Abstract book

Danish Physical Society Annual meeting 2023

Monday 13. November

Prof. Dorthe Dahl-Jensen,
“Greenland Ice Cores Tell Tales on Past Sea Level Contributions”

Session 1a - NICE national meeting 1, Chair: Ian Bearden

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W. Wu, "Probing partonic collectivity in pp and p-Pb collisions"

V. Goumare, "Search for off-shelf ALPs in the ATLAS"

S. Jia, "FoCal-H Readout"

J.B. Hansen, "ATLAS Upgrade"

Session 1b - Quantum light/matter interactions, Chair: Morten Bache

M. Eriksen, "Optoelectronic control of Atomic Bistability with Graphene"

J. A. Nielsen, "DASQ: A Photon-based quantum computing test bed"
S. Ebel, "Inelastic electron scattering at a single-beam structured light wave"

Session 2a - Ultrafast Physical Chemistry with X-ray lasers +
"Atomkraft Ja-Tak", Chair Kristoffer Haldrup

V. Markmann, "Ultrafast Solvation Process in Aqueous Solution"

B. L. Hansen, "Structural characterization of [Fe(tpy)2]2+ derivatives using X-ray Scattering"

C.K Ravn, presenting the "Atomkraft Ja-Tak" project

Session 2b - Experimental methods & detection 1, Chair: Ian Bearden
M. N. Larsen, "A hyperspectral thermal imager based on a low order scanning Fabry-Pérot interferometer"
R. Turtos, "Scintillation and optically stimulated luminescence in the context of medical imaging"
L. Dufke, "Forward Hadronic Calorimeter for ALICE at the LHC"

KIF Prize winner presentation

General Assembly of the DFS

Discussion session: Energy for the Future -- Asc. Prof. Gorm Bruun Andresen (Aarhus Uni.) and Prof. Hans P. Beck (Uni. of Bern)

Tuesday 14. November

Prof. Marco van Leeuwen,
“Understanding the Quark-Gluon Plasma with ALICE at the LHC”

Session 3a - Medical Physics, Chair: Sofie Gregersen

"DSMF – who we are and what we do", S. Damkjær & S. Gregersen

M. Jokivuolle, "See what you treat: the MR-Linac in cancer treatment and research"

C. Nielsen, "Towards measuring the biological effect of proton therapy in 2D"

T. Andersen, "Long-axial Field of View PET. Bigger and better."

S. Gregersen, "X-rays in cardiology - Protection through shielding and behaviour"

Session 3b - Computational Physics, Chair: Verena Markmann
L. Hedemark, "A GraphNeT Attempt at Classifying Low-Energy Tau Neutrinos in the IceCube Upgrade"
B. Schmidt, "Algebraic iterative reconstruction techniques for fast-ion loss detector data analysis"
E. Fangel-Lloyd, "Building a Monte Carlo particle code to simulate atmospheric electric discharges in 3D"
K. T. Pedersen, "Study of Nuclear Reactor Core Stability During Load Follow Operations with ROM Methods"

Asc. Prof Manuel Meyer,
"Light on the Other Side of the Wall: A New Era for the Search of Axions and Axion-like Particles"

Session 4a - NICE national meeting 2, Chair: You Zhou

O. Trinhammer, "Mass and Matter - structures behind the standard model"

M. Petersen, "Transverse momentum and pseudorapidity flow vectors in p-Pb collisions

A. Acharyya, "Astronomy at the highest photon energies"

C. Köhn, "Magnetic monopoles in two dime dimensions"

Session 4b - Experimental methods & detection 2, Chair: TBD

J. Schou, "Martin Knudsen – a pioneer in gas flows"

M. Salim, "Novel instruments for absolute vapor pressure measurements"

M. L. Jensen, "Advanced 3D Dosimetry for Radiation Therapy Using Optically Stimulated Luminescence"

Invited Talks

Greenland Ice Cores Tell Tales on Past Sea Level Contributions

Dorthe Dahl-Jensen
Centre for Earth Observation Sciences, University of Manitoba, Canada and the Niels Bohr Institute, University of Copenhagen, Denmark

The Greenland Ice Sheet is reacting to climate change and is losing progressively more mass every year. One of our challenges in the future is to adapt to rising sea levels. Looking into the past provides knowledge on how the ice sheets react to changing climate, and this can be used to improve future predictions of sea level rise. The deep ice cores from Greenland contain information on past climate that goes back more than 130,000 years, telling tales about past abrupt climate and sea level changes.

The last interglacial, 130,000 to 115,000 years before present, is a key analogue for future climate. At this time, climate was 5ºC warmer over Greenland, and global sea level was 6-9 m higher than present. All the ice cores from Greenland show that the ice sheet survived, making only a modest contribution to global sea level rise of approximately 2 m at this time. Besides from contributions to sea-level rise from Greenland there must have been contributions from Antarctica.

Finally results from the present deep ice core drilling project, EGRIP, will be presented. The EGRIP ice cores are drilled in the Northeast Greenland Ice Stream (NEGIS) with the purpose of learning about ice stream flow. 50% of the present mass loss from the Greenland ice sheet is from discharge from the ice streams and it is a knowledge gab how the ice streams will adjust to the future warmer climate.

Understanding the Quark-Gluon Plasma with ALICE at the LHC

Marco van Leeuwen
Professor, National Institute for Subatomic Physics (Nikhef), Amsterdam and spokesperson for ALICE at CERN

Collisions of lead nuclei at high energy in the Large Hadron Collider (LHC) at CERN provide a unique opportunity to study the 'condensed matter physics' of quarks and gluons, the fundamental particles of the strong interaction, which are normally bound in hadrons. In these collisions, temperatures of around 1012 K are reached, and a plasma of quarks and gluons is formed, under conditions that are comparable to those of the universe briefly after the Big Bang. I will present highlights of the experimental study of the Quark-Gluon Plasma by ALICE at the LHC, showing how we use experimental results to determine the temperature and flow fields in the collisions, as well as the transport properties of the plasma. I will also briefly outline our plans for new studies of the Quark-Gluon Plasma with the recently installed detector upgrades in the ongoing Run 3 of the LHC, as well as our future plans.

Light on the Other Side of the Wall: A New Era for the Search of Axions and Axion-like Particles

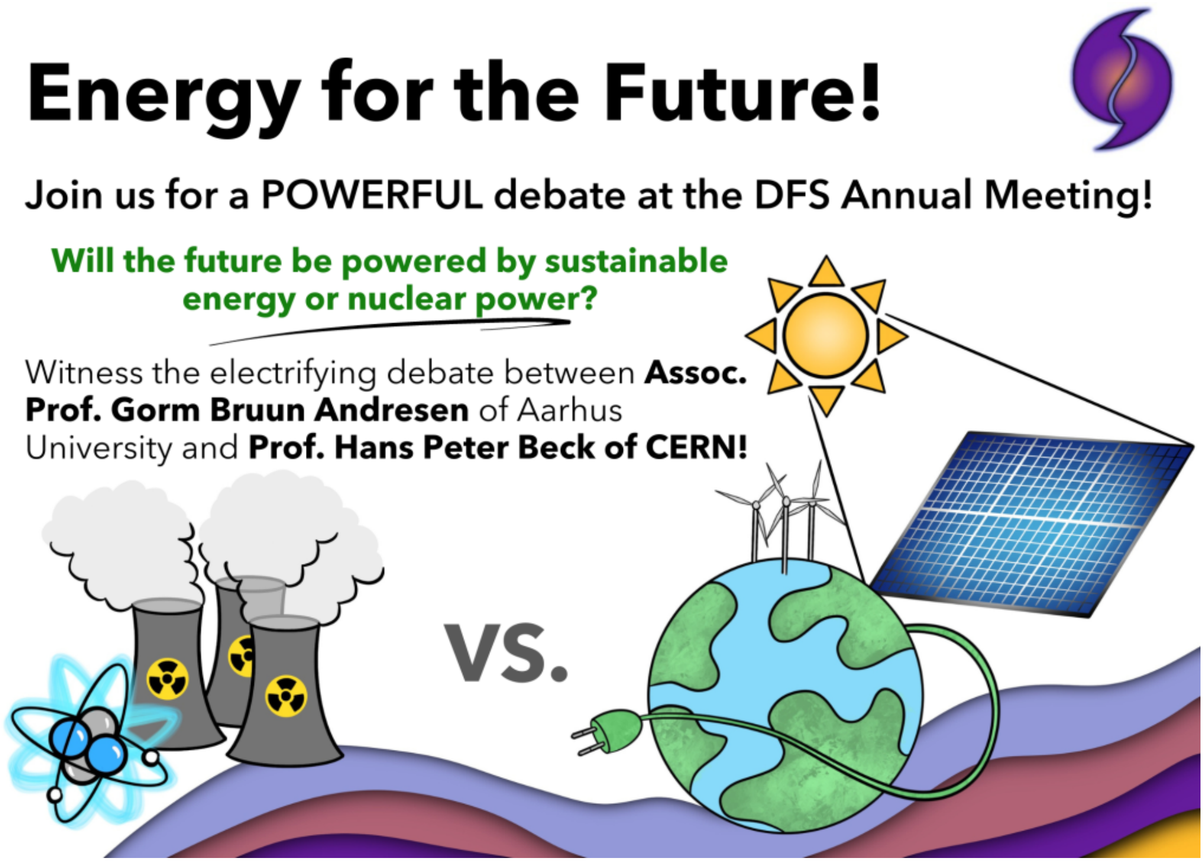
Manuel Meyer
Associate Professor, Department of Physics, Chemistry and Pharmacy, University of Southern Denmark

Astrophysical observations provide overwhelming evidence for the existence of dark matter, which should make up more than 80% of all matter in the Universe. Yet, even after almost a century, we still lack a an understanding of what this substance is made of. One possibility is that it is comprised of so-far undetected fundamental particles. One such candidate is the axion, or more generally axion-like particles, which would also explain the non-observation of an electric dipole of the neutron. Earlier this year, the Any Light Particle Search II (ALPS II) experiment started its first science run. ALPS II is a light-shining-through-the-wall type experiment which will have unprecedented sensitivity for the production and sub-sequent detection of axions. In this talk, I will introduce the experiment. In particular, I will focus on future capabilities and recent characterization results of the superconducting single photon detector foreseen for a later science run. If time permits, I will also highlight how we can use astrophysical observations to search for axions.

