our group with the world record InGaN QW number will be presented.

PROJEKT IT AKADÉMIA VO SVETLE ZMIEN VO FYZIKÁLNOM VZDELÁVANÍ

Zuzana Ješková, Marián Kireš

V súčasnosti častokrát skloňované problémy s prírodovedným vzdelávaním sú v centre pozornosti národného projektu IT Akadémia, ktorého hlavným cieľom je vytvorenie modelu vzdelávania pre aktuálne a perspektívne potreby vedomostnej spoločnosti a trhu práce so zameraním na informatiku a digitálne technológie. V rámci príspevku predstavíme dva kľúčové ciele projektu: inovácia vzdelávania matematiky, informatiky a prírodných vied na základných a stredných školách a príprava učiteľov, v rámci ktorých sa sústredíme na fyzikálne vzdelávanie. Prvý z cieľov je zameraný na aktualizáciu obsahu, metód a foriem výučby. Rozsiahla zbierka metodických materiálov pre výučbu je vytvorená na princípoch aktívneho žiackeho poznávania, zmysluplného využívania digitálnych technológií a využívania stratégií formatívneho hodnotenia žiakov. Vytvorené metodické materiály sú v širokom meradle implementované a overované vo výučbe. Spätná väzba získaná z overovania a vzájomná spolupráca učiteľov z praxe a pracovníkov Univerzít vychovávajúcich budúcich učiteľov má napomôcť k reálnemu uplatneniu vytvoreného modelu vzdelávania v praxi. Nato, aby boli tieto zmeny úspešné, je však potrebné motivovať a pripraviť predovšetkým učiteľa, ktorý vo vzdelávaní zohráva kľúčovú úlohu. Z uvedeného dôvodu je vytvorený vzdelávací program, v rámci ktorého sa učitelia fyziky vzdelávajú v oblasti metód bádateľsky orientovanej

výučby, digitálnych technológií a hodnotenia výsledkov vzdelávacieho procesu. V príspevku predstavíme základné myšlienky a ukážky vytvorených metodických materiálov a koncepciu vzdelávania učiteľov fyziky.

VÝSKUM ÚROVNE POZNÁVACIEHO ZÁUJMU ŽIAKOV O FYZIKU

Andrea Kľučarová, Vladimír Šebeň

Predkladaný príspevok je venovaný pedagogicko-psychologickej téme záujmu, ako jedného z významných činiteľov zohrávajúcich dôležitú úlohu v procese samostatného žiackeho bádania a učenia sa. Autori príspevku sústreďujú svoju pozornosť na záujem žiakov o predmet školskej fyziky. Dôraz pritom kladú na poznávací záujem. Hlavným cieľom príspevku je zistiť prítomnosť poznávacieho záujmu o fyziku na základných školách a následne určiť aktuálny stupeň jeho rozvoja. Na základe skutočnosti, že problematika poznávacieho záujmu v súčasnosti nie je v slovenskej literatúre metodicky dostatočne spracovaná, opierajú sa autori vo svojom výskume o metodiku I.J. Laninovej, ktorá vymedzuje tri základné úrovne poznávacieho záujmu. Vzhľadom na všeobecne známy fakt, že fyzika patrí medzi menej obľúbené predmety, doplnili autori príspevku Laninovej klasifikáciu ešte o ďalšiu, štvrtú, úroveň záujmu – tzv. nulový poznávací záujem, odpovedajúci absolútnemu nezáujmu žiaka o tento predmet. Za účelom naplnenia vytýčeného výskumného cieľa pripravili autori vlastný neštandardizovaný dotazník určený predovšetkým pre žiakov siedmeho ročníka základných škôl. Analýza a vyhodnotenie výsledkov dotazníkového šetrenia sú súčasťou tohto príspevku. Autori v ňom prezentujú svoje

zistenia týkajúce sa jednotlivých úrovní poznávacieho záujmu. Okrem toho, zaoberajú sa aj porovnávaním a skúmaním možného vplyvu niektorých faktorov ako pohlavie či lokalita školy na rozvoj poznávacieho záujmu.

MOŽNOSTI HODNOTENIA ARGUMENTOV ŽIAKOV V RÁMCI VYUČOVANIA FYZIKY NA ZÁKLADNEJ ŠKOLE

Tünde Kiss, Klára Velmovská

Človek je spoločenská bytosť a integrálnou súčasťou spoločenského života je aj komunikácia. Pri komunikácií musíme často zdôvodňovať svoje tvrdenia, presviedčať iných o ich pravdivosti – argumentovať. Schopnosť argumentovať však nie je schopnosť, ktorá je človeku daná pri narodení. Je však možné ju rozvíjať a zlepšovať napríklad tým, že žiaci počas hodín vyjadrujú svoje názory pri riešení rôznych príkladov, alebo na základe niektorých faktov predložia svoje tvrdenia. Na vyučovaní fyziky žiaci často majú uviesť svoje predpoklady, vysloviť hypotézy, alebo vysvetliť rôzne javy a deje. Podľa cieľov predmetu fyziky v štátnom vzdelávacom programe by mali byť spôsobilosti žiakov argumentovať rozvíjané počas vyučovania fyziky. V príspevku sa pozrieme na to, ako vyučovanie fyziky reaguje na požiadavku rozvíjania tejto kompetencie v našom vzdelávacom systéme na Slovensku. Na zistenie úrovne argumentácie sme najprv stanovili kritériá, na základe ktorých možno hodnotiť argumenty žiakov. Uvedieme ukážku konkrétnych odpovedí žiakov na fyzikálne úlohy, v rámci ktorých žiaci potrebovali uplatniť argumentáciu, a ich hodnotenie.

PROBLEMATIKA KLASIFIKÁCIE VÝKONOV ŽIAKA V NEŠTANDARDIZOVANOM DIDAKTICKOM TESTE

Jakub Čevajka, Klára Velmovská

Hodnotenie, ako súčasť výchovno-vzdelávacieho procesu, je v poslednej dobe značne diskutovanou témou medzi odborníkmi v didaktike, učiteľmi, žiakmi, rodičmi ale i v celej spoločnosti. Diskutovanou témou je najmä úloha hodnotenia, jeho funkcie a postavenie vo výchovno-vzdelávacom procese. Taktiež sa vedú úvahy, či je hodnotenie v podobe, akej sa realizuje, objektívne a naozaj posudzuje a klasifikuje žiakov podľa vhodných kritérií tak, aby boli rovnaké výkony žiakov hodnotené totožným klasifikačným stupňom. Proces hodnotenia a klasifikácie žiackych výkonov považujú učitelia za jednu z najnáročnejších úloh učiteľského povolania. Tento fakt je potvrdzovaný viacerými výskumami. Príspevok sa zameria na problematiku náročnosti klasifikácie výkonov žiakov v neštandardizovanom didaktickom teste. V realizovanom prieskume sme analyzovali klasifikáciu výkonov žiakov v neštandardizovaných testových úlohách študentami učiteľstva na FMFI UK. Úlohou prieskumu bolo porovnať jednotlivé hodnotenia navrhnutého neštandardizovaného didaktického testu študentami učiteľstva medzi nimi navzájom a s hodnotením podľa navrhnutej schémy hodnotenia, ktorá vychádza z revidovanej Bloomovej taxonómie. Študenti učiteľstva hodnotili výkony žiakov v didaktickom teste bez kľúča hodnotenia a správnych odpovedí. Do prieskumu sa zapojilo aj niekoľko učiteľov fyziky z praxe a získané dáta sme taktiež podrobili analýze. V príspevku uvedieme

priebeh prieskumu, získané výsledky a odporúčania pre pedagogickú prax, ktoré z prieskumu vyplývajú.

CO NÁM FYZIKOVÉ CHTĚJÍ ŘÍCT K FYZIKÁLNÍMU VZDĚLÁVÁNÍ NA STŘEDNÍCH A ZÁKLADNÍCH ŠKOLÁCH

Petr Kolář, Vojtěch Žák

Cílem výzkumu, o jehož části pojednává tento příspěvek, je zjistit představy zainteresovaných aktérů o fyzikálním kurikulu. Mezi tyto aktéry patří mimo jiné fyzikové–vědci, další přírodovědci, didaktikové fyziky a učitelé fyziky. Na základě sběru a analýzy jejich představ budou formulovány podněty k proměně současného kurikula fyziky pro základní a střední školy.

Cílem příspěvku je zprostředkovat zkušenosti se sběrem a analýzou dat od fyziků–vědců. Podněty vzešlé od této skupiny aktérů mohou přispět k hlubší reflexi fyzikálního vzdělávání, protože fyzikové stojí do značné míry mimo oblast vzdělávání, zato jsou výrazně ukotveni v oboru. Výzkumný problém byl formulován následující otázkou: Co podle českých fyziků by měla zahrnovat výuka fyziky na základních a středních školách? Data byla získána prostřednictvím rozhovorů v rámci metodologie zakotvené teorie. Výsledky této části výzkumu budou využity k výzkumu mezi dalšími skupinami aktérů a měly by vyústit ve formulování doporučení k tvorbě učebnic fyziky.

Jako předběžné závěry rozhovorů, které byly provedeny s 29 z 60 oslovených fyziků, můžeme uvést následující podněty pro výuku: výrazné propojení výuky fyziky s běžným životem; provádění žákovských experimentů; výuka menšího počtu témat, zato v širších

souvislostech; společné vzdělávání různých skupin žáků; zajímavost pro žáky; zařazování současné fyziky, včetně dosud nevyřešených problémů; podpora mimoškolních aktivit.

P01 SOLID-STATE ^{1}H NMR STUDY OF CORNSTARCH PLASTICIZED WITH UREA AND GLYCEROL DURING AGEING

Natália Šmídová, Alojz Šoltýs, Viktor Hronský, Dušan Olčák

Thermoplastic starch, a group of starch-based materials, has often been under review because it can be used as low-cost bioplastics. Native starch is usually processed under the action of high temperature and shear stress with addition of plasticizers such as low molecular weight polyols and/or amide-containing molecules to obtain a moldable thermoplastic material. Such materials are sensitive to ageing and time dependent changes in their structure are of great importance for the use of materials in practice. In this study, solid-state magic-angle spinning 1H NMR was used to characterize structural changes in cornstarch plasticized with glycerol and urea during one-year ageing. It was found that widths of the signals related to urea and glycerol CH/CH2 groups did not change significantly while widths of the signals coming from water and glycerol OH groups decreased by about half after one year of storage. This could mean that urea formed stable hydrogen bonds with starch which were not affected too much during storage whereas hydrogen bonds between glycerol OH groups and urea were disrupted which resulted in increased mobility of glycerol and perhaps also phase separation of glycerol and water during ageing.

P02 VIDEOANALÝZA V STEM VZDELÁVANÍ

Peter Hockicko, Jozef Kúdelčík, Gabriela Tarjányiová

STEM vzdelávanie zamerané na Science, Technology, Engineering a Mathematics zahŕňa v sebe prípravu vysokoškolsky vzdelaného absolventa technickej univerzity, ktorý v priebehu prípravy získal zručnosti zo všetkých spomínaných oblastí. Podľa Bloomovej taxonómie poznávacích cieľov takéto vzdelávanie je realizované na vyšších stupňoch, ako je analýza, aplikácia a hodnotiace posúdenie. Videoanalýza, ako jedna z metód výuky či štúdia, umožňuje rozvíjať matematické zručnosti vo fyzikálnom vzdelávaní a následne pripraviť študentov technického zamerania pre budúcu inžiniersku prax.

