Swedish Physics Days 2025 in Luleå

Wednesday 13 August 2025 - Friday 15 August 2025

Luleå

Book of Abstracts

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Molecular spectroscopy with optical frequency combs

Author: Aleksandra Foltynowicz[1]

[1] *Umeå University*

Optical frequency combs are lasers whose spectra consist of hundreds of thousands of evenly spaced narrow lines spanning a broad spectral range. This unique combination of high spectral resolution and wide bandwidth has revolutionized molecular spectroscopy. Our group uses frequency combs to probe the energy level structure of molecules relevant to astrophysics, such as methane - the first organic molecule detected in the atmosphere of a hot-Jupiter exoplanet. The vibrational energy level structure of this small polyatomic molecule is complex and remains incompletely characterized. I will show how frequency comb double-resonance spectroscopy combined with ab initio calculations provides unique information about highly excited vibrational levels of methane, which is essential for modeling of high-temperature spectra observed in astrophysics.

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The second AI revolution in fundamental science research

Author: Tommaso Dorigo[1]

[1] *Istituto Nazionale di Fisica Nucleare*

In 2012 machine-learning tools achieved paradigm-shifting performance in image classification, but 2012 was also the year when the LHC collider at CERN discovered the Higgs boson. For the first time, a new fundamental particle was discovered with explicit use of machine learning tools. While until then machine learning was frowned upon as a valid tool by the physics community, in 2012 -almost overnight- it became a necessary instrument for data analysis in fundamental science. I call that event the first AI revolution in fundamental science.

Today we are ready for a second revolution, which will allow artificial intelligence to assist in the E3design of the complex instruments required to investigate matter at the shortest distance scales, by providing means for continuous scanning of the very high-dimensional space of design solutions of particle detectors. In order for that to happen, physicists have to team up with computer scientists to create the necessary interfaces (simulation tools, dimensionality reduction methods, optimization algorithms). Of particular importance is the concept of co-design, where hardware and software are optimized together, avoid misalignments that reduce the final performance of the resulting data collection and reduction pipelines. In this presentation I will describe the state of the art in these activities.

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Attosecond lasers

Author: Anne L'Huillier[1]

[1] *Lund University*

Ultrafast cameras, using ultrashort light flashes, allow the capture of ultrafast motion. In atoms or molecules, attosecond light pulses are needed to capture the motion of electrons (1 as = 10^{-18} s). This presentation will highlight the physics behind the generation and application of attosecond light pulses.

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Can you learn by playing games?

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Post-Li batteries: An atomistic perspective

Author: Axel Groß[1]

[1] *Ulm University*

Li-ion batteries are dominating the market for high-performance batteries. However, so-called post-Li batteries in which Li is replaced by other charge carriers such as Na, K, Mg, Ca, Al and even Cl offer the potential for competitive energy densities, but being significantly more abundant. In this talk, I will give an overview over the advantages and also obstacles associated with post-Li batteries. I will also present successful research efforts improving the performance of post-Li batteries, often achieved by a close collaboration between experiment and theory on the atomic level.

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Trapping particles: From research on anti-matter to teaching experimental physics in high-schools

Authors: Dag Hanstorp[1]; Jonas Enger[1]

[1] *University of Gothenburg*

We will in this talk describe and demonstrate the basic principles of traps with a discussion of similarities and difference between optical traps, acoustic traps and electro-magnetic traps. We will give examples of current research where traps are used, with trapping of antihydrogen as the most striking example. The presentation will also discuss various pedagogical suggestions on how traps can be used to demonstrate fundamental physical quantities and how this can be applied in upper secondary schools or in undergraduate classrooms. As examples, we will demonstrate charge quantization and how acoustic traps can be used to demonstrate wave physics.

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