Discussion Session: Energy for the Future

Gorm Bruun Andresen
Associate Professor, Department of Mechanical and Production Engineering, Aarhus University

Hans Peter Beck
Professor, University of Bern



Session 1a - NICE national meeting 1, Chair: Ian Bearden

Probing partonic collectivity in pp and p--Pb collisions

Wenya Wu

Copenhagen, Copenhagen, Denmark

Abstract

Long-range azimuthal angle correlations of the produced particles have been observed in high multiplicity proton$--$lead (p$--$Pb) and proton$--$proton (pp) collisions, indicating the presence of collective effects in small systems. The origin of these effects is the subject of intense debate.

In this talk, we present the measurements of v_{n} of charged particle pairs and identified hadrons as a function of multiplicity and $p_{\rm T}$ in p$--$Pb and pp collisions at $\sqrt{s_{\rm{NN}}}$= 5.02 TeV and $\sqrt{s}$= 13 TeV, respectively. The non-flow contributions are significantly suppressed by the use of forward detectors, allowing a large pseudorapidity separation of the correlated particles up to $|\Delta \eta|$~8. In addition, the template fit method is applied to further suppress the non-flow contamination in the measurements of v_{n}. These results show the evolution of the anisotropic flow with the event multiplicity in small collision systems. It is observed that the splitting between v_{n} of baryons and mesons gradually decreases as the event centrality increases. Comparison with hydrodynamic model calculations indicates that the relative contributions from the quark-coalescence mechanism decrease towards lower multiplicity p$--$Pb collisions.

Search for off-shell ALPs in ATLAS

Vincent Goumarre

Aarhus Universitet, Aarhus, Denmark

Abstract

An Axion Like Particle (ALP) is a Dark Matter candidate, but its expected small mass makes it difficult to detect in resonance searches at the LHC. However, it is possible to search for ALPs as off-shell mediators in s-channel processes. We report results based on ATLAS measurements of differential cross-section of pp->Zγ and pp->WW production. This study leads to new constraints on the allowed parameter space in the context of an effective field theory model for ALPs with mass smaller than 100 GeV.

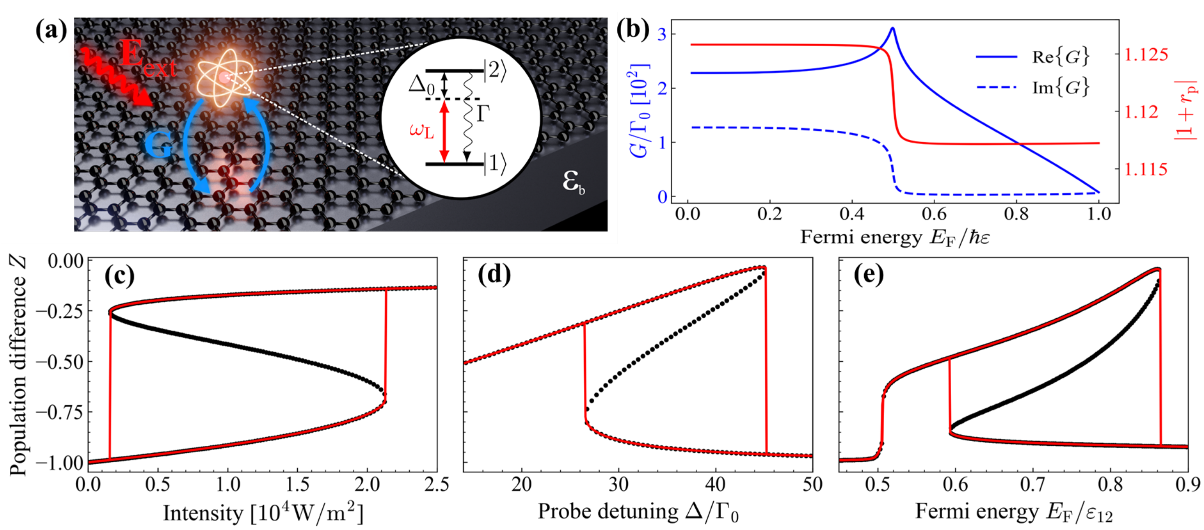
Optoelectronic Control of Atomic Bistability with Graphene

Mikkel Have Eriksen[1], Jakob Emil Olsen[2], Christian Wolff[1], Joel D. Cox[1]

[1]POLIMA—Center for Polariton-driven Light–Matter Interactions, University of Southern Denmark, Odense, Denmark. [2]SDU NanoSyd, University of Southern Denmark, Odense, Denmark

Abstract

Highly doped graphene— the single atom-thick carbon layer— possesses long-lived and actively tunable plasmonic resonances that can significantly enhance near-field coupling. However, these resonances are limited to the IR and THZ spectral ranges, below the operational frequencies of typical quantum emitters. Here we explore the optical bistability emerging from the self-interaction of an atom mediated by the interband transition in an extended sheet of highly-doped graphene. Such interband transitions occur at frequencies above the plasmonic resonance, which allows for coupling to quantum light sources such as rare-earth erbium ions. Our theoretical framework takes into consideration the coupling of the atom to the electromagnetic vacuum modes and the self-interaction of the driven atom, which we demonstrate are sensitive to the actively tunable interband transition. Bistability and hysteresis of the graphene-atom hybrid system manifest in different observables such as the average radiation power, quantum statistics, and resonance fluorescence spectrum of the light emitted by the atom, which exhibits Mollow triplets or Rayleigh peaks in the spectrum when traversing the hysteresis loops. The transitions between the different quantum states cause abrupt quench or creation of the Mollow triplets, reminiscent of first-order phase transitions in thermodynamics. As these transitions are approached, the system experiences critical slowing down to steady state. This system consisting of a driven atom coupled to a nanophotonic environment offers a platform for experimental investigations of driven quantum emitters, while also opening for exploration of active and in situ manipulation of quantum states in integrated nanophotonic platforms.



Center for Polariton-driven
Light-Matter Interactions

DASQ: A photon-based quantum computing test bed

Jens A H Nielsen[1], Emil E. B. Østergaard[1], Oscar C. Boronat[1], Zhenghao Liu[1], Abhinav Verma[1], Niklas Budinger[1,2], Olga Solodovnikova[1], Axel Bregnsbo[1], Jonas S. Neergaard-Nielsen[1], Ulrik L. Andersen[1]

[1]DTU Physics, Lyngby, Denmark. [2]JGU Physics, Mainz, Germany

Abstract

In 1957 the first Danish computer saw the light of day. This device was called DASK (Dansk Aritmetisk Sekvens-Kalkulator). Though outdated today, the DASK computer was one of the fastest computers of its time, being able to do an addition in 56 microseconds. Inspired by this, we at the quantum physics and information technology group at DTU have decided to build the DASQ (Dansk Alsidig Samplet Kvantecomputer) platform, envisioned to be a flexible platform for testing various noisy intermediate-scale quantum (NISQ) algorithms. Being a photon-based platform, DASQ is based around 8 spontaneous parametric down-conversion (SPDC) based squeezed light sources that can be configured to run computations in three different configurations. The first configuration is a small- scale Gaussian boson sampler using six of the squeezers to feed a universal 6 x 6 spatial interferometer with optional homodyne detection or pseudo photon-number-resolving measurements at the outputs. This configuration will be cloud configurable allowing remote researchers to access and run algorithms on the system. The second configuration uses two squeezed light sources to encode a time-multiplexed, two-dimensional cluster state and implement a measurement-based Gaussian boson sampling algorithm. This configuration will be larger in scale, but less programmable compared to the first configuration. The final configuration will use all 8 squeezed light sources to encode a four-dimensional cluster state allowing tests of surface error-correcting codes.

Inelastic electron scattering at a single-beam structured light wave

Sven Ebel[1], Nahid Talebi[2,3]

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Abstract

In free space, electrons undergo inelastic scattering in the presence of ponderomotive potentials generated by light pulses and standing light waves.The findings of this study demonstrate that inelastic scattering of a slow-electron wavepacket can be observed when it interacts with a propagating pulsed Hermite-Gaussian light beam. The pulsed Hermite-Gaussian beam creates a ponderomotive potential for the electron, leading to inelastic scattering and the subsequent formation of discrete energy sidebands. The resulting energy-gain spectra after the interaction are strongly influenced by the selfinterference of the electron within this ponderomotive potential. This effect can be observed across various wavelengths, and the energy modulation can be controlled by adjusting the electron velocity and light intensity.

Session 2a - Ultrafast Physical Chemistry with X-ray lasers + "Atomkraft Ja-Tak", Chair Kristoffer Haldrup

Ultrafast Solvation Process in Aqueous Solution

Verena Markmann, Kristoffer Haldrup

DTU, Lyngby, Denmark

Abstract

This contribution will concentrate on the dynamics of solvation processes in water. Motivated by the influence of environmental conditions on chemical processes in biochemistry, meteorology or photo-physics, we explore the inter-molecular structure of the solvent closest to the solutes, a region known as the solvent shell. Upon photo-excitation, both structural changes of the solutes as well as a redistribution of charges for excited electronic states will influence the structure of the solvent shell. A combined approach from molecular dynamic simulations and experimental scattering enables insight into the relationship between structure and function.

Time-Resolved X-ray Solution Scattering (TR-XSS) experiments observe the direct fingerprint of structural dynamics in solution. The development of free electron lasers has pushed this technique into the ultrafast regime, capable of providing insight into chemical dynamics with a sub-nanometer resolution on a femtosecond timescale. In this talk the TR-XSS technique will be the main tool for examining aqueous halide systems and aquated, small Fe-centered molecules, demonstrating a variety of solvation processes in water and the sensitivity of the scattering probe to molecular structures.

