Großes Physikalisches Kolloquium an der Universität zu Köln

Prof. Dr. Yury A. Litvinov
Institut für Kernphysik, Universität zu Köln, Köln & GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt

Intersection of nuclear-, atomic- and astro-physics: Beta decay of highly charged ions

21.10.2025
16^{30} Uhr
HS III

The famous sentence ‘we all are made of stardust’ implies that all visible matter in the Universe, on the Earth, in our bodies, or somewhere else, has been and still is being created in the hot interior of stars. The only exceptions are the lightest elements, hydrogen, helium, lithium and beryllium, which were probably formed during the first minutes after the Big Bang or in ongoing spallation reactions in interstellar medium. The conception that our roots go back to the cauldrons of long dimmed stars is a keystone of our present perception of the Universe. Nucleosynthesis proceeds by nuclear fusion in massive stars until iron, where it stops because the fusion of still heavier nuclei consumes energy instead of providing it. Nature has, however, invented a ‘trick’ to overcome this dead-end: atomic nuclei can become heavier by capturing neutrons and can also alter their nuclear charge via beta decay (β-decay). Our knowledge of β-decay is based on numerous studies of neutral atoms. But what happens in high temperature environments of stellar interiors, where atoms lose most or even all bound electrons?

In this lecture we will see that the decay properties established in neutral atoms can dramatically change in highly charged ions. The corresponding measurements are done in the experimental storage ring ESR of GSI, where we are able to store freshly produced highly charged radionuclides in ultra high vacuum, thereby preserving their charge state for extended periods of time. An overview of the obtained results as well as remaining challenges will be presented.

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Prof. Dr. Arshia Maria Jacob
I. Physikalisches Institut, Universität zu Köln, Köln

28.10.2025
16^{30} Uhr
HS III

Molecular Clouds: Blueprints of the Cosmos

The universe is built from a hierarchy of structures that span vast physical scales — from the immense filaments of the cosmic web to galaxies, stars, and planetary systems. At the heart of this cosmic architecture lie molecular clouds, cold and dense reservoirs of gas and dust that serve as the blueprints for star and planet formation. Over recent decades, our understanding of how such complexity emerges has deepened, revealing the crucial interplay between large-scale accretion flows and small-scale feedback processes, particularly those linked to stellar birth.

Because star formation is confined to the molecular phase of the interstellar medium (ISM), the evolution of galaxies is intimately tied to the formation, dynamics, and lifecycle of molecular clouds. These clouds not only regulate the star formation process but also act as critical links between the smallest and largest scales of galactic ecosystems. Observational constraints from molecular and atomic gas have significantly shaped our current models, yet many fundamental questions remain about the physical and chemical mechanisms that govern these structures.

Motivated by this, in this talk I aim to illuminate the role of molecules and molecular clouds in shaping galactic evolution.

Großes Physikalisches Kolloquium an der Universität zu Köln

Prof. Dr. Beatriz Noheda
Zernike Institute for Advanced Materials & Groningen Cognitive Systems and Materials center, University of Groningen, The Netherlands

4.11.2025
16^{30} Uhr
HS III

The matter of future computers

Although neuromorphic computing concepts have been put forward half a century ago, the urgency for low power solutions that can handle big data efficiently is a recent development. So far, cognitive/brain-inspired computing is the only paradigm that can offer energy savings of several orders of magnitude. However, getting there requires a huge multidisciplinary effort and a holistic approach that starts with the use of devices with intrinsic plasticity. Here I will highlight how recent progress in materials science is opening the way for future cognitive devices giving examples from the research of my own group. In particular, I will present work on memristive devices with transition metal oxides, such as nickelates and manganites, as well as with novel nanoscale ferroelectrics based on HfO_2.