Predkladaný príspevok informuje o možnostiach využitia videoanalýzy vo výuke fyziky v inžinierskom vzdelávaní. Zároveň poukazuje na to, že využitím tejto metódy vo výuke je možné zlepšiť u študentov chápanie pojmu sily, aplikácie Newtonových pohybových zákonov, čo potvrdzujú aj výsledky z FCI (Force Concept Inventory) testu.

P03 ELEKTRONICKÁ SBÍRKA ŘEŠENÝCH ÚLOH Z FYZIKY A SBÍRKA FYZIKÁLNÍCH POKUSŮ

Marie Snětinová, Petr Kácovský, Dana Mandíková, Zdeňka Koupilová

Sbírka řešených úloh z fyziky a Sbírka fyzikálních pokusů vznikají na Katedře didaktiky fyziky MFF UK.

Jedná se o podpůrné materiály pro studenty a učitele základních, středních i vysokých škol.

Sbírka řešených úloh z fyziky je vyvíjena již 14 let a obsahuje přes 900 úloh v češtině. Je primárně určena vysokoškolským studentům a žákům středních škol, lze v ní ale nalézt i úlohy na úrovni základní školy. Sbírka slouží k prohlubování a opakování učiva či k přípravě na zápočty a zkoušky, hojně ji využívají rovněž pedagogové. Protože jedním z našich cílů je seznamovat uživatele s technikami řešení fyzikálních úloh, obsahuje Sbírka nejenom jejich podrobně komentovaná řešení, ale i strukturované nápovědy, ilustrativní obrázky či interaktivní prvky.

Od roku 2015 vzniká také Sbírka fyzikálních pokusů, jejímž cílem je poskytovat učitelům inspiraci pro experimenty na úrovni základní a střední školy. Experimenty, kterých je aktuálně zveřejněno 165, jsou zpracovány do jednotné struktury s důrazem na videozáznam vzorového provedení a technické a metodické poznámky. Tam, kde je to možné, obě Sbírky propojujeme.

Dále vzniká paralelně Sbírka řešených úloh z matematiky s úlohami na vysokoškolské úrovni a také anglické verze vybraných částí všech uvedených Sbírek.

P04 ÚČAST ČESKOSLOVENSKA NA ZALOŽENÍ SPOJENÉHO ÚSTAVU JADERNÝCH VÝZKUMŮ

Emilie Těšínská

V lednu 1956 bylo Československo přizváno k účasti na založení ústavu pro jaderný, který měl být obdobou Laboratoře Evropské organizace pro jaderný výzkum (CERN) v Ženevě pro země tzv. lidové

demokracie. Československé stranické a vládní orgány nabídku přijaly. Na konferenci o ústavu, která se konala ve dnech 20.–26. března 1956 v Moskvě, byla československou vládou vyslána sedmičlenná delegace vedená tehdejším ministrem energetiky Františkem Vlasákem. Zde byla dne 26. března 1956 podepsána Dohoda o založení Spojeného ústavu jaderných výzkumů. Československo se stalo jednou z jedenácti zakládajících zemí ústavu.

S využitím archivních dokumentů budou v příspěvku doloženy bližší okolnosti československé účasti na založení Spojeného ústavu jaderných výzkumů (obsah iniciačního dokumentu, složení a návrhy československé delegace na moskevské konferenci a volba Václava Votruby jedním z prvých dvou náměstků ředitele ústavu).

P05 CALDEIRA-LEGGET MODEL FOR PARTICLE-BATH SYSTEMS IN THE PRESENCE OF A MAGNETIC FIELD

Vladimír Lisý, Jana Tóthová

The Brownian motion of a particle immersed in a bath of charged particles is considered when the system is placed in a magnetic field. The widely accepted Caldeira-Legget particle-bath model is modified so that not only the charged Brownian particle (BP) but also the bath particles respond to the external field. For stationary systems, two equations for the BP motion across the field are derived. They are of the type of generalized Langevin equations with two memory functions. The time correlation function of the thermal force is connected with

one of these functions through the fluctuation-dissipation theorem but, unlike all previous theories, it is found to depend on the external field. In the absence of the magnetic force, the other memory function disappears. Analytical expressions are obtained for the velocity correlation functions and other relevant quantities such as the mean square displacement and the diffusion coefficient of the BP for different distributions of the eigenfrequencies of the bath oscillators. Assuming the Drude distribution of the frequencies, it is found that at long times the motion of the particle is sub-diffusive, with the exponent 1/2. The case of the fractional thermal noise is also analyzed.

P06 BROWNIAN MOTION IN A BATH AFFECTED BY AN EXTERNAL HARMONIC POTENTIAL

Jana Tóthová, Vladimír Lisý

The Brownian motion of a particle in a bath of other particles is effectively described by the generalized Langevin equation (GLE). Following Kubo, it is usually assumed that if external forces act on the system, they do not affect the thermal force and the memory function that enter the GLE. The action of such forces is restricted to the Brownian particle (BP), leaving the bath particles unaffected by the external field. However, there are many physical situations, when not only the BP but also the bath particles are subjected to the external field. We show that for stationary systems in a harmonic potential the corresponding generalization of the Zwanzig-Caldeira-Legget theory leads to the GLE for which Kubo's fluctuation-dissipation theorem remains valid but both the

memory function and the thermal force depend on the elastic constant of the confinement potential. As a result, the correlation functions describing the random motion ofthe BPs change in comparison with those in the original model as well. We discuss possibilities to calculate these functions and show several specific solutions for them depending on the frequency distribution of the bath oscillators and the coupling between the bath and the BP.

P07 BIPARTITE ENTANGLEMENT IN THE SPIN-1/2 ISING-HEISENBERG PLANAR LATTICE CONSISTING OF INTER-CONNECTED TRIGONAL BIPYRAMIDS

Lucia Gálisová

The present work deals with the exactly solvable spin-1/2 Ising-Heisenberg model on an infinite but regular two-dimensional lattice composed of identical inter-connected bipyramidal plaquettes with the aim to clarify a bipartite entanglement between the Heisenberg spins at zero as well as finite temperatures. The quantity called concurrence is used as an indicator for determining a strength of this quantum-mechanical correlation. It is demonstrated that the Heisenberg spins of each bipyramidal plaquette can be mutually entangled at zero temperature only if the two-fold degenerate spontaneously ordered quantum phase characterized by a symmetric quantum superposition of three possible up-up-down (or down-down-up) states of these spins is stable. Otherwise, the bipartitite quantum entanglement of the Heisenberg spins is totally absent. Interestingly, the entanglement between the Heisenberg spin pairs persists also at finite temperatures, even far above the critical

temperature of the model if the exchange anisotropy between these spins is sufficiently strong. The entangled Heisenberg spin states can also be thermally activated above non-entangled ground state if the values of the exchange anisotropy parameter are taken sufficiently close to the boundary with the quantum ground-state phase.

P08 PHASE BIREFRINGENCE DISPERSION FUNCTION AS A COMPLEMENTARY TOOL FOR INVESTIGATION OF NEMATIC LIQUID CRYSTAL STRUCTURE

Norbert Tarjányi, Marek Veveričík, Daniel Káčik

If we put a several tens of microns thin sample of nematic liquid crystal with planar alignment of molecules with respect to the LC cell surface in between two crossed plane polarizers, illuminate it by white light and rotate appropriately, then using a fiber optic spectrometer we can observe a quasi-periodic spectral distribution of intensity of light behind the output polarizer. The spectral distribution of intensity of light emerges due to liquid crystal birefringence. Based on the polarizability models from which imply models describing the extraordinary and ordinary refractive indices n_e a n_o, respectively, the phase birefringence dispersion function of LC in the spectral region of wavelengths without resonant frequencies can be expressed. Comparison of the measured spectrum with that obtained by calculation according to the model one can find parameters characterizing mean resonance (absorption) wavelengths as well as coefficients expressing the strength of the influence of these absorption bands to resulting birefringence. The approach

could complement absorption or ellipsometric measurements the aim of which was to characterize optical properties of a liquid crystal sample.

P09 ROLE OF WATER MOLECULES IN THE PHASE TRANSITIONS IN LAWSONITE

Filip Kadlec, Ivan Gregora, Christelle Kadlec, Elena Buixaderas, Dmitri Nuzhnyy, Jan Petzelt, Stanislav Kamba

Lawsonite [CaAl2Si2O7(OH)2·H2O] is an uncommon mineral found in metamorphic rocks, occurring at subduction zones, supposedly at depths of up to 250 km. It contains 11.5 wt% water in its crystal structure. At room temperature, it is orthorhombic, crystallizing in the Cmcm space group. Its structure contains a silicate tetrahedra framework with four formulas in the unit cell. Each chemical formula comprises one water molecule embedded in a structural cavity; these cavities form channels parallel with the c axis. The protons form O-H bonds, and they may diffuse along the channels. The static and dynamic orientations of the water molecules plays a key role in two low-temperature phase transitions—a structural one at 270 K, and a ferroelectric one at 124 K. We studied the lattice dynamics in a single crystal of lawsonite using infrared, Raman and THz time-domain spectroscopies. We have found a strong soft phonon mode linked to the ferroelectric phase transition. The observed unusual hardening of other phonons with heating is linked to anomalous temperature dependence of a unit cell parameter. In view of a dielectric anomaly identified earlier, our results show that the ferroelectric

phase transition is of mixed displacive / order-disorder type.

P10 COMPLEX VOLUME CHANGES INDUCED BY HIGH PRESSURE AND EXTERNAL MAGNETIC FIELD IN Ni_2MnSn-BASED HEUSLER ALLOY

J. Kamarád, J. Kaštil, O. Isnard, Z. Arnold, M. Míšek

The Heusler $Ni_2Mn_{1+x}Sn_{1-x}$ alloys exhibit structural martensitic transformation from cubic (austenite) into orthorhombic (martensite) phase in a narrow composition range, $0,4 \leq x \leq 0,6$, only. The transformation is accompanied by a significant changes of volume, magnetization and by large anomalies in transport properties. We have studied forced volume magneto-striction, Joulian magnetostriction, thermal expansion and effect of high pressure on magnetization of the $Ni_{1.92}Mn_{1.56}Sn_{0.52}$ alloy in wide range of temperature, magnetic field and pressure. The pronounced decrease of magnetization under pressure, = $-11.8*10^{-3}$ GPa^{-1}, points to an itinerant character of magnetism of the alloy. Using the Maxwell relation, $d\omega/dH = - \rho dM/dP$, the received value of $d\ln M/dP$ can be perfectly compare with value of forced volume magnetostriction, $d\omega/dH = 3.11*10^{-6}$ T^{-1}, received by dilatometric measurement at field above 0.3 T. The Joulian magnetostriction at low temperature and low magnetic field (with $\Delta L_{||} < 0$ and $\Delta L_{\perp} > 0$) confirms a competition between strengths of magnetocrystalline anisotropy and elastic energy in martensite of $Ni_{1.92}Mn_{1.56}Sn_{0.52}$ that is characterized by a zig-zag twins structure. The relevant model proposed by O´Handley will be discussed. The observed change of volume during

martensitic transformation of the alloy was verified by X-ray diffraction measurements.