Structural characterization of a series of $[Fe(terpy)_2]^{2+}$ derivatives using X-ray Solution Scattering

Bianca Laura Hansen[1], Kristoffer Haldrup[1], Verena Markmann[1], György Vanko[2]

[1]Technical University of Denmark, Department of Physics, Kgs. Lyngby, Denmark. [2]Wigner Research Centre for Physics, Budapest, Hungary

Abstract

The $[Fe(terpy)_2]^{2+}$ (terpy = 2,2':6',2''- terpyridine) is a photoswitchable model complex exhibiting interesting tunability quintet properties when substituting different electron withdrawing or electron donating groups on the 4' position of the terpyridine. To better understand the physics behind the photoswitching performance, a deeper insight into the potential energy surfaces and molecular structure of the excited quintet structure is needed. This contribution presents the work of structural characterization of a series of $[Fe(terpy)_2]^{2+}$ derivatives with systematic ligand substitution.

In this work, we utilize Time Resolved X-ray Solution Scattering (TR-XSS) to structurally characterize a series of modified $[Fe(terpy)_2]^{2+}$ systems in aqueous solution following photoexcitation to investigate the quintet molecular structure, relaxation kinetics, and energy difference between the Ground State (GS) (singlet) and the Excited State (ES) (quintet). To interpret the measurements the analysis of the TR-XSS data is assisted by Density Functional Theory (DFT) and molecular dynamics (MD) simulation. The results show that the lifetime of the quintet state is strongly dependent on the substitution group but the structural change in the metal-ligand bond distances is not.

The data shown in this presentation were acquired at ESRF at id09 in 2021 in a project led by G. Vanko, Wigner Research Center in Physics, Budapest, Hungary. The work is performed as a collaboration between the group of G. Vanko and K. Haldrup.

Session 2b - Experimental methods & detection 1, Chair: Ian Bearden

A hyperspectral thermal imager based on a low order scanning Fabry-Pérot interferometer

Mads Larsen[1,2], Anders Jørgensen[2], Victor Petrunin[2], Jakob Kjelstrup-Hansen[3], Bjarke Jørgensen[2]

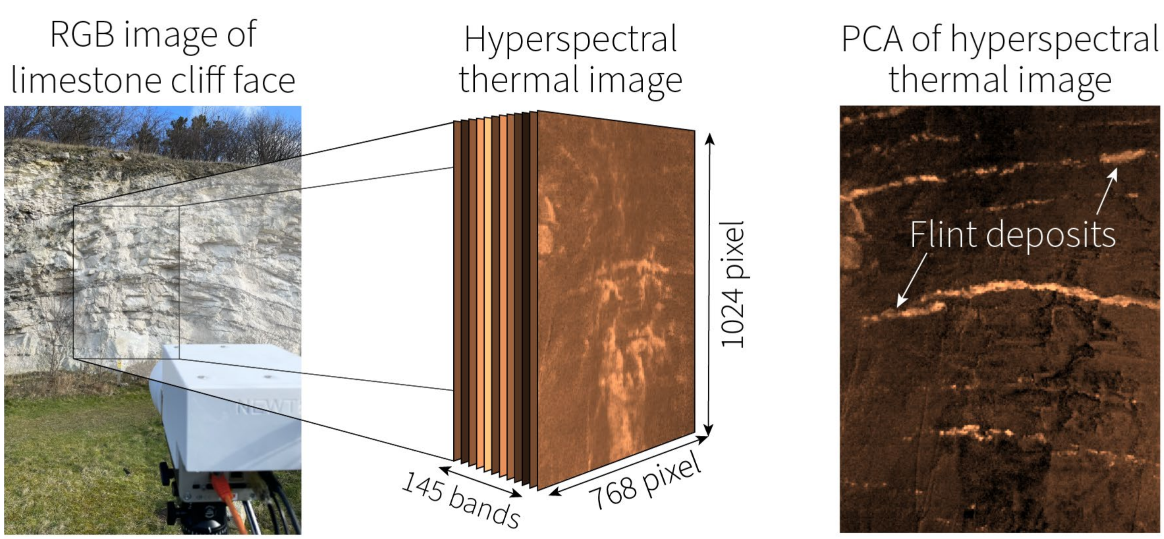
[1]University of Southern Denmark, Sønderborg, Denmark. [2]Newtec Engineering A/S, Odense, Denmark. [3]University of Southern Denmark, Odense, Denmark

Abstract

The long-wave infrared (LWIR) regime is conventionally employed by thermal cameras to assess the surface temperature of objects. However, this spectral range also contains material specific information, and can thus be used for material analysis and identification. Most existing spectral instruments operating in this range are restricted to single-point measurements or rely on push-broom techniques to acquire both spatial and spectral information. This is impractical for many applications working with large objects or for field measurements.

We have developed a spectral scanning hyperspectral thermal imagining system, which is described in this work. It is based on a thermal camera equipped with a 1024×768-pixel uncooled microbolometer sensor sensitive to wavelengths ranging from 8 – 14 µm. The hyperspectral capabilities are due to a low order scanning Fabry-Pérot interferometer (FPI) placed in front of the camera's collecting lenses. The mirror separation of the FPI determines the distribution of wavelengths, which enter the camera. Piezo actuators are used to control the mirror separation distance which ranges from ≈ 3 – 13 µm. This range is sufficient to capture more than the two first transmission orders of the FPI. A hyperspectral data cube is constructed by acquiring images while gradually moving the mirrors apart.

The presentation will include the approach for controlling the mirrors as well as the spectral calibration procedure employed in post processing. Furthermore, this presentation demonstrates the practical application of this hyperspectral imager for classification of minerals.



Scintillation and optically stimulated luminescence in the context of medical imaging

Camilla L. Nielsen, Mads L. Jensen, Brian Julsgaard, Peter Balling, Rosana M. Turtos

Aarhus University, Aarhus, Denmark

Abstract

The understanding of ionizing radiation interacting with matter, specifically with crystals, has for many decades been enabling the development of modern medical imaging and dosimetry, both linked to the diagnosis and treatment of cancer.

In a simplistic picture, ionizing radiation generates electronic excitation in wide-band-gap solids on a time scale ranging from femtoseconds to picoseconds. These excitations then relax and can be both promptly (nanosecond) or slowly (micro-miliseconds) converted into optical photons, giving rise to scintillation or radioluminescence (RL), with ample use in many nuclear imaging techniques. A fraction of the energy deposited by the ionizing particle proceeds to be stored in electron-hole traps in localized metastable states within the lattice of the solid. Such stored energy can be accessed at a later time, i.e. hours or days, by exciting the material with light, giving rise to the luminescence phenomenon known as optically stimulated luminescence (OSL). This delayed luminescence finds ample use in radiation monitoring and shows potential in the development of novel dosimetric techniques applied to the field of radiotherapy.

In this contribution, we will present the connection between scintillation and OSL and show that the latter acts as a memory of the scintillation mechanism in activated materials, having a dopant as a luminescence center. This idea is extended to the case of self-activated scintillators, i.e. materials with intrinsic luminescence via the formation and decay of self-trapped-excitons.

The work provides an overview of the OSL mechanism in activated and intrinsic inorganic scintillators in the landscape of medical imaging techniques.

Forward Hadronic Calorimeter for ALICE at the LHC

Laura Marie Dufke

Niels Bohr Institutet, København, Denmark

Abstract

Studying the gluon density in nucleons and nuclei require measurements at low-x. The Forward Calorimeter (FoCal) upgrade for ALICE will provide just such measurements. FoCal comprises two components, an Electromagnetic calorimeter (FoCal-E) and a Hadronic Calorimeter (FoCal-H). This presentation will present results for the first prototype that informed the design of the second prototype. In particular, I will present recent results from testbem measurements performed with FoCal-H second prototype at the CERN SPS, and how this compare to Monte Carlo simulations using different GEANT physics lists. Finally, I will present simulations of physics processes of interest based on realistic performance parameters of FoCal-H

Session 3a - Medical Physics, Chair: Sofie Gregersen

See what you treat: the MR-Linac in cancer treatment and research

Minea Jokivuolle

Laboratory of Radiation Physics, Department of Oncology, Odense University Hospital, Odense, Denmark. Department of Clinical Research, University of Southern Denmark, Odense, Denmark

Abstract

The MR-Linac is a modern radiotherapy treatment device, which equips the workhorse of every radiotherapy department, the radiation-generating linear accelerator (Linac), with a magnetic resonance (MR) imaging device. MR images have superior soft tissue contrast compared to the computed tomography (CT) images used in conventional radiotherapy treatments. Thus, the MR-Linac allows visualization of the cancer tumours and the surrounding organs with unprecedented clarity. This has provided new opportunities for both radiotherapy treatments and related research.

In this presentation, I will introduce the technical principles of MR-Linacs and go through the challenges, which have been resolved to ensure safe delivery of radiotherapy in the strong magnetic field required for the acquisition of MR images. I will tell about the opportunities and the paradigm shift the MR-Linac has provided for radiotherapy treatments but also about the challenges, the use of such complex device poses for everyday clinical work. Finally, I will give examples of the research fronts related to the MR-Linac focusing on the potential the MR-Linac offers for search and development of biomarkers, i.e. quantitative measurements about tumours, which could allow higher level of individualization of radiotherapy.

OUH
Odense
University Hospital

Towards measuring the biological effect of proton therapy in 2D

Camilla Nielsen[1], Mads Jensen[1], Liliana Stolarczyk[2], Morten Jensen[2], Peter Skyt[2], Simon Vindbæk[2], Brian Julsgaard[1], Rosana Turtos[1], Ludvig Muren[2], Peter Balling[1]

[1]Department of Physics & Astronomy, Aarhus University, Aarhus C, Denmark. [2]Danish Center for Particle Therapy, Aarhus University Hospital, Aarhus N, Denmark

Abstract

Proton therapy is an emerging radiotherapy modality that is currently being explored clinically for an increasing number of tumor sites. The biological effectiveness of proton therapy has traditionally been based on the radiation dose – the average energy deposition to millions of cells – with a uniform correction factor relative to conventional radiotherapy. However, it is being realized that the local spatial density of energy transfer, often expressed as the linear energy transfer (LET), might also determine the biological effectiveness of proton therapy. Importantly, the LET of a proton beam varies by more than an order of magnitude from entry to the point where the protons stop. Unfortunately, the localized nature of LET makes it very difficult to measure clinically – particularly in 2- and 3D.