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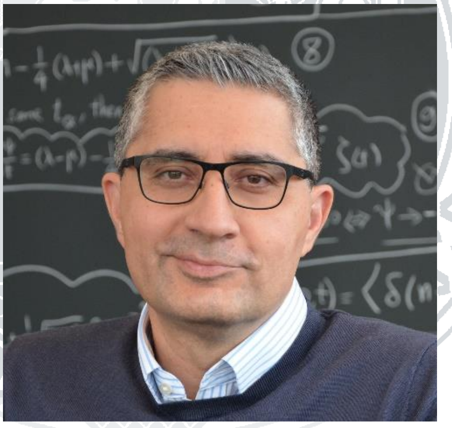
Prof. Dr. Leticia Cugliandolo
Université Pierre et Marie Curie - Paris VI / Sorbonne Université, Paris, France

18.11.2025
16^{30} Uhr
HS III

Classical Statistical Physics Out of Equilibrium

Equilibrium statistical physics provides a bridge between microscopic dynamics and macroscopic behavior. It explains the emergence of thermodynamic concepts such as temperature and pressure, and accounts for collective phenomena like phase transitions. By contrast, a comparable understanding of systems out of equilibrium remains elusive, and is the focus of intense research across many areas of physics. In this talk, I will concentrate on a particular class of nonequilibrium dynamics: those realized in classical integrable systems. I will demonstrate how modest extensions of standard statistical physics tools can capture the long-term behavior of these systems in various ways, illustrating the results with a simple model.

Großes Physikalisches Kolloquium an der Universität zu Köln

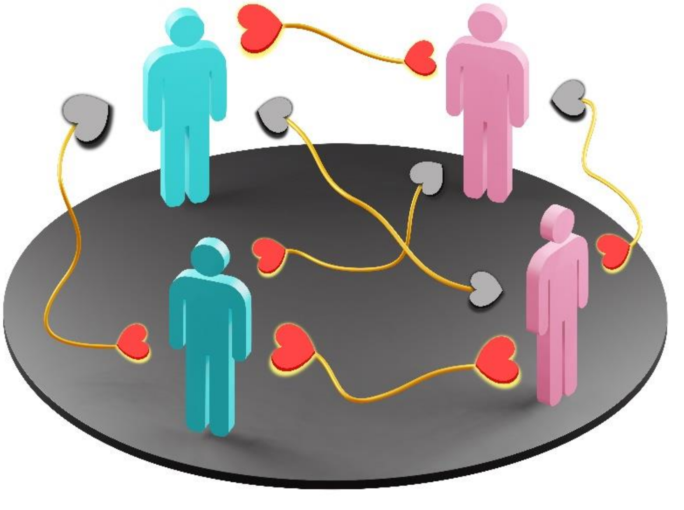


Prof. Dr. Ramin Golestanian
Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen

Non-reciprocal active matter

25.11.2025
16^{30} Uhr
HS III

Non-reciprocal interactions (NRIs) are quite natural among higher organisms including humans, as we all know that the way two humans act towards each other does not derive from a mutual translationally symmetric ``interaction potential'' that gives rise to action=-reaction. It is, however, a remarkably surprising that NRIs can exist at the microscopic scale among brain-less particles, in particular enzymes, when they are catalytically or metabolically active, i.e. under non-equilibrium conditions. In this Colloquium, I will introduce the topic and discuss some of its non-trivial consequences, following the developments in the field over the last decade. In particular, we discuss how non-reciprocal active matter can provide a paradigm within which we can understand how it may have been possible to form self-organized metabolic cycles at the early stages of life formation in a fast and robust manner.



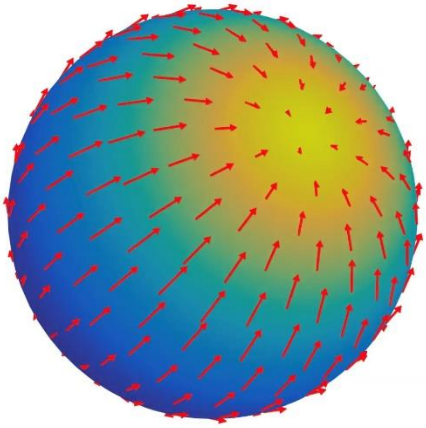
Großes Physikalisches Kolloquium an der Universität zu Köln

Prof. Dr. Frank Jülicher
Max-Planck-Institut für Physik komplexer Systeme, Dresden

Dynamic Organization of Biological Cells

13.01.2026
16^{30} Uhr
HS III

Living matter is highly dynamic and organizes into complex patterns and spatial structures. Cells and tissues are maintained far from thermodynamic equilibrium by a continuous supply of chemical energy through metabolic processes. I will discuss how active processes drive cells away from equilibrium and present general concepts from irreversible thermodynamics that capture the physics of such activity. Fluid flows generated by contraction through active stresses provide a general mechanism for the establishment of cell polarity. Phase-separated droplets create compartments in cells that organize biochemistry. These biological condensates motivate the study of chemically active droplets that can mimic cell-like behaviors such as spontaneous division. Active droplets also serve as physical models of protocells. At larger scales, many cells organize collectively during the morphogenesis of organisms. These examples show that living matter is a form of active matter governed by nonequilibrium physics.