P11 NEW VIEW ON THE ORIGIN OF HIGH CONDUCTIVITY OF POLYANILINE FILMS PROTONATED BY HYDROCHLORIC ACID

Radka Rutsch, Jiří Toušek, Jana Toušková

Polyaniline (PANI) is a material known for its high conductivity and also huge range of obtainable conductivities. In general, three types of charge carriers are considered in PANI salt, namely holes, polarons and protons. Many authors attribute the high conductivity of acid doped PANI to polarons [1-3]. We show that conductivity of polarons might not be necessarily the prevailing mechanism of charge transport. In our research in order to separate contributions from different charge carriers PANI/Si heterojunction was studied. Impedance spectra were measured to distinguish between polaron and hole mobilities. From V-A characteristics on PANI/Si structure contribution of polaron and hole conductivity was calculated. Dielectric spectra of heterojunction were measured to estimate conductivity of ions. Both measurements resulted in values in order of magnitude ~ 10^{-7} S.cm^{-1}. On the contrary conductivity of several S.cm^{-1} on films of PANI on glass substrates were obtained using ohmic gold electrodes. To explain discrepancy between obtained values of conductivity a model utilising redox reaction of hydrogen and chlorine was proposed and diffusion of hydrogen and chlorine molecules in PANI films were studied.

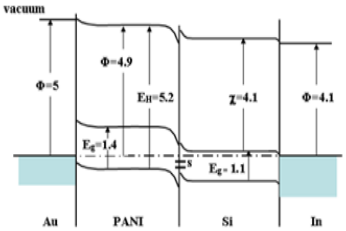

Figure 1. The band diagram of PANI/Si heterojunction. (values are in eV).

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P12 MÖSSBAUER SPECTROMETRY IN THE STUDY OF METALLIC GLASSES

Marcel Miglierini, Martin Cesnek

Metallic glasses are still attracting the interest of researchers namely for their very good soft magnetic properties. With the aim to enhance their practical applications, new compositions are continuously scrutinized. Here, we present Mössbauer spectrometry study of a novel $Fe_{51}Co_{12}Si_{16}B_8Mo_5P_8$ metallic glass prepared in a form of ribbons by conventional method of planar flow casting. Samples in as-quenched state as well

as after annealing at selected temperatures were investigated.

Mössbauer spectrometry is one of few analytical tools that can describe disordered amorphous systems. This can be done via hyperfine interactions between nuclei and electron shells which sensitively probe local short-range order arrangement. Experiments performed in a broad range of temperatures provide information on the evolution of microstructure. This is reflected by continuous modification of the hyperfine interactions from magnetic dipole towards electric quadrupole ones. Eventually, the Curie temperature of the investigated metallic glass can be established.

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P13 MONTE CARLO SIMULACE PRODUKCE UPSILON MEZONU

Jakub Češka, Leszek Kosarzewski, Miroslav Myška, Jaroslav Bielčík

Kvarkonia jsou důležitou sondou k vyšetřování vlastností kvark-gluonového plasmatu. Proton-protonové srážky jsou nezbytným prostředkem k ustanovení základních vlastností, které slouží ke studiu kvarkonií v proton-jaderných a jádro-jaderných srážek. Tento poster prezentuje základní charakteristiky Upsilon mezonů zjištěné pomocí Monte Carlo generátorů v proton-protonových srážkách při $\sqrt{s_{NN}} = 500$ GeV. Monte Carlo generátory srážek PYTHIA a Herwig byly využity k generování dat. Hlavním cílem těchto simulací je výzkum

závislosti normalizované produkce Upsilon mezonů na normalizované multiplicitě. Závislost na normalizované multiplicitě je vhodným nástrojem k porozumění mechanismům produkce částic a souhry měkých a tvrdých procesů kvantové chromodynamiky.

P14 PHASE TRANSFORMATIONS IN Al-Li-BASED ALLOY STUDIED BY IN-SITU TEM

Miroslav Cieslar, Rostislav Králík, Sára Belejová, Barbora Křivská, Michaela Šlapáková, Lucia Bajtošová, Olexandr Grydin, Mykhailo Stolbchenko

Al-Li based alloys of AA2195 type are designed mainly for aerospace applications. They exhibit a very high strength due to a presence of strengthening precipitates of a nanometric size. However, materials prepared by a conventional direct-chill casting and following rolling exhibit strong crystallographic texture and inhomogeneous mechanical properties. This inconvenient behavior could be suppressed by a direct twin-roll casting of the material to a final gauge and subsequent precipitation annealing. Phase transformations occurring at selected temperatures could be characterized using in-situ transmission electron microscopy (TEM) annealing experiments. Nevertheless, the processes could be significantly influenced by a constrained volume of thin foils used in TEM. A formation of platelike Li and Cu-rich non-equilibrium precipitates was studied in materials annealed conventionally in a furnace and in-situ in TEM.

P15 EXOMARS 2022: PLANNED MEASUREMENTS OF ELECTROMAGNETIC RADIATION ON THE SURFACE OF MARS

O. Santolík, I. Kolmašová, R. Lán, L. Uhlíř, J. Souček, I. Vlček

Dust grains in the Martial dust storms or dust devils may be electrically charged by triboelectric effects and laboratory experiments show that under specific conditions electric discharges might occur in the dusty Martian atmosphere. Remote measurements from the Earth using a 34-m Deep Space Network antenna have shown a non-thermal component of electromagnetic radiation from Mars which has been attributed to the effects of discharges in the dust storms but observations of the radar receiver onboard the Mars Express spacecraft showed no credible radio signals from Martian lightning between 4 and 5.5 MHz. Direct measurements of electromagnetic radiation on the surface of Mars are needed to solve this puzzle.

The Exomars 2022 Surface Platform instrumentation will include the Wave analyzer module, consisting of an assembly of magnetic and electric antennae and dedicated electronics, as a part of the Martian ground electromagnetic tool instrument. The module will be dedicated to the measurement of electromagnetic field fluctuations in the frequency band from 100 Hz to 8 MHz. We plan to experimentally investigate possible radio emissions of atmospheric origin generated by electrical discharges, as well as electromagnetic waves linked to the interactions of

interplanetary plasma medium with the Martian ionosphere and magnetic anomalies.

P16 PROPERTIES OF LIGHTNING-INDUCED ELECTROMAGNETIC WAVES DETECTED CLOSE TO JUPITER

I. Kolmašová, O. Santolík, M. Imai, W. S. Kurth, G. B. Hospodarsky, D. A. Gurnett, S. J. Bolton, J. E. P. Connerney

The Waves instrument onboard the Juno spacecraft recorded numerous cases of dispersed electromagnetic waves generated by Jovian lightning. These waves, also known as whistlers, propagated through ionospheric and magnetospheric plasmas before their detection by Juno during its close approaches to Jupiter. We present observations of nearly five thousand low-dispersion lightning whistlers detected below radial distances of 5 Jovian radii during the first half of the Juno mission. We have found that Jovian lightning discharges occur predominantly at mid-latitudes. We have found an asymmetry in the whistler occurrence in both hemispheres: the average lightning stroke rate in the northern hemisphere was approximately twice higher than in the southern hemisphere in the first quarter of the mission, but the mysterious asymmetry surprisingly disappeared in its second quarter. This effect might be explained by a random distribution of thunderstorms. A lack of whistlers in the tropics might be a consequence of their propagation in field-aligned ducts which would not allow them to reach the altitude of Juno. Generation of lightning at Jupiter's equatorial regions might be also suppressed due to the solar radiation received at Jupiter's

equator, which actually inhibits the rise of warm air from within the planet into the upper atmosphere.

P17 THE COMPOUND [Ni(2*aepy*)$_2$Cl (H_2O)] Cl·H_2O AS A CANDIDATE APPROACHING A TOPOLOGICAL QUANTUM CRITICAL POINT OF A SPIN-1 ONE-DIMENSIONAL ANTIFERROMAGNET

Mariia Holub, Slavomíra Šterbinská, Juraj Kuchár, Juraj Černák, Erik Čižmár

The idea of controlling the magnetic ground state of a spin-1 one-dimensional antiferromagnetic (1d AFM) quantum magnets has long been of interest to physicists. In the study of anisotropic 1d AFM systems based on Ni^{2+} compounds, a series of topologically protected quantum phases was observed, one of these phases is the topologically protected Haldane phase [1, 2]. The magnetic ground state of such a system is sensitive to the relative magnitude of the single-ion anisotropy (*D*) and the intrachain (*J*) exchange interaction parameters. The *D/J* ratio dictates the system's placement in one of three competing phases: a Haldane gapped phase, a quantum paramagnet, and an *XY*-ordered state, with a quantum critical point at their junction at *D/J* = 1. We present the study of the crystal structure and magnetic properties of compound [Ni(2*aepy*)$_2$Cl (H_2O)] Cl·H_2O (2*aepy* = 2 – aminoethylpyridine). Hexacoordinate Ni^{2+} ions form a zig-zag chain based on hydrogen bonds and running along crystallographic *b*-axis. The analysis of the experimental susceptibility using a model of spin-1 anisotropic AFM

chain yielded parameter values D/k_B = 4.05 K and J/k_B = 3.55 K. A theoretical prediction of D/k_B = 3.7 K using *ab initio* approach is very close to our experimental value.

P18 SHORT-RANGE CORRELATION INVESTIGATION IN DEUTERON INDUCED REACTIONS

Marian Janek, Vladimir P. Ladygin, Alexander V. Averyanov, Eugene V. Chernykh, Dan D. Enache, Yuri V. Gurchin, Alexandr Yu. Isupov, Julia-Tatiana Karachuk, Anatoly N. Khrenov, Dimitry O. Krivenkov, Pavel K. Kurilkin, Nadezhda B. Ladygina, Alexei N. Livanov, Olena Mezhenska, Semen M. Piyadin, Sergei G. Reznikov, Yaroslav T. Skhomenko, Arkadyi A Terekhin, Alexei V. Tishevsky

One of the approaches to investigate the equation-of-state of dense nuclear matter is the study of the short-range correlations of nucleons in nuclei. Short-range correlations have densities comparable to the density in the center of a nucleon and they can be considered as the drops of cold dense nuclear matter. Dp elastic and dp breakup processes are investigated at Internal Target Station of Nuclotron; dp elastic process in angular range from 60 – 135 degree in c.m. in the energy range from 400 - 2000 MeV; dp breakup reaction in angular the range from 19 – 56 degree from 300 - 500 MeV. Results which comes from analyzing powers of dp elastic scattering show strong sensitivity to the short-range spin structure of the isoscalar nucleon-nucleon correlations. Description based on relativistic multi-scattering model provides reasonable agreement at small and large angles but the problem is related to angles between them.

P19 ANALÝZA TOMOGRAFICKÝCH REKONSTRUKCÍ Z DAT TOKAMAKU COMPASS

Jakub Svoboda, Martin Imríšek, Jan Mlynář, Ondřej Ficker, Michael Komm, Vladimír Weinzettl

Tokamak COMPASS je vybaven dvěma sadami diagnostik, které jsou rutině využívány k počítání tomografických inverzí. Jedná se o polovodičové diody, které slouží buď jako bolometry (měří celkový vyzářený výkon), nebo jsou vybaveny beryliovým filtrem a měří měkké rentgenové záření.

V důsledku omezení pozorovacích úhlů je tomografická inverze na tokamacích nedostatečně určená, a proto se k inverzi dat často využívá algoritmus Minimalizace Fisherovy informace využívající Tichonovovu regularizaci. Tento příspěvek se zabývá analýzou takto spočítaných inverzí pomocí metod umožňujících zkoumat časový a prostorový vývoj emisivity plazmatu. Princip spočívá ve sledování oblastí zájmu, které mohou mít jak obdélníkový tvar, tak tvary odvozené od tvaru magnetických povrchů. Tyto metody lze využít ke zpracování rekonstrukcí z více diagnostik najednou.