We have developed an inexpensive and flexible two-dimensional detector that utilizes the contrast between two types of synthesized nanoparticles to obtain a high-resolution map of both the LET and dose distributions. Using the physical phenomenon of optically stimulated luminescence, this system can be irradiated and speedily read out using a custom-built system based on a sensitive camera and a set of pulsed LEDs. The respective responses of the two nanopowders can be extracted using their different readout times, and their ratio has been found to be LET-dependent based on a series of calibration experiments. The reusability of the dosimeter facilitates easy implementation in a clinical workflow to test, study, and validate treatment plans. This would open the road towards planning proton therapy with optimized biological response.

Long-axial Field of View PET. Bigger and better.

Thomas Lund Andersen

Rigshospitalet, Copenhagen, Denmark

Abstract

The recent introduction of long axial field of view (LAFOV) positron emission tomography (PET) scanners with 1 m. FOV or more into the medical imaging community has re-spurred interest and enabled measurements to further understand basic human physiology.

PET scanners are commonly used in clinical diagnosis and staging due to the unique ability to image and quantify physiological processes in-vivo by the use of radioactive tracers. The LAFOV PET scanners recently introduced in the clinics have enabled new scanning paradigms and further advanced the field of phamacokinetic modeling due to the increased scan coverage, improved sensitivity and fast time resolution.

In this talk I will give an overview of the LAFOV PET technology and highlight some of the recent applications both in terms of model development and new clinical opportunities. I will highlight cases where LAFOV scanners have changed the standard practice of care and give perspective of the future direction of the field.

REGION H Rigshospitalet

X-rays in cardiology - Protection through shielding and behaviour

Sofie Gregersen

Medicoteknik, Region Syddanmark, Odense, Denmark

Abstract

In the Cardiology Laboratory, the heart of the patient is studied through x-ray guided procedures. The cardiologist is working next to the patient and in close proximity to the x-ray tube and the irradiated area of the patient. In cardiac procedures, high radiation doses are distributed to the patient. Scattering events result in secondary radiation that expose cardiologists and other healthcare professionals to a considerable amount of x-ray radiation. This exposure to ionizing radiation is a health concern for radiation workers.

In this talk, you are invited into the Cardiology Laboratory. I will discuss radiation concerns in cardiac interventions, and initiatives to ensure a safe radiation environment for the workers. This includes optimizing procedures and testing equipment for radiation protection.

Session 3b - Computational Physics, Chair: Verena Markmann

A GraphNeT Attempt at Classifying Low-Energy Tau Neutrinos in the IceCube Upgrade

Linea Hedemark

Niels Bohr Institute, Copenhagen, Denmark

Abstract

The coming IceCube Upgrade will give us the unique ability to probe the low energy region of the atmospheric neutrinos and enable better measurements of neutrino oscillation than ever before. Observing tau neutrinos event by event would make it possible to make more accurate predictions and bring us closer to answering the big questions within neutrino physics.

This project uses a graph neural network approach to classifying tau neutrino events specifically and explores the reasons why this type of analysis is still out of reach for the IceCube experiment even with first-class machine learning methods.

Algebraic iterative reconstruction techniques for fast-ion loss detector data analysis

Bo S Schmidt[1], Joaquín Galdon-Quíroga[2], Jesús Poley-Sanjuán[3], José Rueda-Rueda[2], Henrik Järleblad[1], Bernard C G Reman[1], Mads Rud[1], Andrea Valentini[1], Manuel Garcia-Munoz[2], Mirko Salewski[1]

[1]Technical University of Denmark, Kgs. Lyngby, Denmark. [2]University of Seville, Seville, Spain. [3]École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Abstract

Fast-ion loss detectors (FILDs) are integral tools for understanding the loss mechanisms of fast ions in magnetically confined plasmas. A detailed understanding of these mechanisms includes knowledge of the velocity distribution of the lost fast ions. However, current reconstruction methods such as Tikhonov regularization are often constrained by limitations in speed, robustness, and the subjective choice of the regularization parameter. Such constraints can compromise the quality and reliability of the reconstructions. In this study, we adapt three well-established algebraic iterative reconstruction techniques (ARTs) for FILD data analysis. Each technique completes a single iteration in approximately 20 ms. Given that a full reconstruction typically requires on the order of 100 iterations, this computational efficiency enables reconstructing the full FILD signal between individual discharges. Additionally, the three ARTs are highly robust, as demonstrated by the stability of their solutions over a wide range of iterations. Furthermore, we introduce a mathematically justified stopping criterion based on the minimum resolvable distances in gyroradius and pitch angle. This criterion helps identify iterations close to semi-convergence, preventing overfitting without impacting the computational speed. Lastly, we use ARTs to analyze FILD measurements from an ELMy H-mode discharge with a magnetic field rampdown at ASDEX Upgrade. We capture the time evolution of the gyroradius for the neutral beam injection (NBI) populations, showcasing the enhanced capabilities of ARTs in temporal analysis of high-energy features.

Building a Monte Carlo particle code to simulate atmospheric electric discharges in 3D

Elloïse Fangel-Lloyd[1], Federica Defranchi Bisso[1], Mathias Gammelmark[2], Sven Karlsson[2], Saŝa Dujko[3], Christoph Köhn[1]

[1]National Space Institute (DTU Space), Kgs. Lyngby, Denmark. [2]DTU Compute, Kgs. Lyngby, Denmark. [3]Institute of Physics, Belgrade, Serbia

Abstract

Streamers are branching discharges occurring before bolts of atmospheric lightning and are also observed above thunderstorms. Prior to the production of a streamer, an avalanche of electrons must take place in an ambient electric field, and tracing these large numbers of electrons is computationally expensive. Additionally, lightning occurs over a large range of spatial scales, further complicating modelling. Thunderstorm processes are not entirely understood, and numerically simulating these processes can provide significant insight on these extreme natural phenomena.

Here we present a particle code capable of simulating electron avalanches and streamers in 3D. The Monte Carlo particle-in-cell approach can trace individual electrons in an ambient electric field while they experience collisions with ambient background gas, and accurately represent the quantum mechanical effects inherent in the system. Validation results from benchmarking against existing codes will also be presented. The program is optimised for multithreading and some GPU implementation has taken place; details on these will also be presented along with basic runtime comparisons.

DTU Space
National Space Institute

Study of Nuclear Reactor Core Stability During Load Follow Operations with ROM Methods

Kristoffer Tofveson Pedersen, Christophe Demazière, Paolo Vinai

Chalmers, Gothenburg, Sweden

Abstract

An intrusive reduced order model based on a modal expansion method is presented to study xenon oscillations in pressurized water reactors. The model uses a two-group, three-dimensional heterogeneous formalism with nodal macroscopic nuclear cross sections. The comparison between the model and an equivalent one-group homogeneous model shows that the computed time-dependent evolution of the eigenmodes of the system differs significantly. The underlying equations of the two models, which describe the deviations of neutron flux, iodine concentration, and xenon concentration from the equilibrium condition, are investigated to identify the reasons behind the discrepancies. The terms of the equations containing products between the spatial eigenmodes and the stationary neutron flux or xenon concentration are most affected by the increase in energy and spatial resolution. The use of one or two energy groups causes the largest discrepancies, but the spatial resolution of system heterogeneity is important in calculating the coupling of the eigenmodes when the equilibrium neutron flux distribution is characterized by spatial offsets. As a result, the 2-group heterogeneous model predicts a more unstable system with respect to xenon oscillations.

CHALMERS
UNIVERSITY OF TECHNOLOGY

Session 4a - NICE national meeting 2, Chair: You Zhou

Mass and matter – structures behind the Standard Model

Ole L. Trinhammer

Dept. of Physics, Technical University of Denmark, Kongens Lyngby, Denmark

Abstract

An underlying structure behind the Standard Model of particle physics is unfolded in a quest to understand its background and possibly reduce the number of ad hoc input parameters. We suggest the three gauge groups SU(3), SU(2) and U(1) to originate from a common compact configuration space U(3) for baryon mass eigenstates, excitable by kinematic generators from laboratory space. Accurate expressions derive for the neutron mass and the Higgs mass in closed forms that cannot be obtained within the Standard Model.

We introduce quark flavour generators that seem to relate the Cabibbo and the Weinberg angles. We suggest up and down quark masses to originate in intrinsic curvature of the configuration space. We derive Higgs self-couplings and Higgs to gauge boson couplings that differ from Standard Model expectations at the 6-8 percent and 3 percent levels respectively, possibly distinguishable at HL-LHC. As the newest result we predict anisotropic transverse gluon densities for the proton from projections of the intrinsic configuration dynamics to laboratory space.

"On quarks and the origin of QCD: Partons and baryons from intrinsic states", Eur. Phys. Lett. **133** (2021) 31001.
"On Cabibbo angle from theory", Eur. Phys. Lett. **124** (2018) 31001.
"Excess Higgs to gauge boson couplings", Eur. Phys. Lett. **125** (2021) 41001.
"Transverse proton gluon anisotropy points behind the Standard Model", Eur. Phys. Lett. **142** (2023) 24001.
"Neutron charge radius from intrinsic quark flavour generation", Eur. Phys. Lett. **134** (2021) 61002.

DTU

Transverse momentum- and pseudorapidity dependent flow vector fluctuations in p-Pb collision systems

Mikkel Petersen

Niels Bohr Institute, København, Denmark

Abstract

In relativistic heavy-ion collisions, the final state collectivity is characterized by the anisotropic flow, measured through flow vector estimations. Hydrodynamics calculations and experimental data show that the flow vector fluctuates as a function of the particle kinematics event-by-event, indicating fluctuations in the initial energy density of the nuclear collisions. In heavy-ion collisions, the ratio between the flow vectors constructed from the azimuthal distribution of particles from different kinematic intervals deviates from unity along with its characteristic dependence on the p_T or η of the corresponding particles. The similar study in small system would be helpful to understand the origin of collective-like effects observed in high-multiplicity classes of small collision systems.

This presentation will include the flow harmonic factorization ratio in p-Pb collision at $\sqrt{s_{NN}}$ = 5.02 TeV along with the corresponding AMPT model calculations. The p_T- and η-dependent flow coefficients are estimated from the two-particle correlation technique, while state-of-the-art "non-flow" suppression techniques have been applied. The results obtained from this study will help to provide tight constraints on the fluctuating initial conditions, allowing us to explore how anisotropic flow develops from the initial geometry through the dynamic evolution of the created system in p-Pb collisions.