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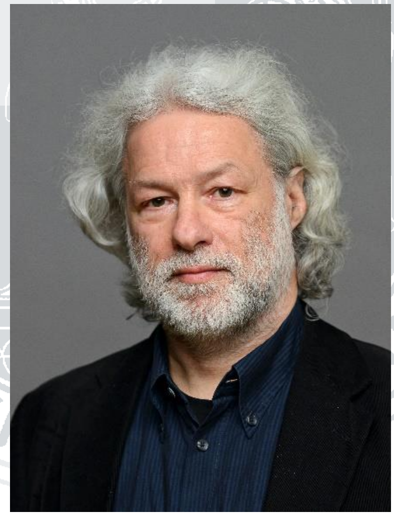


Prof. Dr. Moritz Epple
Goethe-Universität Frankfurt, Frankfurt

Between Ideology and Collaboration: On Physicists and Mathematicians who Remained in Nazi Germany

20.01.2026
16^{30} Uhr
HS III

When the Nazis came to power in Germany in 1933, an unprecedented expulsion of scientists from the country began. What can be said about those academics who remained in Germany? The talk focuses on physics and mathematics and provides an overview of the most important reactions to the new political situation. On the one hand, it describes attempts to form new movements such as ‘Deutsche Physik’ and ‘Deutsche Mathematik,’ which openly embraced and supported Nazi ideology. On the other hand, it discusses the less ideological but probably more important forms of working with and for the state, whether for its war efforts or, in some cases, even for the Holocaust.

All this raises questions about the practice of science in and for a state that commits crimes against humanity.

Admiral Doenitz besucht Wernher von Braun in der Heeresversuchsanstalt Peenemünde

Großes Physikalisches Kolloquium an der Universität zu Köln

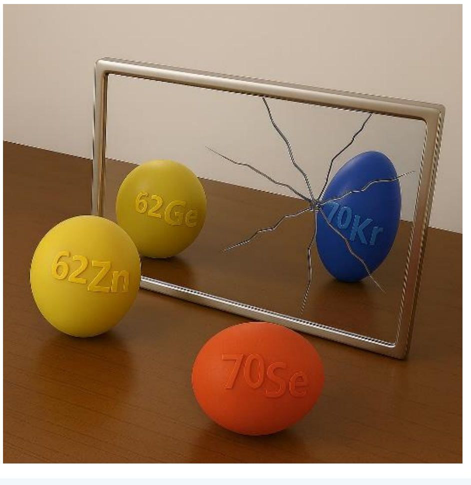
Prof. Dr. Kathrin Wimmer
Institut für Kernphysik, Universität zu Köln, Köln

Testing Symmetry in the Nuclear Mirror: Probing the Shape and Structure of Mirror Nuclei

27.01.2026
16^{30} Uhr
HS III

The atomic nucleus is governed by a subtle, almost perfect symmetry: the near-interchangeability of protons and neutrons, called isospin symmetry. Conserving isospin, the physics of mirror nuclei, pairs where the numbers of protons and neutrons are swapped, would be identical. However, the small electromagnetic force and other subtle effects break this symmetry, offering a window into the inner workings of the nucleus.

In this talk, I will present recent experimental studies that use electromagnetic transition rates as a stringent and model-independent test of isospin symmetry. We observed a striking breakdown of this symmetry in the mirror nuclei with mass number 70: instead of being identical, ^{70}Kr is significantly more deformed than its mirror ^{70}Se. In stark contrast, a second study of the lighter A=62 nuclei shows perfect agreement with isospin symmetry predictions, making it the most precise test of its kind to date.



These results illustrate how small symmetry violations can result in large nuclear structure changes and dramatically different deformations. I will also discuss future directions for improving these measurements, including new instrumentation that will enable even higher-precision studies in more exotic systems.