V příspěvku budou prezentovány analýzy rekonstrukcí vybraných výbojů tokamaku COMPASS. Analýza rekonstrukcí měkkého rentgenového záření se zaměří na pilovou nestabilitu a vnitřní smyčkovou nestabilitu. Analýza dat z bolometrů bude zaměřena na jev tzv. oddělení plazmatu od divertoru a na studium okrajové nestability.

P20 STRUCTURE AND GROWTH OF ω-Ti NANOPARTICLES IN β-Ti SINGLE CRYSTALS STUDIED BY ANOMALOUS X-RAY DIFFRACTION

Václav Holý, Jana Šmilauerová, Petr Harcuba

Nanoparticles of hexagonal ω phase in bcc-Ti(Mo) single crystals (β phase) occur due to a diffusionless athermal β to ω transformation and they grow during follow-up ageing at elevated temperatures, while the alloying atoms (Mo in our case) are expelled from the nanoparticle volumes. We used anomalous x-ray diffraction for the study of local chemical composition of growing ω particles and we found that a Mo-rich shell at the particle/matrix interface is created during the particle growth. Moreover, the expelled Mo atoms create a cloud with higher Mo density around each particle and its Mo concentration profile was studied by anomalous x-ray diffraction and small-angle scattering.

P21 EVOLUTION OF MAGNETISM IN $UCo_{1-x}Ir_xGe$ SYSTEM

Dávid Hovančík, Jiří Pospíšil, Akinari Koriky, Petr Doležal, Marian Reiffers, Vladimír Sechovský

The uranium based intermetallics are intensively studied because of dual character of uranium 5f electrons. Unique coexistence of ferromagnetism and superconductivity has been revealed in URhGe and UCoGe crystalizing in the orthorhombic TiNiSi-type structure. Since UCoGe (T_C =2.5 K) is very close to

magnetic instability, it is a candidate to observe vanishing of ferromagnetic order and ferromagnetic quantum critical point. The chemical substitution was found as an effective tool to destabilize the ferromagnetic order in UCoGe by substitution on Co site by transition metal. $UCo_{1-x}Ru_xGe$ or $UCo_{1-x}Fe_xGe$ systems have showed vanishing of ferromagnetism in quantum critical point at critical concentration ~30 % of substituent element. However, in $UCo_{1-x}Rh_xGe$ or $UCo_{1-x}Pd_xGe$ where both parent compounds order magnetically, finite ordering temperature is conserved, thus quantum critical phenomena have not been observed.

We have decided to investigate $UCo_{1-x}Ir_xGe$ system. Since UCoGe is ferromagnet and UIrGe antiferromagnet, its alloy system is promising candidate to observe interesting evolution of magnetism. We will show that $UCo_{1-x}Ir_xGe$ is the first case of disappearance ordering temperature between two magnetic parent compounds. Therefore, two quantum critical point of different nature of ferromagnetic and antiferromagnetic-type are expected.

In order to investigate evolution of the magnetism we have prepared polycrystalline samples throughout whole concentration range. Subsequently, we have performed measurements of magnetization, electrical resistivity and heat capacity.

P22 PROPERTIES OF YELLOW BAND IN GaN LAYERS

Tomáš Hubáček, Vítězslav Jarý, Karla Kuldová, Alice Hospodková, Jiří Pangrác and Eduard Hulicius

Nitride semiconductors became the second most important semiconductor material after silicon in the last two decades. Many daily used devices, such as blue light emitting diodes or high electron mobility transistors in electronic devices, are based on nitride semiconductors. Despite the nitride devices mass production, there are many open questions and not well understood phenomena which have to be solved.

Epitaxially grown GaN layers contain different bands in their luminescence spectra. There is very fast excitonic band and also different kinds of defect bands, which have mostly slow decay time. Fast decay time without any slow components is necessary for many scintillation applications. Especially defect band with the maximum emission around 2.2 eV (called yellow band) has very slow decay time (microsecond range) and needs to be suppressed in fast scintillators.

In our previous work [1], we have shown that different technological parameters during Metal Organic Vapour Phase Epitaxy (temperature, carrier gas, etc.) influence properties of yellow band quite significantly. In this work, we continue to study properties of yellow band of GaN layers grown with different parameters. Photoluminescence, time-resolved photoluminescence and other measuring techniques are used for investigation of yellow band properties. Origin of yellow band will be discussed.

[1] T. Hubáček et al., J. Cryst. Growth 531 (2020) 125383.

P23 THE STUDY OF LATTICE DYNAMICS IN LOW-DIMENSIONAL QUANTUM MAGNETS WITH CHAIN-LIKE CRYSTAL STRUCTURE

O. Vinnik, L. Lederová, R. Tarasenko, L. Kotvytska, K. Zakuťanská, N. Tomašovičová, A. Orendáčová

Current work is focused on the lattice subsystem of $Cu(en)Cl_2$, $Cu(tn)Cl_2$ and $Cu(en)(H_2O)_2SO_4$ (en = $C_2H_8N_2$, tn = $C_3H_{10}N_2$), quasi-two-dimensional quantum magnets with one-dimensional polymeric structure. Magnetic layers were described within spin = 1/2 Heisenberg models on the rectangular and zig-zag-square lattice with nearest-neighbor couplings $J_1 > J_2$. The largest spatial anisotropy $R = 1\text{-}J_2/J_1$ and the strongest effect of interlayer coupling J' was observed in $Cu(en)Cl_2$, while somewhat lower R and much weaker J' in $Cu(tn)Cl_2$ and $Cu(en)(H_2O)_2SO_4$.

Specific heat in zero magnetic field was measured from 2 to 300 K and Raman spectra at 300 K. In $Cu(en)Cl_2$ and $Cu(tn)Cl_2$, specific heat anomalies observed at 138 K and 160 K, respectively, are associated with a structural phase transition. No structural phase transition was observed in $Cu(en)(H_2O)_2SO_4$. The contribution of acoustic modes is described within Debye approximation with Debye temperatures Θ_D = 147 K, 109 K and 93 K for $Cu(en)(H_2O)_2SO_4$, $Cu(en)Cl_2$ and $Cu(tn)Cl_2$, respectively. The larger Θ_D value of $Cu(en)Cl_2$ and the Raman shift towards higher energies correspond well with the $Cu(en)Cl_2$ specific heat values which are lower than those of $Cu(tn)Cl_2$ in the whole temperature region. The influence of acoustic modes on the magnetic correlations is discussed.

P24 SOLID-STATE 1 H NMR STUDY OF CORNSTARCH PLASTICIZED WITH UREA AND GLYCEROL DURING AGEING

M. Černý

Thermoplastic starch, a group of starch-based materials, has often been under review because it can be used as low-cost bioplastics. Native starch is usually processed under the action of high temperature and shear stress with addition of plasticizers such as low molecular weight polyols and/or amide-containing molecules to obtain a moldable thermoplastic material. Such materials are sensitive to ageing and time dependent changes in their structure are of great importance for the use of materials in practice. In this study, solid-state magic-angle spinning 1 H NMR was used to characterize structural changes in cornstarch plasticized with glycerol and urea during one-year ageing. It was found that widths of the signals related to urea and glycerol CH/CH 2 groups did not change significantly while widths of the signals coming from water and glycerol OH groups decreased by about half after one year of storage. This could mean that urea formed stable hydrogen bonds with starch which were not affected too much during storage whereas hydrogen bonds between glycerol OH groups and urea were disrupted which resulted in increased mobility of glycerol and perhaps also phase separation of glycerol and water during ageing.

P25 INTERDIFFUSION IN ALUMINIUM – STEEL CLAD

Barbora Křivská, Michaela Šlapáková, Lucia Bajtošová, Rostislav Králík, Olexandr Grydin, Mykhaylo Stolbchenko, Miroslav Cieslar

Bonding of aluminium and steel into one single material – an aluminium-steel clad – represents an excellent composite material, which provides high potential for applications in automobile industry by combination of properties of respective materials – high stiffness and strength of steel and durability, corrosion resistance, thermal capacity and high specific strength of aluminium. microstructure. Optimal process conditions during clad strips production should result in the formation of a continuous diffusion layer of several Fe-Al phases. However, such layer may reduce the bonding strength and formability of the material.

Diffusion and phase transformations in aluminium - steel clad sheet prepared by twin-roll casting were studied by means of light optical microscopy, electron microscopy and resistometry. Effective interdiffusion coefficient was evaluated by Boltzmann-Matano method from measured concentration profiles through the interface. Simulated results were in a direct contradiction with in-situ TEM/SEM observations showing surprisingly a formation of Fe-Al phases in the steel layer. Results confirm that a simple diffusion driven model could not cover complex processes occurring at the interface.

P26 CHARACTERIZATION OF THIN FREE-STANDING Al-Mg FILMS

Lucia Bajtošová, Rostislav Králík, Barbora Křivská, Hana Libenská, Jozef Veselý, Miroslav Cieslar

Small-scale thin films are frequently used in microelectronic devices and micro-electro-mechanical systems where they are commonly subjected to high strains during their dynamic motion. However, mechanical behavior of thin films significantly differs from the behavior observed in bulk materials. To understand the size dependent properties of deformation mechanisms, characterization of the grain properties of nano-scale materials is essential along with mechanical tests. A promising method is in-situ transmission electron microscopy deformation, which combines mechanical tests on a nano-scale with a direct observation of the structure even with an atomic resolution. Thin Al-based free-standing films prepared by DC magnetron sputtering were characterized by atomic force microscopy, conventional and in-situ transmission electron microscopy and automatic phase and orientation mapping in TEM.

P27 RECRYSTALLIZATION OF TWIN-ROLL CAST AA8079 ALUMINUM ALLOY AFTER HOMOGENIZATION

Rostislav Králík, Barbora Křivská, Lucia Bajtošová, Miroslav Cieslar

Twin-roll casting of AA8079 aluminum sheets creates non-equilibrium structure as a result of high solidification rates. Homogenization treatments consisting of an exposure of the as-cast material to high temperatures close to the melting point result in a redistribution of solute atoms and a formation of a more stable structure. Newly formed equilibrium particles have different crystallographic structure, size and also their distribution is more homogeneous. Their features have a significant influence on softening processes and recrystallization occurring in sheets rolled from the homogenized material. Two different processes controlling the kinetics of recrystallization were identified by electron microscopy, light optical microscopy and microhardness measurements. It was shown, that a particle stimulated nucleation dominates in materials homogenized at high temperatures while a Zener drag is a controlling process in sheets exposed to lower homogenization temperatures.

P28 NANOFLUID BASED ON A NEW GENERATION OIL

Katarína Paulovičová, Jana Tóthová, Michal Rajňák, Milan Timko, Peter Kopčanský, Vladimír Lisý

Magnetic fluids belong to special nanomaterials with many application possibilities. One of the fields of their use is the energy industry, where the demands on the performance of electrical equipment are constantly rising. As a result, there is a need to use modern insulation systems. Adding nanoparticles to conventional media could be one way to obtain them. In this study, we focused on the complex characterization of potential magnetic

nanofluids based on isoparaffin hydrocarbons extracted from natural gas. These new generation gas-to-liquid (GTL) derived electrical insulation fluids are cleaner, chemically stable, and the thermal conductivity values of these electrical insulating fluids are higher, indicating improved heat transfer properties. For the preparation of magnetic nanofluids, we used sterically stabilized nanoparticles of iron oxide with a volume fraction in samples in the range of 0.3–3.0%. The saturation magnetization, magnetic susceptibility, density, and viscosity were investigated showing a significant enhancement with an increase of the volume fraction. Our experimental results show that the nanoliquid prepared on the basis of the GTL technology has a stable colloidal character that is necessary for its application as a potential cooling medium in electro-energetics.