Astronomy at the Highest Photon Energies

Atreya Acharyya

University of Southern Denmark, Odense, Denmark. University of Alabama, Tuscaloosa, USA

Abstract

Most astronomical telescopes observe thermal radiation. However, this does not include the most energetic gamma-rays photons, produced by large particle accelerators in space, which also act as tracers for cosmic-ray sources.

While gamma-rays can be observed using space-based detectors, their relatively small effective area leads to a reduced sensitivity at the highest energies, typically above a few hundred GeV. This is also the energy regime in which ground-based telescopes become important in conducting a study of the Cherenkov radiation produced by the most energetic photons on entering the Earth's atmosphere.

I present an overview of gamma-ray astronomy, beginning with the emission processes, current instruments and source classes observed. I then move on to the scientific potential of the discoveries, in particular those relating to active galactic nuclei, including addressing questions in astrophysics and fundamental physics and the important relation of gamma-rays to other cosmic messengers such as neutrinos before concluding with an overview of the next generation gamma-ray observatory, the Cherenkov Telescope Array.

SDU

University of
Southern Denmark

Magnetic monopoles in two time dimensions

Christoph Köhn, Jonas Elsborg

Technical University of Denmark, Kgs. Lyngby, Denmark

Abstract

Magnetic monopoles are a mystery in nature. They would symmetrize Maxwell's equations – in its canonical form only based on electric monopoles – and explain fundamental properties such as the quantization of the electric charge. However, their existence has been a long-standing problem; they have never been observed and even the covariant electromagnetic theory yields the asymmetric Maxwell equations excluding magnetic monopoles. We here propose to solve this enigma by introducing a second time-like dimension to 4D space-time positioning this theory on the boundary between particle physics and cosmology. We construct a theory in five dimensions and perform a Kaluza-Klein reduction, hence deriving symmetrized 5D Maxwell equations including magnetic monopoles. We argue that these equations do not violate current experimental evidence since a second time dimension only acts on small length scales which gives a natural explanation of why magnetic monopoles have not been observed yet. Finally, we discuss their effect on the quantization of the electric charge.

Session 4b - Experimental methods & detection 2, Chair: TBD

Martin Knudsen – a pioneer in gas flows

Jørgen Schou

DTU Electro, Technical University of Denmark, Roskilde, Denmark

Abstract

The Danish Physicist Martin Knudsen (1871- 1949) has recently passed his 150th anniversary. He was working as a shepherd during the summer when he grew up, and finished his career as a professor in physics and president at the University of Copenhagen. In the period from about 1910 to 1920 he was investigating the behavior of the gas flow in vacuum systems, in particular for low-pressure systems, in which the mean-free-distance and dimensions of the vacuum system were comparable. He introduced several concepts, the Knudsen Number, Knudsen gas, (Hertz-)Knudsen equation and Knudsen cells, which are still used today. The influence of Knudsen's work on recent work will be outlined as well.

Novel instruments for absolute vapor pressure measurements

Mohsen Salim, Robin V. Nielsen, Henrik B. Pedersen, Aurelien Romain Dantan

Aarhus University, Aarhus C, Denmark

Abstract

The saturation vapor pressure (SVP) of liquids and solids plays important roles in physical processes in nature as well as in technological applications. For example, SVP is the key parameter that determines the partitioning of atmospheric substances between interfaces like air-water and air-aerosols; SVPs are thus essential for understanding the formation of secondary aerosols or controlling the formation of fuels.

We will describe the realization of a new instrument with which the SVP of pure, low-volatile substances can be accurately and directly determined. The accuracy of the setup for SVP measurement was validated with standard chemicals and used to measure the SVPs of reference fatty acids. The setup also forms a platform for the development of novel absolute pressure sensors. In particular, we will report our progress in improving optomechanical pressure sensors exploiting squeeze film effects on the motion of micromechanical membranes.

AARHUS UNIVERSITY

Advanced 3D Dosimetry for Radiation Therapy Using Optically Stimulated Luminescence

Mads Lykke Jensen[1], Brian Julsgaard[1,2], Rosana Martinez Turtos[1], Camilla Lønborg Nielsen[1], Peter Sandegaard Skyt[3], Morten Bjørn Jensen[3,4], Ludvig Muren[3,5], Peter Balling[1,2]

[1]Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark. [2]Interdisciplinary Nanoscience Center, Aarhus University, Aarhus, Denmark. [3]Danish Centre for Particle Therapy, Aarhus University Hospital, Aarhus, Denmark. [4]Department of Medical Physics, Aarhus University Hospital, Aarhus, Denmark. [5]Department of Clinical Medicine, Aarhus University, Aarhus, Denmark

Abstract

Dosimetry is an indispensable part of radiotherapy (RT), providing quality assurance of treatment facilities and the of complex fields of ionizing radiation delivered to patients. Modern RT utilizes variations of a large parameter space to realize complex three-dimensional (3D) treatment plans and an emerging requirement for dosimetry systems is the ability to read out doses in 3D. A few dosimetry systems with 3D capabilities are available, but their application in a clinical workflow is limited for various reasons, primarily originating from their chemical nature. In this contribution, we present a novel dosimetry system with 3D capabilities of a clinically relevant size based on the physical mechanism known as optically stimulated luminescence (OSL). Unlike chemically based dosimeters, OSL-based dosimeters offer reusability, a highly desirable feature in clinical settings. We demonstrate the functionality of the system using both photon and proton irradiations, retrieving 3D dose maps from irradiations consisting of multiple fields, both overlapping and spatially separated. To assess precision and accuracy, we perform irradiations using two opposing photon fields and compare the retrieved 3D dose map to Monte Carlo simulations. Our findings suggest that this OSL-based dosimetry system holds promise for clinical applications and opens avenues for further research into tissue-equivalent, 3D dosimetry.

AARHUS UNIVERSITY

Ultrafast X-ray investigations of solvation dynamics in photosensitizer systems for solar energy harvesting

Kristoffer Haldrup

DTU Physics, Kgs Lyngby, Denmark

Abstract

The process of "solvation" whereby the molecules of a given solvent locally adapt to the presence of another molecular species has long been recognized as a highly important concept in Physical Chemistry. This importance stems in part from how the local adaption may take the form of a solvation "cage", where the solvent molecules form a well-defined structure around the solute, where the detailed structure and temporal persistence may greatly affect e.g. chemical reactivity. Further, the solvation processes may also directly affect the solute species as seen by for instance solvent-dependent lifetimes of excited states. However, insights into the fundamental physical mechanisms have been difficult to obtain due to the atomic length-(Å) and time- (picoseconds) scales involved.

This presentation seeks to outline recent advances in the fundamental understanding of exactly how the process of solvation influences the functionality of molecular systems for photovoltaics. New insights have been obtained based on real-time X-ray investigations on picosecond and sub-picosecond time scales at X-ray Free Electron Lasers (XFELs) and particular emphasis will be placed on how XFEL data has enabled the development of Fe-based photosensitizers for photovoltaic applications to replace the current generation of sensitizers based on ruthenium, which is scarce and extremely expensive. In the Outlook we will present new data and simulations of solvation dynamics in the prototypical $Fe(bpy)(CN)_4$ photosensitizer system where the nature of the solvent may change the lifetime of the key Metal-to-Ligand Charge Transfer states by orders of magnitude.

Poster abstracts

Classification of muon- and electron neutrino events for the ESSnuSB Near WC Detector using Graph Neural Networks

Kaare Endrup Iversen, Lund University, Lund, Sweden

Abstract

Accurate and fast event reconstruction is central for the design and performance of the ESSnuSB detectors. While precise, the currently proposed likelihood-based method for event reconstruction is computationally expensive. In recent years, machine learning methods have been implemented for reconstruction in several high energy physics experiments, including neutrino experiments, enabling fast reconstruction without reducing performance and in some cases even improving it.

In this work, we investigate the use of Graph Neural Networks (GNNs) for classification of muon and electron events and muon- and electron neutrino charged current events in the Near Detector of the proposed ESSnuSB experiment. We demonstrate that the accuracy of the GNN method is comparable to that of the likelihood method, and that the GNN can even learn the signatures of, and accurately identify, complex events that are currently discarded, while providing a factor 104 increase in reconstruction speed. Furthermore, we study the performance of the GNN by investigating the relation between event signatures and reconstruction performance.

Using the GNN based method will enable fast event reconstruction when making changes to the detector design, and will thus allow for easier investigation of different detector designs. Eventually, the GNN could also be used for regression tasks, such as energy reconstruction. In this talk, we will present the method and results of training and running a GNN on simulated events for the ESSnuSB detectors, and compare the performance and reconstruction speed to the likelihood-based method.

ESS neutrino Super Beam plus

Towards a 3D streamer discharge fluid model using AMREX

A. Ricardo Jara J., Elloïse Fangel-Lloyd, Matthias Gammelmark, Christoph Köhn

Danmarks Tekniske Universitet, Kongens Lynbgy, Denmark

Abstract

Streamer discharges form the transition between electron avalanches in an ambient electric field and the occurrence of the long bright lightning channels. Streamers occur in nature as precursors of lightning or as bright visible phenomena above thunderstorms and play a role in plasma technology, such as plasma medicine, which is why it is of utter importance to fully understand streamer properties As the processes inside thunderclouds occur on a multi-scale level ranging from several nm of electron scattering to the km long lightning channels, we need to develop models that cover a wide range of temporal and spatial scales. We present here the first version of our model implemented in the AMREX framework by treating the streamer discharges as a fluid . AMREX allows to implement the necessary equations for streamer propagation using parallelization and GPU support to accelerate the block structured adaptive mesh refinement. We present here preliminary results used to benchmark the code against existing fluid models. This code will form the basis for a fully hybrid (fluid + particle) code running on the newest generation of pre-exascale computers. In the future, such a code will allow us to gain insight on the mechanisms involved in lightning formation and related phenomena.

CO_2 Mineralisation: Can waste building materials convert CO_2 gas to solid?