P29 DESIGN OF NOVEL MATERIALS: ARPES EXPERIMENTS AND THEORY

Ján Minár

Angle-resolved photoemission spectroscopy (ARPES) is a leading experimental probe for studying the electronic structure and complex phenomena in quantum materials. Modern experimental arrangements consisting of new photon sources, analyzers and detectors supply not only spin resolution but also extremely high angle and energy resolution [1]. Furthermore, the use of photon energies from few eV up to several keV makes this experimental technique a rather unique tool to investigate the electronic properties of solids and surfaces [2]. On the theoretical side, it is quite common to interpret measured ARPES data by simple comparison with calculated band

structure. However, various important effects, like matrix elements, the photon momentum or phonon excitation, are in this way neglected. Here, we present a generalization of the state of the art description of the photoemisison process, the so-called one-step model that describes excitation, transport to the surface and escape into the vacuum in a coherent way [3,4]. Nowadays, the one-step model allows for photocurrent calculations for photon energies ranging from a few eV to more than 10 keV, for finite temperatures and for arbitrarily ordered and disordered systems, and considering in addition strong correlation effects within the dynamical mean-field theory. Application of this formalism in order to understand ARPES response of new materials like low-dimensional magnetic structures [6], Rashba systems [5], topological insulator materials [1], materials relevant for photo-catalysis [8] or ultrafast femtosecond spin dynamics [7] will be shown.

In this presentation I review some of the recent ARPES results and discuss the future perspective in this rapidly developing field. In addition I will introduce our new spin polarised ARPES laboratory.

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WEDNESDAY

P30 VÝZKUM PŘECHODU DO REŽIMU ZLEPŠENÉHO UDRŽENÍ PLAZMATU NA TOKAMAKU COMPASS

M. Peterka, O. Grover, J. Seidl, T. Markovič, P. Bílková, R. Dejarnac, J. Adámek, K. Bogár, O. Bogár, A. Casolari, J. Cavalier, M. Dimitrova, P. Háček, J. Havlíček, M. Hron, M. Imríšek, P. Junek, L. Kripner, R. Pánek, M. Šos, M. Tomeš, J. Varju, P. Vondráček, V. Weinzettl, G. V. Zadvitskiy

Provoz v režimu s vysokým udržením energie plazmatu (H-mód) je jedním z klíčových předpokladů pro úspěšné dosažení hlavního cíle tokamaku ITER, jímž je desetinásobné fúzní zesílení výkonu. Přechod do H-módu však může být významně ztížen v důsledku přítomnosti chybových polí, které v tokamaku nevyhnutelně vznikají jako důsledek nepřesností v umístění magnetických cívek či centrálního solenoidu. Tokamak COMPASS je vybaven světově unikátní sadou cívek pro kontrolu chybových polí, umístěných na vnější i vnitřní straně tokamaku, a v nedávných experimentech prokázal, že za určitých okolností vede přítomnost těchto chybových polí během přechodu do H-módu k zamknutí rotace magnetických ostrovů a následnému kolapsu celého plazmatu. Dále se experimentálně podařilo prokázat vliv polohy divertorové singularity magnetického pole na dosažení H-módu skrze ovlivnění síly toků generovaných elektrickým polem, které rozbíjí turbulentní struktury zodpovědné za většinu energetických ztrát. V neposlední řadě se připravují unikátní experimenty pro měření potenciální vorticity, která souvisí se samo-organizací zonálních toků, které

regulují míru turbulence a mohou způsobit přechod do H-módu.

P31 STUDY OF RING-LIKE STRUCTURES IN PARTICLE EMISSION IN RELATIVISTIC NUCLEAR INTERACTIONS

Adela Kravčáková, Stanislav Vokál

The substuctures in the emission of relativistic particles in central ^{197}Au and ^{208}Pb interactions with Ag, Br targets in nuclear emulsions at beam momenta 11.6 and 158 A GeV/c, respectively, have been investigated. The nonstatistical ring-like substructures of produced particles in azimuthal plane of a collision as result of hydrodynamic waves in nuclear matter have been searched and their parameters have been determined. The experimental results have been compared with the results simulated by Monte Carlo method.

P32 COR SYSTEM FOR COSMIC RAYS TRAJECTORIES IN MAGNETOSPHERE SIMULATION

Daniel Gecášek, Pavol Bobik, Ján Genči

Cosmic rays are particles, coming from space. The system COR (Cut-off rigidity) provides access for the wider scientific community to models of simulation of cosmic ray trajectories in the magnetosphere via a web interface. The system offers simulations of vertical directions or, from multiple nonvertical directions covering half sphere (2Pi solid angle) with the center of the sphere

in the point of interest. The simulation particle tracing is realized in combined internal (IGRF) and the external geomagnetic field (Tsyganenko 96 or Tsyganenko 05) covering the years 1968 to 2020. We call this Standard simulation module. There is also a module for simulation in an earlier period called Historic simulation module that uses a couple of geomagnetic field approximations for last two millennia (years from 0 to 1968).

The system also contains individual trajectory visualizations for standard modules and a magnetosphere simulation module that allows users to evaluate the magnetic field in the magnetosphere for selected space and time range.

Simulations based on space and time ranges are also available for Standard and Historical cosmic ray trajectories models.

P33 SEARCH FOR PSEUDORAPIDITY FLUCTUATIONS IN HIGH ENERGY NUCLEAR COLLISIONS

Janka Vrláková, S. Vokál, M. Vaľa

Emission of relativistic particles produced in central nuclear collisions in emulsion detector has been studied for different beam energies and primary nucleus - 16O, 20Ne, 28Si, 32S, 197Au and 208Pb. A preliminary study of multiplicity and target dependence of particles fluctuations on pseudorapidity distribution in terms of the quantity Φ has been made. Search for the event-by-event fluctuations of observable Φ and its dependence on the mass and energies of colliding nuclei, and the degree of centrality has been performed. The comparison of experimental data with model predictions has been made.

P34 DEDICATED RUNAWAY ELECTRONS STUDIES AT THE TOKAMAK COMPASS

E. Macúšová, O. Ficker, J. Mlynář, T. Markovic, M. Tomes, J. Cerovsky, J. Caloud, A. Casolari, D. Bren, J. Cavalier, M. Farnik, A. Havranek, M. Hron, P. Kulhanek, M. Marcisovsky, D. Naydenkova, R. Panek, P. Vondracek, V. Weinzettl and the COMPASS team

Runaway electrons (RE) can emerge within a tokamak plasma either at low density, during the start-up or as a result of rapid termination, associated with sudden plasma cooling causing a significant electric field induction. In the presence of strong electric field electrons can reach several tens of MeV (kinetic energy ~ tens of MJ). RE present one of the major concerns for future tokamaks, since their uncontrolled localized RE losses can compromise the integrity of tokamak device and its hinter operation. The fully effective mitigation strategy was not still identified despite the increased effort of the fusion community. Several approaches have to be explored. The COMPASS tokamak is an ideal device for testing such strategies and developing new ones due to its high flexibility, advanced RE feedback, compact size and the high reproducibility of RE scenarios. The main studied mitigation strategies are the injection of impurities and the application of external resonant magnetic perturbations (RMPs). Results dedicated to studies of effects of the combination of mentioned mitigation strategies with emphasis on RMPs will be present and conclusions toward larger devices will be derived.

P35 STATISTICAL ERROR OF FP EQUATION SOLUTION FOR COSMIC RAYS DISTRIBUTION IN THE HELIOSPHERE

Viačeslav Michajlenko, Pavol Bobik

Cosmic rays propagate the heliosphere from interstellar space till orbit of planets and Sun. The problem of their distribution, described by Fokker-Planck equation is solved by a couple of methods, one of the most used is the stochastic method based on Ito lemma.

Presented work is focused on the estimation of statistical error of Fokker – Planck equation solution of the 1D forward stochastic method, for evaluation cosmic rays distribution in the heliosphere. Error dependence on simulation statistics and energy for 1AU is presented. The 1% precision criterium is defined as a function of solar wind velocity and diffusion coefficient value. The systematic error of the FP equation is also discussed.

P36 DIELECTRIC SPECTROSCOPY OF TRANSFORMER OIL-BASED FERROFLUIDS WITH Mn-Zn FERRITE NANOPARTICLES

M. Karpets

Transformers are one of the significant parts of the electrical power system. As the power transmission system is opting for high voltage high power transmission, high performance insulating materials are drawing attention of the electrical power industry. Nanofluids, formed by adding nanoscale particles to insulating oil, are stable and homogeneous suspensions that present

advanced performance of electrical insulation and heat dissipation. Transformer oil-based ferrofluids with Mn-Zn ferrite nanoparticles have been characterized at different concentrations of particles. The dielectric-spectroscopy experiments were performed on the LCR meter in the frequency range up to 2 MHz for different AC and BC voltage. We demonstrate changes in the observed relaxation process by applying el ectric field with different intensity. Dielectric dissipation factor of ferrofluids samples was also compared. The low-frequency relaxation process features observed in experiments was assigned to the electric double layer polarization. How to reduce the negative effect of nanoparticles on dielectric loss of nanofluids, needs to be investigated further.

P37 SUPER-KLEIN TUNNELING OF DIRAC FERMIONS THROUGH ELECTROSTATIC GRATINGS IN GRAPHENE

V. Jakubský

We use the Wick-rotated time-dependent supersymmetry to construct models of two- dimensional Dirac fermions in presence of an electrostatic grating. We show that there appears omnidirectional perfect transmission through the grating at specific energy. Additionally to being transparent for incoming fermions, the grating hosts strongly localized states.

P38 H–FUNCTION CALCULATION FOR SELECTED SPECTRAL BANDS OF OXYGEN

J. Pokorný

The H–function is the most important part for determining the absorption coefficient. This article deals with the calculation of the H–function of selected bands of molecular oxygen. Program calculations are performed on the basis of freely available data from world databases (NIST) and book sources (e.g. Glushko, Rosen) providing the possibility of comparison.

For the structural calculations of oxygen bands, the Orca program, created at the Max–Planck Institute by Frank Nees, et al., was selected. The outputs of this program are used by our program NKrov2, which provides the final mathematical and graphical outputs.

P39 A SETUP FOR MEASUREMENT OF THE TOTAL REACTION CROSS SECTION

I. Siváček

Measurements of energy dependence of the total reaction cross section with exotic, neutron- rich nuclei are used to study the phenomena related to the structure of weakly bound neutrons in neutron halo and neutron skin. A spectrometer „MULTI-2“ for direct measurement of the total reaction cross section with radioactive beams is presented, together with some results obtained on the setup. The spectrometer consists of a multi-detector telescope for the beam projectile identification and a 4π

gamma-ray spectrometer for detection of prompt gamma-rays and neutrons accompanying nuclear reactions. The characteristics of the gamma-ray spectrometer important for the evaluation of the measurements – registration efficiency as a function of energy and multiplicity of emitted gamma rays, spectrometer response and a total energy deposition were evaluated with Monte Carlo method. Results were confirmed by measurement with 60 Co spectroscopic source.