Alexandra Beltrami[1], Athene Demuth[2,1], Petros Kanelis[1], Nicolas Bovet[3], Susan Stipp[1]

[1]DTU Physics, Kgs Lyngby, Denmark. [2]KU NBI, Copenhagen, Denmark. [3]DTU Offshore, Kgs Lyngby, Denmark

Abstract

Every year, Denmark produces tons of waste building materials, which take a lot of space for disposal. Also every year, Denmark emits about 38 MT CO_2 (mega, million). Could we combine these two problems to make a solution?

The short answer is "yes". We can do it by learning from Nature. Møns Klint, the Cliffs of Dover, the Alps of Austria, Italy and Switzerland have stored CO_2 as calcite, $CaCO_3$, in chalk and limestone for more than 60 M years. Calcite is 44% CO_2!

Our research group is investigating the capacity of waste building materials to solidify CO_2 in carbonate minerals, such as calcite. CO_2 dissolves rapidly in water, making an *acidic* solution. Stone wool, used for heat and noise insulation, is very fine grained, *alkaline* glass so it dissolves in the CO_2 rich water. When the solution becomes saturated, calcite forms, trapping CO_2.

We use potentiometry and spectrophotometry to analyse the composition of the solutions, X-ray diffraction (XRD) to identify the secondary phases, scanning electron microscopy (SEM) to see the micrometre scale particles and X-ray photoelectron spectroscopy (XPS) to determine surface composition.

The goal of our research is to make the reaction faster and to control the secondary phases that form so we can design a process to mineralise the CO_2 from chimney flue gas, using waste stone wool and other waste building materials. We expect the final product to be valuable as an additive in concrete, thus also reducing its CO_2 footprint.

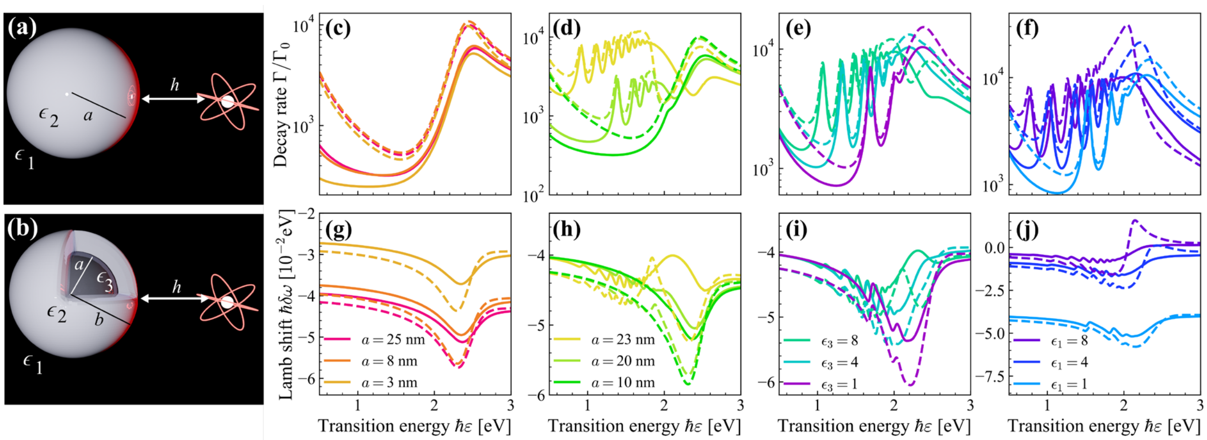
Nonlocal effects in atom-plasmon interactions

Mikkel Have Eriksen[1], Christos Tserkezis[1], N. Asger Mortensen[1,2], Joel D. Cox[1,2]

[1]POLIMA—Center for Polariton-driven Light–Matter Interactions, University of Southern Denmark, Odense, Denmark, Odense, Denmark. [2]Danish Institute for Advanced Study, University of Southern Denmark, Odense, Denmark

Abstract

Light-matter interactions in nanoscale systems consisting of quantum emitters in plasmonic environments offer avenues to explore quantum mechanics while promising applications within fields such as information technologies and sensing. Nonlocal and quantum mechanical corrections to models of the optical response in noble metal nanostructures become increasingly crucial when the relevant length scales in hybrid nanostructures reach the few-nanometer regime. To address this, we include surface response functions (SRFs) in the form of Feibelman d-parameters at metal-dielectric interfaces. We show that SRFs dramatically influence the optical response of metallic nanostructures – also affecting quantum electrodynamic phenomena, such as the Purcell enhancement and Lamb shift, in quantum emitters close to noble metal nanostructures. When increasing the permittivity of the dielectric material interfacing a noble metal, the corrections become more pronounced when calculating the SRFs using the specular-reflection model. Furthermore, the role of SRFs is enhanced in nanostructures characterized by large surface-to-volume ratios, such as thin planar metallic films or shells of core-shell nanoparticles. Decreasing the width of the metal region or elevating the permittivity of the dielectric materials results in larger changes in the Lamb shift, Purcell enhancement, and spontaneous emission spectrum of nearby emitters due to the SRFs in the metallic nanostructure.



POLIMA
Center for Polariton-driven Light-Matter Interactions

Gaussian Approximation Potentials for CO-oxidation over Pt Nanoparticles

Lea Vestergaard, DTU, Kongens Lyngby, Denmark

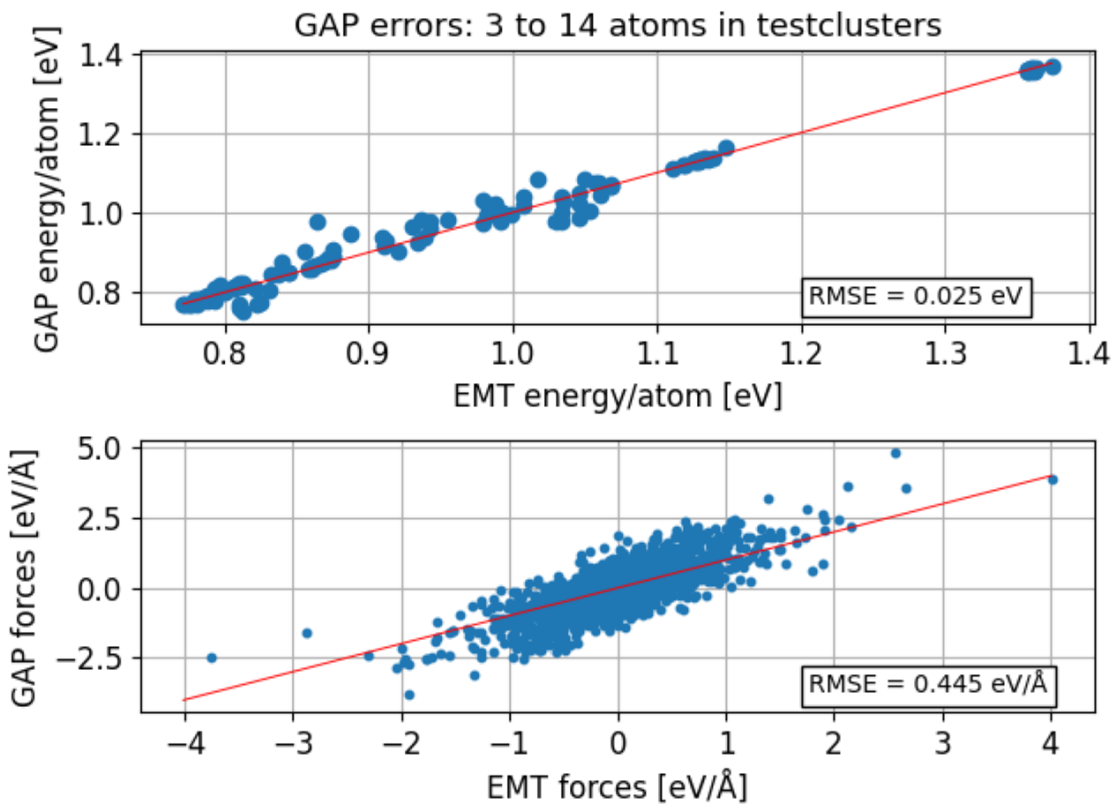
Abstract

Electronic structure calculations necessary for understanding atomic interactions and thereby catalytic reactions are computationally demanding and therefore severely limited in the system sizes and timescales possible in simulation. This prevents the study of a wide range of interesting materials properties and reaction mechanisms.

Gaussian Approximation Potentials (GAPs) may be a solution. The GAP framework is based on machine-learning the potential energy surface from large sets of density-functional theory (DFT) calculations and it enables atomic simulations with close-to DFT accuracy at a computational cost several orders of magnitudes lower. GAP has been applied for simulating bulk and surface properties of amongst other elements Silicon, Carbon and Boron, but less results have been presented for dynamic systems involving several elements interacting.

Therefore, my project focused on applying the GAP framework for CO-oxidation over Platinum. I have mainly been concerned with how the reference database used for fitting should be constructed, but also briefly considered parameters in the fitting procedure itself.

For constructing a database representing interactions of Pt, C and O in general, a random generation approach was used to generate 1000 configurations. When fitting GAPs to these data, good accuracy was achieved when measured on the space of such random configurations, namely an RMSE in predicting energies of 0.030 eV/atom and in predicting forces of 0.31 eV/Å. Although the final fitted GAPs predicted wrong or very unlikely reaction mechanisms for CO-oxidation, the framework seems promising for fitting interactions of several elements as required for simulating dynamical systems.


GAP errors: 3 to 14 atoms in testclusters
GAP energy/atom [eV]
EMT energy/atom [eV]
RMSE = 0.025 eV
GAP forces [eV/Å]
EMT forces [eV/Å]
RMSE = 0.445 eV/Å

Correlation and fluctuation of flow using Event Shape Engineering in Pb-Pb collisions at $\sqrt{s_\mathrm{NN}}=5.02$ TeV

Joachim Hansen

Lund University, Lund, Sweden

Abstract

Anisotropic flow provides valuable information on the key properties and the evolution of the quark-gluon plasma (QGP) created in heavy-ion collisions. In this poster, we present the latest measurement of anisotropic flow correlations and fluctuations for various flow harmonics using Event Shape Engineering (ESE) in Pb-Pb collisions at $\sqrt{s_\mathrm{NN}}=5.02$ TeV with ALICE. The event shape selection is performed using the q_n-selection from different pseudorapidity regions defined by the TPC, V0-A and V0-C detectors, to investigate the possible non-flow effects. A p_T-differential study is performed to judge whether the event selection is purely based on the eccentricity, or is affected by fluctuations. In addition, correlations between different orders of anisotropic flow are investigated via ESE, allowing the linear and non-linear modes of the fourth flow harmonic to be extracted. Such measurements will further contribute to the understanding of non-linear hydrodynamic response of the QGP to initial conditions.