P40 PRESSURE INDUCED SUPERCONDUCTIVITY IN A $CeRhSi_3$ SINGLE CRYSTAL – HIGH PRESSURE STUDY

D. Staško

Pressure-induced superconductivity in $CeRhSi_3$ and $CeIrSi_3$ has attracted a significant attention for unconventional nature of the superconductivity in a non-centrosymmetric lattice. All previous results, however, were limited to maximum 3 GPa of applied pressure. We focus on a high-pressure-region behavior of the pressure-induced superconductivity in $CeRhSi_3$. Our study was performed employing the good-quality Sn-flux-grown single-crystal (electrical current along [110]) and Bridgman anvil cell allowing to apply pressures up to 6 GPa. The initial shift of antiferromagnetic transition to higher temperatures with applied pressure, up to 1.1 GPa; emergence of superconductivity at this pressure; subsequent decrease of Néel temperature and increase of SC temperature with further pressure application were followed. The critical SC temperature reaches a maximum at 2.9 GPa. No signs of magnetic transition are observed. Further application of pressure shifts SC to lower

temperatures, forming a typical SC dome. The superconductivity is expected to be completely suppressed between 5 and 6 GPa. Measurements in magnetic fields revealed a considerable decrease of critical field above 3 GPa, which exceeds the value of 19 T at the top of SC dome. Presented results are summarized in the completed T-p and H-T phase diagrams, complementing previous results.

P41 PHASE DIAGRAMS OF Ce_2Pd_2In INTERMETALLIC COMPOUND

P. Král

Thanks to the specific electronic structure the rare earth-based compounds, especially those containing Yb, Ce or Eu, often exhibit exceptional magnetic properties. In our study we have focused on cerium-based compound Ce_2Pd_2In belonging to the family of R_2T_2X compounds crystallizing in tetragonal Mo_2FeB_2-type structure. Previous studies revealed presence of two magnetic phase transitions ($T_C \approx 4.1$ K and $T_N \approx 4.5$ K) and strong dependence of magnetic ground state on the changes of chemical composition [Giovannini, *Phys Rev B* 2000].

We present the pressure-temperature phase diagrams both for hydrostatic and uniaxial pressure. Hydrostatic pressure acts in the same way on the whole lattice, while the uniaxial one allows to act solely in the chosen direction. The results are put into context with temperature evolution of crystal lattice investigated by low temperature X-ray diffraction. Based on these results, hydrostatic pressure is supposed to act more on the a-parameter, which leads to approaching of atoms in the basal plane, affecting the exchange interactions in the

system and preference antiferromagnetic phase over the ferromagnetic one. On the other hand, the uniaxial pressure acts on the parameter c showing no significant effect on the temperatures of phase transition.

ENHANCING GOLD BY GOLD: PLASMON ENHANCED LUMINESCENCE OF GOLD NANOCLUSTERS ON GOLD NANORODS

Ondřej Pavelka, Klaudia Kvaková, Petr Cígler, Jan Valenta

One of the fundamental features of nanotechnology is that properties of a certain material can be changed just by varying its shape and size. This exactly is the case for the two types of gold nanostructures in our study, where luminescent gold nanoclusters (AuNCs) benefit from the presence of plasmonic gold nanorods (AuNRs). Despite the limited number of atoms, AuNRs with characteristic dimensions ranging from ~10 to 100 nm still retain their metallic properties. Consequently, collective oscillations of the nearly free conductive electrons (so called *localized surface plasmon resonance; LSPR*) can be excited in AuNRs upon interaction with an incoming electromagnetic radiation. In recent years, LSPR has been widely used to enhance the optical performance of other nearby objects (e.g. surface-enhanced Raman scattering or luminescence).

The electronic structure of AuNCs with diameter of ~1 nm is, on the other hand, rather molecular-like, which can result in near-infrared photoluminescence from the nanoclusters.

In the present study, we attempt to increase the radiative rate in AuNCs by coupling their emission to plasmons of AuNRs in a core@shell AuNRs@AuNCs structure. By measuring the changes in luminescence of AuNCs upon attachment to AuNRs we demonstrate that it is indeed possible to enhance gold by gold.

DIELEKTRICKÁ SPEKTROSKOPIA FUNKCIONALIZOVANÝCH KARBÓNOVÝCH NANORÚROK

Jozef Kúdelčík

Štúdium dielektrických parametrov vedie k lepšiemu porozumeniu polarizačných a relaxačných javov v nových materiáloch. Táto štúdia je zameraná na mnohostenné karbónové nanorúrky funkcionalizované magnetickými nanočasticami. Pomocou dielektrickej spektroskopie sa študoval vplyv elektrického poľa na zmeny dielektrických parametrov i štruktúrneho usporiadania MWCNT/Fe_3O_4. Frekvenčná závislosť disipačného faktora sa merala v rámci frekvenčného rozsahu od 10 mHz do 2 MHz v rozmedzí teplôt od 15 °C do 65 ° C pomocou kapacitnej metódy. Analýza nameraných údajov sa uskutočnila pomocou relaxačného Cole-Cole modelu. Pozorované nízkofrekvenčné relaxačné maximum disipačného faktora je vysvetlené Schwarzovou teóriou polarizácie elektrickej dvojvrstvy pričom s teplotou sa posúvalo do oblasti vyšších frekvencií. Elektrické pole vplýva na zmenu elektrického dipólového momentu nanorúrok, nanočastíc a orientáciu v smere elektrického poľa spojenú aj s tvorbou reťazcov.

QUANTUM DOTS GROWN BY METALORGANIC VAPOR PHASE EPITAXY

Eduard Hulicius, Alice Hospodková, Markéta Zíková

This paper focuses on quantum dots (QDs) embedded inside semiconductor heterostructures

prepared by Metalorganic Vapor Phase Epitaxy (MOVPE) technology and is based on our contribution in [1].

Light emission from atoms/molecules in a glass matrix or in gas is strongly monochromatic. Semiconductor direct-bandgap materials have much higher energy conversion efficiency than the other light sources, but they have a broad band or multimode light emission spectra. QDs inside semiconductor heterostructures can fundamentally improve the quality of spectrum, temperature dependencies and also light efficiency emission.

The main technological procedure used for MOVPE preparation of QDs embedded inside the heterostructure is self-assembled Stranski–Krastanov growth mode. Growth procedures and parameters will be briefly described.

Mostly used material combination for embedded QDs is InAs QDs in a GaAs matrix.

Embedded MOVPE-prepared QDs are currently used for semiconductor lasers, optical amplifiers, LEDs and photodetectors. High extinction coefficient of QDs is promising for possible optical applications. QDs can operate like a single-electron transistor and show the Coulomb blockade effect. QDs have also been suggested for quantum information processing. QD technology is relevant to solid-state quantum computation.

DETERMINING THE ALIGNMENT OF THIN MoS_2 LAYERS FROM RAMAN AND GIWAXS MEASUREMENTS

Martin Hulman, M. Sojková, K. Végsö,P. Šiffalovič,N. Mrkývková

Thin MoS_2 layers grown by sulfurisation of Mo films can be aligned horizontally or vertically depending on the initial Mo thickness. So far, the vertical alignment of MoS_2 layers has been detected by TEM measurements. However, TEM provides information only from a very limited area of the sample and requires time consuming and laborious sample preparation. Alternatively, grazing incidence wide-angle X-ray scattering (GIWAXS) can be used for detecting the layer alignment in MoS_2 thin films. Still, this technique is not widely used. We present here that Raman spectroscopy (in combination with GIWAXS measurements) can provide information equivalent to that from GIWAXS or TEM on the layer alignment. Raman spectroscopy is a fast method, easy to use and needs no special sample preparation. We present measurements of the intensity of A_{1g} and E_{2g} lines as a function of the angle between the polarisation of the incident and scattered light in backscattering geometry. From the measurements, a depolarisation ratio for both Raman modes was obtained, showing its distinctive values for the two layer alignments indeed. We demonstrate the method by specifying the alignment of MoS_2 grown on a sapphire substrate partially coated by reduced graphene oxide flakes.

WHAT CAN WE LEARN FROM COMPARATIVE CHARACTERIZATION OF MATERIALS ON THE MACRO- AND NANO-SCALE

Anna Fučíková, Matěj Černý, Helena Valentová, Jan Valenta

The physical and chemical properties of materials tested on the macro- or nano-scale may differ

dramatically. For example, when measuring the Young's modulus of elasticity, we assume an “infinite” depth of material, which is not fulfilled especially when the Young’s modulus is measured at the nano-scale. Another example, the interaction of nanomaterials with biological environment and their toxicity is dependent on properties of individual nanoparticles, such as shape, surface passivation, zeta-potential (surface charge in colloidal state), chemical reactivity etc. and conflicting results about the same nanomaterial toxicity are published quite often. We decided to study those materials with our home-designed micro-spectroscopy setup combined with atomic force microscopy device equipped with several additional modules. In this contribution we would like to present our knowledge about studying various systems at nanoscale and their comparison to bulk measurements. The new field of nano-reconnaissance can help us to understand for example the chemical reactivity of nanoparticles or reasons of secondary inflammatory reactions caused by deformation of proteins in the protein corona formed on the nanoparticle in a living organism.

THURSDAY

PARALLEL SESSIONS: LASERY, FYZIKALNI PLAZMA, TURBULENCE

LASER – PRACOVNÍ NÁSTROJ 21. STOLETÍ

Martin Smrž

Laserové systémy prošly od svého objevení v roce 1960 dlouhou cestu a v posledních letech se stávají stále častěji běžně využívaným pracovním nástrojem. Centrum HiLASE Fyzikálního ústavu se od svého vzniku zaměřuje na vývoj špičkových, zejmna pulsních, diodově buzených pevnolátkových laserů pro moderní průmyslové aplikace. Takové lasery s vysokou účinností, středním výkonem až 1 kW a dobou trvání pulsu v řádu nanosekund až femtosekund jsou schopny zajistit v průmyslových podmínkách výrobu rychlých polovodičových čipů, zvýšit životnost a spolehlivost leteckých součástek, vrtat vysoce přesné otvory pro moderní motory, vytvořit funkční a antibakteriální povrchy na řadě materiálů a mnoho dalších.

Centrum Hilase v současné době disponuje laserovou technologií na bázi tzv. tenkých disků, kdy laser využívá výhody účinného chlazení velkoplošných krystalů s tloušťkou pouze stovek mikrometrů, popř. technologií kryogenně chlazených keramických desek pro pulsy s vyšší energií. Základní emisní oblast v okolí 1030 nm může být technikami nelineární optiky rozšířena do viditelné i střední infračervené oblasti. Přednáška shrne stav vývoje v laserovém centru HiLASE.

VÝZKUM FÚZNÍHO PLAZMATU VE VÝBOJÍCH PLAZMOVÉHO FOKUSU

Pavel Kubeš, Marian Paduch, Marek Jan Sadowski, Jakub Cikhardt, Daniel Klir, Jozef Kravarik, Karel Rezac, Krzysztof Tomaszewski, Roch Kwiatkowski, Ewa Zielinska

V plazmovém fokusu je husté a horké plazma vytvářeno kompresí proudu procházejícího plazmatem vlastním magnetickým polem. Prezentované výsledky vedoucí v deuteriové náplni k fúzní DD reakci byly prováděny v IPPLM ve Varšavě na aparatuře PF-1000, která dosahuje°neutronový zisk 10^{11} A při proudu 1 – 2 MA. Na aparatuře je využívána komlexní rentgenová, laserová, částicová a neutronová diagnostika. Interpretace publikovaných výsledků prokázala existenci organizovaných toroidálních a sférických struktur v komprimovaném sloupci a jejich vývoj. K produkci fúzních neutronů dochází při vzniku a zániku těchto strurtur o hustotě 10^{24} - 10^{25} v m^{-3} a teplotách 50 -200 eV. Tyto struktury a jejich vývoj jsou vysvětleny pomocí uzavřených proudů s poloidní a toroidální komponentou a jejich vzájemnou přeměnou. Magnetická pole jsou generována principem magnetického dynama, podobně jako v planetách nebo ve hvězdách. Fúzní neutrony vznikají srážkami rychlých deuteronů o energiích stovek keV s klidovými deuterony. Mechanismus urychlení těchto částic je netepelný a v prezentaci je vysvětlen na principu rekonekce magnetických silokřivek filamentárních proudů. Prezentované výsledky jsou porovnávány s pozorováním energetických částic v tokamakovém, laserovém a astrofyzikálním plazmatu.