Tomographic reconstructions of fast-ion distribution functions in fusion plasmas

Mads Rud Larsen[1], Dmitry Moseev[2], Fabien Jaulmes[3], Klara Bogar[3], Yiqiu Dong[4], Per Christian Hansen[4], Jacob Eriksson[5], Massimo Nocente[6], Henrik Järleblad[4], Garrett Prechel[7], Bernard Reman[1], Bo Simmendefeldt[1], Antti Snicker[8], Luke Stagner[9], Andrea Valentini[1], Mirko Salewski[1]

[1]Department of Physics, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark. [2]Max-Planck-Institut für Plasmaphysik, 17491 Greifswald, Germany. [3]Institue of Plasma Physics of the Czech Academy of Sciences, 18200 Prague, Czech Republic. [4]Department of Applied Mathematics and Computer Science, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark. [5]Department of Physics and Astronomy, Uppsala University, 751 20 Uppsala, Sweden. [6]Department of Physics, University of Milano-Bicocca, 20126 Milano, Italy. [7]Physics & Astronomy, University of California, Irvine, Irvine, California, USA. [8]VTT, Technical Research Centre of Finland, Espoo, Finland. [9]General Atomics, San Diego, California, USA

Abstract

To realise nuclear fusion as a reliable energy source, it is necessary to understand the behaviour of the most energetic particles of a fusion plasma, dubbed fast ions. Fast ions are inevitable in a fusion plasma, as they are born in fusion reactions at very high energies and via different heating schemes. Also, the fast ions can cause instabilities leading to losses of particles and energy. Therefore, a thorough understanding of the fast-ion distribution function in phase-space is vital.

Fast ions in tokamak plasmas are conveniently described by their three constants of motion, spanning a 3D space (COM-space). Low collisionality of fast ions ensures the conservation of kinetic energy. From the axisymmetric magnetic equilibrium follows the conservation of toroidal canonical angular momentum. Lastly, the magnetic moment of the fast ions is an adiabatic invariant, thus taken to be a constant of the motion. A single point in COM-space corresponds to a full closed trajectory of the fast-ion motion in the plasma.

Here we present tomographic reconstructions of a full fast-ion distribution function in COM-space in a tokamak plasma using projected velocities of the fast ions along the diagnostic lines of sight, as a proxy for spectra of several fast-ion diagnostics. This allows a completely analytical understanding of the diagnostic sensitivity in COM-space.

Since the problem of inferring the distribution function from the spectra is ill-posed, regularisation is needed to stabilise the solution. Prior information about the physical system is incorporated into the regularisation by penalising undesired properties of the solution.

Combining many-body localization and quantum many-body scars

Michael Iversen

Aarhus University, Aarhus, Denmark

Abstract

While most isolated many-body quantum systems reach thermal equilibrium, several phenomena are known to evade thermalization. One such phenomenon is many-body localization which occurs when certain quantum systems are exposed to sufficiently strong disorder. Localization stands in sharp contrast to thermalization since any nonequilibrium initial state fails to reach thermal equilibrium even after long time. Quantum many-body scars represent another nonthermal phenomenon. In scarred models, a small number of nonthermal energy eigenstates - called scar states - are embedded in an otherwise thermal spectrum. The scar states represent a small fraction of the full spectrum and most initial states display thermal dynamics. However, when prepared in certain initial states, scarred models display atypical dynamics such as persistent revivals. Many-body localization and quantum many-body scars exist separately, but the two nonthermal phenomena may also be realized simultaneously. In this case, the scar states are embedded among many-body localized eigenstates. The scar states hence violate localization instead of thermalization and they represent "inverted scars". Interestingly, the nonthermal dynamics of quantum many-body scars are amplified by the presence of a many-body localized background. In a thermal system, an impure initialization of a scarred initial state briefly displays nonthermal behavior but quickly thermalizes. In a localized system, however, the nonthermal dynamics from the same initial state is preserved for a longer time. In this way, many-body localization reinforces quantum many-body scars.

AARHUS UNIVERSITY

Narrow-linewidth optical microcavities using ultrathin suspended mirrors

Trishala Mitra, Gurpreet Singh, Ali A Darki, Søren P Madsen, Aurelien Dantan

Aarhus University, Aarhus, Denmark

Abstract

Pretensioned, ultrathin suspended silicon nitride films benefit from outstanding mechanical and optical properties, which can be exploited for a wide range of photonics and sensing applications. I will report on our progress in realizing narrow-linewidth, ultrashort “Fano” microcavities consisting of a standard broadband, highly reflective mirror and an ultrathin (150 nm) SiN film patterned with a photonic crystal structure possessing a high-Q optical resonance. Experimental characterization and simulations of such Fano cavities and their comparison with equivalent broadband mirror cavities will be presented.

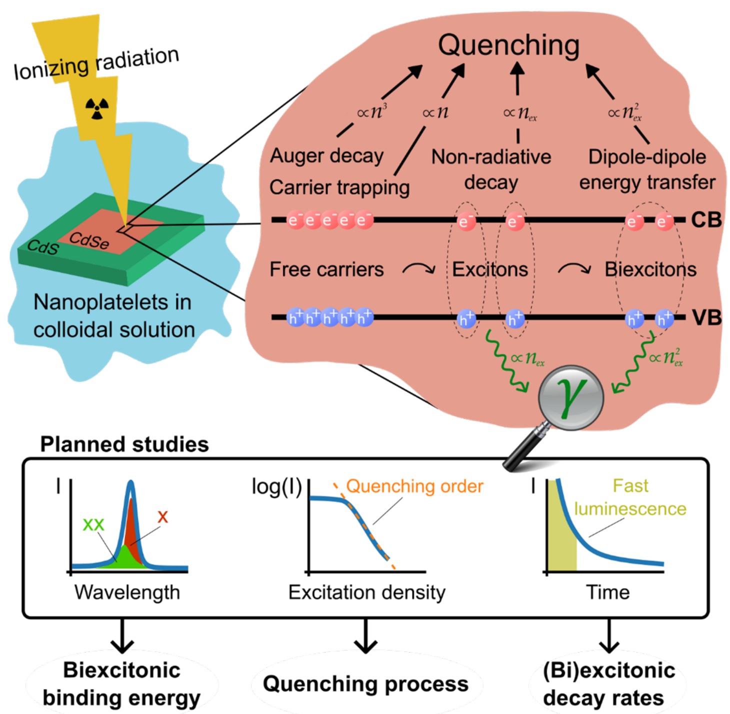
Can CdSe nanoplatelets improve the time resolution of PET scanners?

Simon Jessen, Rosana Martinez Turtos, Brian Julsgaard, Institute of Physics and Astronomy, Aarhus University, Aarhus, Denmark

Abstract

Scintillators are materials that can convert ionizing radiation into optical photons, and they form the basis of many radiation detection systems. One such system is Positron Emission Tomography (PET) scanner where two 511 keV gamma photons are detected in coincidence to image cancerous tumors. The image quality is directly related to the time resolution of the scintillation detectors which is fundamentally limited by the material response of the scintillator. This motivates the search for new materials with fast and bright scintillation properties, with a rate of 100 ph/MeV/ps. One such material is CdSe nanoplatelets which have many interesting optical properties including a unique sub-ns radiative decay channel associated with a biexcitonic population.

In this study, we report photoluminescence measurements of the platelets at excitation densities up to $2{\cdot}10^{20}$ electron hole pairs per cm^3, which mimics the energy deposition of ionizing radiation. This is achieved using a femtosecond laser and a translating lens using the z-scan method. As a preliminary result, we report an apparent non-semiconductor-like quenching characteristic of the CdSe nanoplatelets which is instead more akin to a wide band-gap scintillator. This is both surprising – as CdSe is a semiconductor – and unsurprising as the platelets have exciton-based luminescence just like a wide bandgap intrinsic scintillator. Further studies will allow us to determine the order of the quenching process and the total quenching fraction which are crucial parameters in the assessment of whether the use of CdSe nanoplatelets to enhance the time resolution of PET scanners is feasible.



Spinons in One-Dimensional Anti-Ferromagnetic Heisenberg Spin Chains

Anne Sofie Darket , DTU Fysik, Lyngby, Denmark

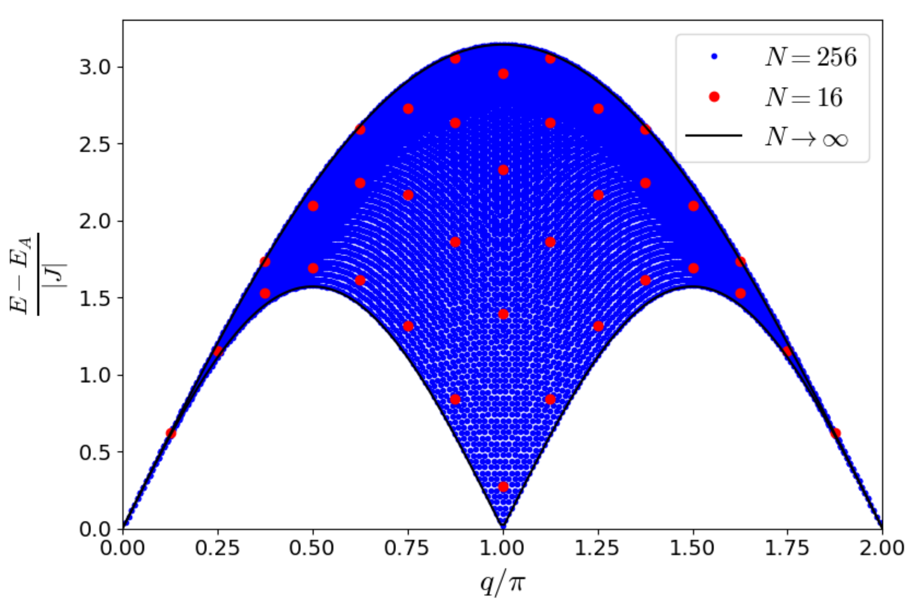
Abstract

Low-dimensional magnetism has been of theoretical interest for the past century, but only recently has it been possible to study the phenomenon in quasi-1D and -2D materials experimentally. When the magnetic interaction in such systems is antiferromagnetic, quantum spin liquids (QSLs) can occur - systems with a macroscopic number of entangled spins, showing no magnetic order even at zero temperature. QSLs provide new, interesting physics that are important to current fields such as quantum computing and high-temperature superconductivity. Therefore, we present a study of the one-dimensional, antiferromagnetic Heisenberg spin-1/2 chain as a simple example of a QSL.