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PLASMALAB@CTU - NEW FACILITIES IN SUPPORT OF FUSION EDUCATION

Jana Brotánková, Jan Mlynář, Miroslav Pfeifer, Vojtěch Svoboda

The contribution focuses on a new plasma laboratory, currently in commissioning phase. Its aim is to provide doctoral and undergraduate students as well as non-fusion experts with hands-on experience and support for their experimental research relevant to modern fusion technology. The laboratory consists of four main sections: Electric and magnetic fields, Plasma, Optics, and the GOLEM tokamak [1]. All the experiments support remote control operation as much as feasible. The contribution will present the technical solutions of the particular experiments and first measurements.

[1] O. Grover et al., Fusion Eng. Design 112 (2016) 1038-1044

ANALYZING MYSTERIOUS TURBULENCE

Daniel Duda, Vitalii Yanovych and Václav Uruba

Turbulence is one of the most fascinating phenomena in nature existing from Ångström length-scales (quantized vortices in superfluid helium [La Mantia et al. 2016]) up to galactic scales [Vatistas 2010]. One of the main features

of turbulence is the presence of interacting vortices of various strengths sizes and orientations. But the present description of turbulence is based on statistical analysis of velocities or pressures. The *vortex filament method* is used in numerical simulations of superfluid [Varga et al. 2017] or classical viscosity-damped [Marchevsky 2020] turbulent flows. We introduce the approach of *individual vortices* into experiments. We use the spatially resolved 2D velocity data obtained by using the experimental method Particle Image Velocimetry (PIV) to find the individual vortices in the turbulent field and then we analyze their properties statistically.

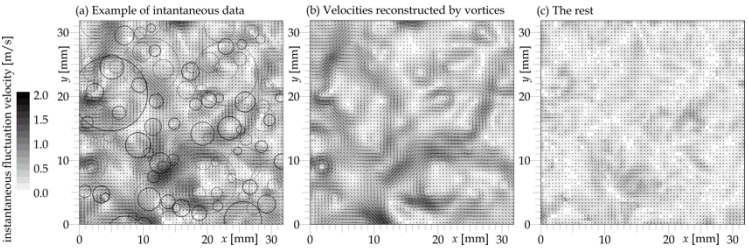

Figure: (a) Example of a single velocity field obtained by the method Particle Image Velocimetry (PIV) with the individual vortices identified by our algorithm. (b) is the velocity field of such vortices and (c) is the remaining not covered by the vortices.

ADVANCED SCANNING PROBE MICROSCOPY OF LOW-DIMENSIONAL MOLECULAR SYSTEMS REVEALING EXOTIC QUANTUM STATES

Pavel Jelínek

Low dimensional materials offer very interesting material and physical properties due to reduced dimensionality. At present, 2D materials are the focus of attention. However, 1D systems often show far more exotic features, such as Tomanaga-Luttinger liquid, Peierls distortion, etc.. In this talk, we will present π-conjugated molecular chains of distinct topological classes formed on metallic surfaces by on-surface synthesis, which physical properties were investigated by low temperature UHV scanning probe microscopy supported by theoretical analysis. We will reveal fundamental connection between topological phase transition and the level crossing driving a variation of the π-conjugation of polymers [1]. The proximity of the quantum phase transition, in principle, allows us to design intrinsically conductive polymers despite of the Peierls distortion.

[1] B. Cierra et al. Nature Nanotechnology. (2020). DOI: 10.1038/s41565-020-0668-7

UNUSUAL PROPERTIES OF PIEZO-RESONATORS AT MILLIKELVIN TEMPERATURE RANGE AND HIGH MAGNETIC FIELDS

Marcel Človečko, Peter Skyba

We present unusual properties of the commercial quartz tuning forks (QTFs) operating at resonance frequencies of 32 kHz, 77 kHz and 100 kHz at temperature range below 1K and in high magnetic fields up to 7.5 T. We show tha in millikelvin temperature range, the quartz tuning forks exhibit the property of the coherent oscillations. These are manifested as a temperature-dependent, extremely accurate tune-up of QFTs resonance frequencies in 9th order with very high frequency stability characterized by the low values of the Allan deviations comparable with those in lasers. Even more, we demonstrate that a normalized resonance frequency of the tuning forks manifests a universal temperature dependence, which is independent on the magnetic field strength. This feature makes the QTFs a very promising low temperature thermometer in high magnetic fields in temperature range below 1 K while having the B/T ratio up to 1000. We also discuss the physical origin of the observed dependencies.

THE MOMENTUM SPECTRUM VERSUS THE PROBABILITY FLUX DIRECTION IN QUANTUM MECHANICS

J. Dittrich

Simple examples that the direction of the momentum, defined by its spectral support in a given state, and the direction of the probability flux may be locally uncorrelated in 1+1 dimensional space-time are given for the Schrödinger and the Dirac particle with non-zero mass. For the zero-mass Dirac particle, they are always correlated.

PHYSICS AT FUTURE EIC EXPERIMENT

Michal Krelina

The future experimental facility EIC (Electron-Ion Collider) that will be built in Brookhaven National Laboratory in the USA introduces new opportunities for precise study in high energy nuclear physics. This contribution is an overview of the author's research related to this topic. Particularly, in this contribution, we focus on topics as nuclear shadowing, quarkonia wave function study, or exclusive and diffractive processes.

The goal is to study various nuclear effects, such as nuclear shadowing. Nuclear shadowing is a phenomenon of depletion of the cross section in comparison with a cross section on the proton target. The situation is more complicated since the interaction is not completely coherent at EIC kinematics, leading to more advanced formalism based on Green functions.

The studied nuclear shadowing is universal and will be applied in fact to most of the processes on nuclear targets such as vector meson (VM) diffractive and, particularly, exclusive production. The goal in such measurement is to study gluon distribution or, generally, the universal gluon Wigner distribution. However, for that, we need to minimize the uncertainty from VM wave

functions by its and its effects detailed study such as quark-antiquark potentials, Melosh spin rotation, or the structure of the VM vertex and the role of the D-wave component.

VZŤAHY MEDZI ELEKTRÓNOVOU ŠTRUKTÚROU A MIKROŠTRUKTÚROU TENKÝCH VRSTIEV POLYFLUORÉNU A KOPOLYMÉRU ZALOŽENÉHO NA FLUORÉNE

Katarína Gmucová, Karol Végsö, Vojtech Nádaždy, Tomáš Váry

V posledných rokoch vzrástol význam syntézy konjugovaných kopolymérov spájajúcich v jednej molekule rôzne monoméry. Takéto materiály nachádzajú široké uplatnenie v mikroelektronike aj vo fotovoltike, keďže ich cielaná syntéza umožňuje nielen vhodné nastavenie šírky zakázaného pásu, ale aj zvýšenie účinnosti konverzie slnečného žiarenia na elektrickú energiu spojením monomérov s dierovou a elektrónovou vodivosťou do jednej molekuly. Aj keď v organických polovodičoch dominujú molekulové vlastnosti nad štruktúrnymi, vzťahy medzi mikroštruktúrou tenkých vrstiev kopolymérov a ich elektrickými vlastnosťami sú silné a stále nie plne pochopené. V tomto príspevku porovnáme elektrónovú štruktúru a mikroštruktúru tenkých vrstiev modelového homopolyméru a kopolyméru syntetizovaného na jeho základe. Metódami ER-EIS a GIWAXS budeme analyzovať vplyv žíhania na vlastnosti vrstiev, menovite na ich elektrónovú štruktúru a kryštalinitu.

MAGNETIC, MAGNETOCALORIC, THERMAL AND TRANSPORT PROPERTIES OF $Gd_3Ni_2In_4$

K. Arun, T.P. Rashid, **Marian Reiffers**, Andrea Dzubinska, R. Nagalakshmi

The new polycrystalline intermetallic compound $Gd_3Ni_2In_4$ has been prepared. We have investigated the structural, magnetic, magnetocaloric, thermodynamic and transport properties. X-ray powder diffraction pattern displays that $Gd_3Ni_2In_4$ crystallizes in hexagonal $Lu_3Co_2In_4$ – type of crystal structure. The presence of two magnetic transitions, antiferromagnetic $T_N = 21$ K and ferromagnetic T_C at 55.5 K was observed in magnetization studies. The maximal value of magnetic entropy change, $-\Delta S_M$, determined from isothermal magnetization data in a magnetic field of 9 T is 4.57 J/kg K, which is spread over a wide temperature range (ΔT = 61.5 K) and hence it yields to a relative cooling power (RCP) of 281 J/kg. In addition, the compound shows a significant positive magnetoresistance, MR (T = 2 K) = 44 % in magnetic field B = 9 T. Taking into account these results one could conclude that $Gd_3Ni_2In_4$ compound is exhibiting successive reversible magnetic transitions. Thus, it may comprise a distinct class of magnetocaloric materials as they work in a wider temperature range than conventional refrigerant materials.

MICROSCOPIC ORIGIN OF LINEAR MAGNETO-OPTICAL EFFECT IN BCC Fe

Ondřej Stejskal, Martin Veis, Jaroslav Hamrle

We present analysis of microscopic origin of magneto-optical spectra from the electronic structure of bcc Fe. The magneto-optical (MO) permittivity spectra are obtained by the WIEN2k code and compared to the corresponding experimental MO Kerr effect spectra. The ab-initio spectra are given by the Kubo formula, i.e., as a result of summation over all pairs of electronic bands and integration over the Brillouin zone that all sum up to the single MO spectrum. We investigate what features of electronic structure contribute to the outgoing total MO spectrum. We have also developed several novel ways of visualizing MO-related phenomena in the Brillouin zone.

It turns out that strong MO signal comes from several isolated k-points in the Brillouin zone, where the band degeneracy is avoided by the spin-orbit interaction. There are two major types of MO contributions determined by the nature of the avoided degeneracy (given by topology of the approaching bands), that contribute differently to the total MO spectrum. Both types are visualized and their contributions to the total spectrum are demonstrated in the form of local MO spectra.

ELECTRICAL TRANSPORT PROPERTIES OF $Ni_{1.92}Mn_{1.56}Sn_{0.52}$ MAGNETIC SHAPE MEMORY MATERIAL

Jiří Kaštil, Jiří Kamarád, Olivier Isnard

The $Ni_{1.92}Mn_{1.56}Sn_{0.52}$ belongs to a family of Heusler alloys with peculiar magnetic, structural and transport properties that can be potentially useful for applications. They show structural transition from high temperature cubic austenite (A) to low temperature orthorhombic martensite (M) with significant changes of

volume, magnetization, resistivity and Hall effect. We have performed study of temperature dependence of electrical resistivity, Hall coefficient and heat conductivity of $Ni_{1.92}Mn_{1.56}Sn_{0.52}$ in temperature region between 4 K and 400 K. The ferromagnetic ordering accompanied by sharp change of resistivity T-derivative was established below T_C = 320 K. Structural A-M transition at cooling, T_{A-M} = 282 K, induces a large increase of resistivity and vice versa, M-A transition at heating, T_{M-A} = 294 K, induces a decrease of resistivity. It is worth to note that A-M transition is associated with transition from ferromagnetic austenite to martensite with almost zero magnetization. The re-entrance of magnetization at T_c = 235 K is accompanied with any resistivity anomaly. The maximum of resistivity around 150 K is followed by a shallow T^2 resistivity dependence. An unusual character of temperature dependence of the Hall effect points to dramatic changes in electronic structure during the structural transition.