We solve the system using three different methods; 1) the Bethe ansatz which is an exact analytical method, 2) the NIM approximation which is a semi-classical approximation, and 3) the Lanczos method which is an exact numerical method.

We apply the Bethe ansatz to the 1D ferromagnetic spin-1/2 chain to study two-magnon excitations, where the resulting Bethe quantum numbers provide an important physical interpretation. For the antiferromagnetic chain, we show the ground state to be magnetically unordered and derive a dispersion relation for the lowest excited states, spinons, which is gap-less in the thermodynamic limit. The results are compared to the NIM approximation.

To study the magnetic order in the presence of anisotropy, we apply a staggered magnetic field B-field. Using the Lanczos method, we show qualitatively that the ground state for an anisotropic system orders magnetically in the thermodynamic limit, thus transitioning away from being a QSL.



Uncertainty quantification for bad models and great data

Teitur Hansen, Thomas Bligaard, Karsten Wedel Jakobsen

Technical University of Denmark, Copenhagen, Denmark

Abstract

In this presentation I will be talking about a method currently being developed with the goal of training a model to predict uncertainties when given a set of great data. Here the uncertainties are due to using a bad model which cannot perfectly predict the data.

2D membranes as gas seals studied with density functional theory

Benjamin Hinrichsen[1], Stig Helveg[1], Thomas Bligaard[2]

[1]DTU Physics, Kongens Lyngby, Denmark. [2]DTU Energy, Kongens Lyngby, Denmark

Abstract

Graphene is promising for use as gas seal for in situ studies of catalysts due to its proven impermeability to gases. In this study, I simulate the diffusion of Argon atoms through interfaces consisting of a 2D material and a silicon oxide surface using density functional theory aiming to explore combinations of a 2D material and a bulk structure with adequate sealing properties for use in catalyst characterization experiments.

Characterization of silicon spin-qubit devices in a rapid cooldown cryostat

Ida Vaaben Ladefoged, Agnete Garbrecht Larsen

University of Copenhagen, Copenhagen, Denmark

Abstract

Quantum computing has garnered significant attention as classical computing nears its limits, yet the development of stable, scalable quantum circuits remains a challenge. Among the various types of qubits, spin qubits implemented in silicon-based quantum dot systems have been shown to be promising candidates due to their potential for long coherence times and compatibility with existing silicon fabrication technologies. This compatibility enables the integration of large-scale qubit arrays and the potential for industrial-scale fabrication, providing a clear pathway towards commercialization and widespread adoption.

This bachelor thesis focused on characterizing foundry-fabricated SiMOS devices using a continuous adiabatic demagnetization refrigeration (cADR) cryostat. The primary goal was to evaluate the potential of using this rapid-cooling cryostat for efficient, large-scale device testing and asses the quality of the foundry-fabricated SiMOS devices. Additionally, in-house Si/SiGe devices were tested to examine noise characteristics and electron temperatures within the cryostat.

Lennard-Jones parameters of iodine (I^0) in an aqueous solution.

Jaysree Pan, Kristoffer Haldrup

Technical university of Denmark (DTU), Kongens Lyngby, Denmark

Abstract

We present Lennard-Jones (LJ) parameters for iodine (I^0) in an aqueous context, an essential contribution to improving the precision of molecular simulations and deepening our understanding of the interactions involving neutral iodine ions and water molecules. LJ parameters are instrumental in characterizing intermolecular interactions, encompassing van der Waals forces and repulsive interactions, with ϵ specifying interaction strength and σ representing the effective interaction radius. While LJ parameters for aqueous iodide (I^{-1}) are well-known, our research fills the knowledge gap by establishing LJ parameters specific to aqueous iodine (I^0). We used femtosecond time-resolved X-ray scattering (TR-XSS) data gathered at the free-electron laser SACLA (Japan) and the European Synchrotron Radiation Facility (ESRF, France), providing a robust experimental foundation for the meticulous determination and validation of these parameters.

Search for a small droplet of Quark-Gluon Plasma with flow-vector fluctuations in pp collisions

Anders Sandermann Mortensen

The Niels Bohr Institute, Copenhagen, Denmark

Abstract

Quark gluon plasma (QGP) can be produced in relativistic heavy ion collisions, and will result in an anisotropic flow of particles, which can be quantified by studying the magnitude and orientation of so called flow vectors. Flow vector fluctuations are understood as a tell-tale sign of QGP production in collider experiments. Flow analysis of pp-collision data have shown flow like signals. We attempt to study these by way of flow-vector fluctuations. This will improve our collective understanding of flow-like signals in small collision systems and in the long term help answer whether these are due to QGP-production or other physics.

Student understanding of refraction: Network analyses of a conceptual questionnaire that uses different formulations of representation

Jesper Bruun

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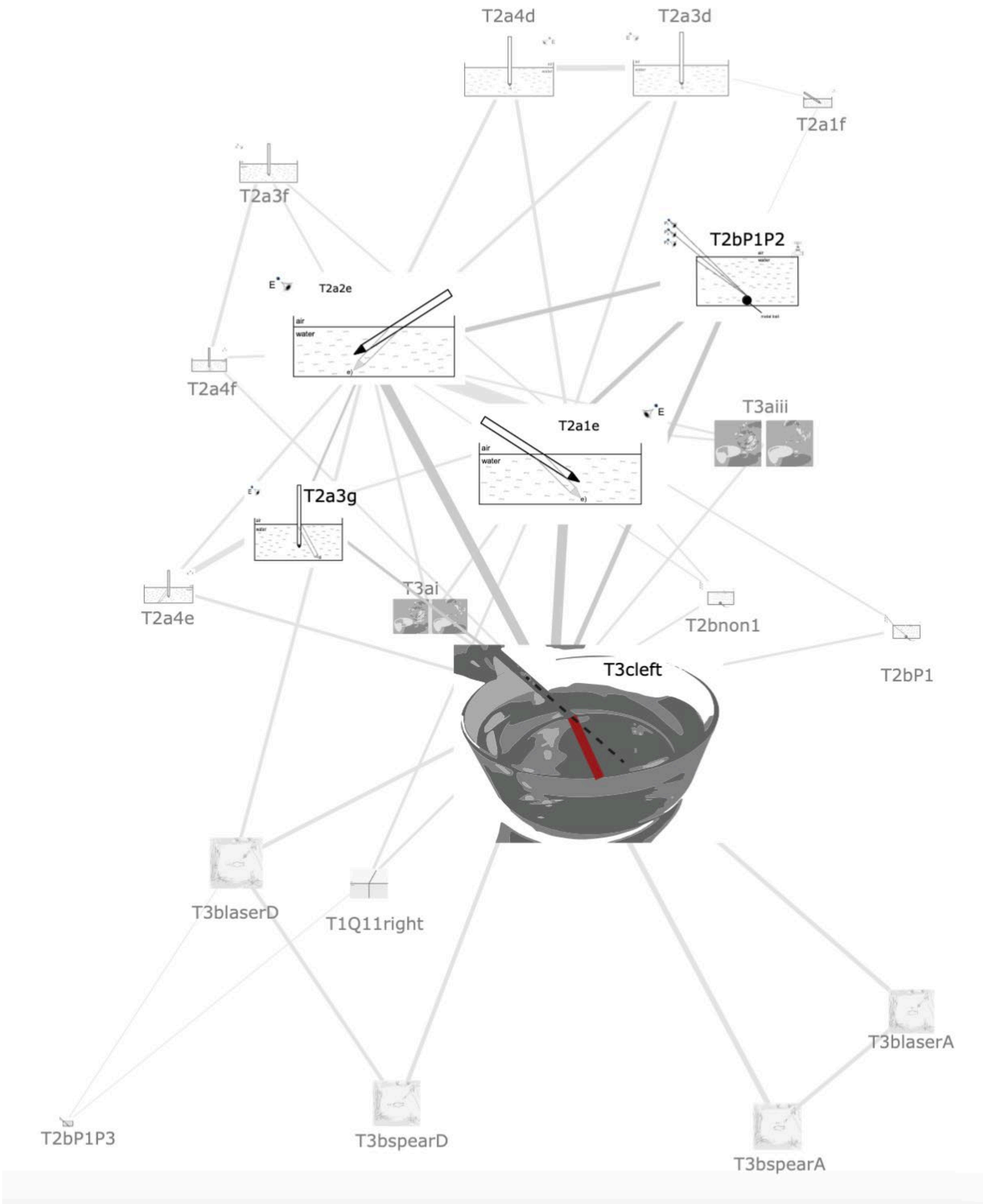
Abstract

This study investigates the role of representations (such as drawings, graphs, experimental setups, mathematics, ...) in the teaching and learning of physics. Theories in this area have been developed qualitatively with each study focusing on a small number of students. This study is an example of a large-scale study that investigates the relationship between a given object of learning and different representations - focusing on the case of visual representations. The study uses data obtained from a questionnaire on refraction of light given to 1368 students drawn from 12 universities. The questionnaire items were analyzed using modular (network) analysis of multiple-choice responses (MAMCR) and using a similarity network approach. MAMCR finds three clusters of connected student responses that are connected to relevance structures; structures that are available to students in the given context. These insights can inform teaching of refraction of light by aiding teachers in the selection and use of visual representations in their teaching/learning activities. The similarity network approach revealed groups of similarly answering students that seemingly make use of the identified relevance structures to a varying degree. The composition of similarity groups did not seem dependent on the university in which students were inrolled. This is surprising, because we can expect different universities to teach the concepts of refraction differently.



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