WIDE TEMPERATURE RANGE MAGNETOCALORIC EFFECT IN $Dy_{6.5}Co_2Si_2$

K. Arun, T. P. Rashid, Ivan Curlik, **Sergej Ilkovic**, Marian Reiffers, Andrea Dzubinska, R. Nagalakshmi

We report that this alloy has been formed in three phases Dy_5Si_3, $Dy_3Co_{2.2}Si_{1.8}$, and Dy_3Co with four successive magnetic transitions. The important role in the magnetic behavior plays competing ferromagnetic and antiferromagnetic interactions in the alloy. The number of successive magnetic transitions together with competing magnetic interactions exhibit broadened magnetocaloric effect (MCE) peak with temperature width of ΔT = 83.8

and 93.2 K and consequently a large RC value of 474 and 739 J/kg, for a magnetic field change of 0–5 and 0–7 T, respectively.

NIHILNOVI – A NOT SO NEW APPROACH TO DATA VISUALISATION PROMOTING PORTABLE AND SIMPLE TEXT FORMATS

F. Dominec

With an aim of promoting open-source software and text files for data storage and processing, the author presents a program [1] that attempts to resolve the less-than ideal situation in this field.

The usual approach is to either load the data into a point-and-click application for scientific plotting, or learn basics of programming and type the commands in a scientific math package. However, manually handling larger or repeated datasets is inefficient. Programming languages are inappropriate for trivial or interactive tasks. Less advanced programs re-implement only a fairly limited subset of mathematical or graphical functions used in science today. More advanced ones often bind the researcher to one particular proprietary software and data formats.

The major novelty of the program is paradoxically in that it does almost *nothing new*: It does *not* implement a new plotting library, nor does it promote its custom scripting language – Python/Matplotlib/Numpy is already a popular environment for data processing.

The talk will be practically focused, with several use cases where the concept of doing (almost) nothing new to achieve great results will be illustrated.

[1] F. Dominec: Nihilnovi source code repository (2020,11th May), retrieved from https://github.com/FilipDominec/nihilnovi

APPLICATION OF MACHINE LEARNING IN SINGLE CRYSTAL GROWTH

František Hájek, Jiří Oswald, Alice Hospodková, Filip Dominec, Robert Horešovský

Development of a new material with required properties is a very complex task. Theoretical models for growth procedure are usually not available, at least at the beginning. Therefore, many attempts are made to achieve required properties of the material and many characterization datasets are obtained. However, the way how the physical properties of the material are affected by the growth conditions does not have to be straightforwardly evident. For such a case, machine learning can be very helpful. In this contribution, applications of several simple machine learning approaches are applied to the development process of the InGaN/GaN scintillator structure. A properly trained neural network is capable to predict luminescence properties from the growth parameters of the structure. This enables optimization of the growth parameters from empirical data only. On the other hand, understanding of underlying physics is not guaranteed but the predictions of the model can give a clue.

IMPACT OF MACROSCOPIC PARTICLE COMPOSITION ON GaN EPITAXIAL GROWTH MORPHOLOGY AND LUMINESCENCE

K. Kuldová, F. Dominec, R. Novotný, S. Sayedová, F. Hájek, A. Hospodková

We describe macroscopic defects on InGaN/GaN multiple quantum well structures caused by accidental contamination with dust particles during the metalorganic vapour phase epitaxy. Gallium nitride and InGaN/GaN heterostructures are promising materials for many optoelectronic devices, such as light emitters, high power and high-frequency electronics, detectors of ionizing radiation, scintillators. During the preparation of these structures, great attention is paid to optimization of the growth parameters and to reduce the density of dislocations and point defects in this material. However, only a small number of studies were performed on macroscopic defects due to particles fallen from the reactor chamber or scratches from substrate polishing. Understanding the impact of each of the contaminating elements is not only important for sample diagnostics, but it also provides insight into the complex physical and chemical processes during epitaxy.We focus on the influence of macroscopic defects on photoluminescence of GaN/InGaN multiple quantum well structures and present a Raman spectroscopy study of macroscopic defect containing regions of the samples.

MULTIPLE QUANTUM CRITICAL POINTS IN Ce_3PtIn_{11}

J. Fikáček, M. Hrůzová Kratochvílová, K. Uhlířová, S. Kambe, H. Sakai, Y. Tokunaga, T. Hattori, N. Higa, R.E. Walstedt, M. Brando, **J. Custers**

The properties of the heavy fermion compound Ce_3PtIn_{11} are rather enigmatic. Not only the compound possesses two inequivalent Ce-sites but at ambient pressure it exhibits two successive antiferromagnetic

(AFM) transitions at T_1 = 2.2K and T_N = 2K, respectively [1]. Upon further cooling superconductivity is found with T_c = 0.32K. Entropy analysis conjectured the idea that the Ce2-ions are responsible for the magnetic ordering whereas the second Ce1-ions evokes superconductivity. Here we present our recent ^{115}In NMR/NQR and specific heat results. From these we infer that Ce_3PtIn_{11} possibly harbors two quantum critical points (QCP) i.e., zero temperature phase transtitions – one close to/or at ambient pressure [2] and one to be reached by an applied hydrostatic pressure of p_c = 1.5GPa [1]. Each QCP can be associated with a particular Ce-site. The critical magnetic fluctuations accompanying the QCPs are at the origin of Cooper-pairing.

This work was supported by the Czech Science Foundation (GAČR) Grant No. 18-23606S, the EU COST Action CA16218 and by the Czech Ministry of Education under the COST project scheme, project No. LTC18024.

[1] J. Prokleška *et al.,* Phys. Rev. B **92,** 161114(R) (2015).
[2] S. Kambe *et al.,* Phys. Rev B. **101,** 081103(R) (2020).

OPEN CHARM AND CHARM-TAGGED JETS PRODUCTION WITH ALICE AT LHC

Jakub Kvapil for the ALICE collaboration

Charm quarks are mostly produced in hard partonic scattering processes in the early stages of a heavy-ion collision, before the quark-gluon plasma (QGP) is formed. Because of their large mass the production cross section can be calculated using perturbative quantum chromodynamics down to zero transverse momentum. Therefore, they are ideal probes of the properties of this hot, dense, and strongly interacting medium.

Measurements of heavy-flavour tagged jets bring more relevant information of the initial parton kinematics than traditional hadron measurements and can provide information on heavy-quark energy loss in the QGP, in particular on how the radiated energy is dissipated in the medium. Moreover, the study of charm-baryon production in heavy-ion collisions provides unique information on hadronization mechanism.

This talk focuses on the latest results of charm-tagged jets and open charm production with the ALICE detector at the LHC.

OTEVŘENÁ DATA LHC EXPERIMENTU ATLAS

Jiří Chudoba

Experimenty na největším světovém urychlovači LHC v mezinárodní laboratoři CERN zaznamenávají

velké množství dat ze srážek protonů a těžkých iontů. Tato data jsou ukládána ve speciálních formátech a procházejí několika kroky zpracování, než jsou vhodná pro fyzikální analýzu. Část zpracovaných dat byla některými experimenty uvolněna pro všechny zájemce. Spolu s daty jsou k dispozici i nástroje pro jejich zpracování a detailní dokumentace postupů a objasnění používaných pojmů. Na veřejně dostupných datech experimentu ATLAS ukážu možnosti jejich využití pro propagaci oboru i pro verifikaci některých výsledků nezávislými experty.

ALICE ITS UPGRADE

Isakov Artem for the ALICE Collaboration

The ALICE Inner Tracking System detector is undergoing a major upgrade in order to cope with the increased data rates and to meet the requirements as set out by the physics goals of the experiment after Long Shutdown 2. The new ITS will be completely made up of ALPIDE monolithic active pixel sensors based on a CMOS 180nm process. A single sensor measures 15mm x 30mm and contains half a million pixels distributed over 512 rows and 1024 columns. These 50um thick sensors, with 27um x 29um pixel pitch, are mounted on ultra-lightweight carbon composite support structures with an embedded cooling system. This results in a considerable reduction of the material budget (down to 0.35% X_0 for the inner layers and ~1% X_0 for the outer layers) and a significant improvement of the impact parameter resolution and tracking efficiency. The innermost ITS layer will be moved as close as 23mm to the interaction point. The integration of the ITS detector assembly, made of the three innermost

and four outermost layers, has been almost completed and the commissioning, first in the laboratory, is ongoing. The detector will be installed in ALICE in 2020. This talk will give a brief overview of the motivation for the upgrade and will present the first results of the detector performance obtained during the commissioning.

NOVEL HIGH-LUMINOSITY FIXED-TARGET EXPERIMENT AT THE LHC

Barbara Trzeciak

Extraction of the multi-TeV proton and lead LHC beams with a bent crystal or by using an internal gas target allows one to perform the most energetic fixed-target experiment ever. pp, and pA collisions at collision energy of 115 GeV and Pbp and PbA collisions at 72 GeV can be studied with high precision and modern techniques over a broad rapidity range. Using the LHCb and ALICE detectors in a fixed-target mode offers unprecedented possibilities to study, among others: the quark, gluon and heavy-quark content of the nuclei in the poorly known region of the high-momentum fractions, heavy-flavour production in a new energy domain, half way between the SPS and RHIC.

In this talk, the technical solutions to obtain a high-luminosity fixed-target experiment at the LHC will be reviewed and their possible implementations with the ALICE and LHCb detectors will be discussed. Projection studies for various observables such as Drell-Yan, charm, beauty and quarkonium production, with both detector set-ups used and with various nuclear targets and the LHC lead beams will be presented.

THURSDAY

PLENARY TALKS: FYZIKA PEVNÝCH LÁTOK

HIGHLIGHTS IN PHYSICS OF TWO-DIMENSIONAL CRYSTALS THROUGH CRYOMAGNETIC OPTICS

Jana Vejpravova

The discovery of graphene – the archetype two-dimensional (2D) system, stimulated the frantic pace of research in the area of 2D materials (2DM). The rapid progress of the field, particularly in the growth technologies, is enabling expanding the research interests in other 2DM with outstanding optical, transport, magnetic and other properties giving rise to a plethora of tailored functionalities. Looking beyond the flatland, the 2D slabs can also be reassembled into designer heterostructures made layer by layer in a precisely chosen sequence. Such heterostructures (often referred to as 'van der Waals') reveal unusual properties driven by the stacking and mutual orientation of the 2D building blocks. In my talk, I will review the current state of knowledge on the most topical areas of 2DM research. First, the stacking phenomenon responsible for numerous exotic states ranging from superconductivity to Mott metal-insulator transition will be discussed. Next, the phenomenon of 2D magnetism will be revisited and I will review the limits imposed on boosting the material's properties given by the Mermin–Wagner theorem. Finally, several recent experimental reports will be highlighted and future prospects in the field of 2DM will be outlined.

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