TECHNISCHE UNIVERSITÄT WIEN

EINLADUNG

Invitation
to the
Physics Colloquium TU Wien

to be delivered by
Ass. Prof. Dr. Emanuela Bianchi
Ass. Prof. Dr. Andrej Pustogow
Ass. Prof. Dr. Eva Sevcsik

28. April 2026
16:00

Welcome and Opening Remarks
Andrei Pimenov
Dean of the Faculty of Physics

Date & Time:
Tuesday, 28 April 2026 at 16:00 s.t.

Venue:
Freihaus FH 8 Nöbauer HS - MATH
Wiedner Hauptstraße 8-10
1040 Wien

Light refreshments will be served following the lecture.

Emanuela Bianchi obtained her Master's degree and PhD in Physics from the University of Rome La Sapienza. She subsequently held several prestigious research fellowships, including the Alexander von Humboldt, Lise Meitner, and Elise Richter fellowships, and carried out postdoctoral research in Austria and Germany.

In 2018, she was awarded the START Prize by the Austrian Science Fund and became Assistant Professor at the Institute of Theoretical Physics at TU Wien in 2019. Since December 2024, she is Associate Professor at the same institution. Her research focuses on the theoretical and computational investigation of soft matter systems.

Insights into Protein Effective Interactions and Phase Behavior

Proteins in solution are intrinsically charged objects whose surface charge is highly heterogeneous due to the spatial distribution of ionizable amino acids. This charge patchiness is comparable in scale to the protein size and results in strongly anisotropic and directional interactions. Understanding these interactions is crucial not only for fundamental physics, but also for applications ranging from protein formulation in pharmaceutical solutions to biomolecular condensation in living cells.

A detailed microscopic description of protein–protein interactions, while in principle accessible via electrostatic theories and atomistic simulations, becomes prohibitively complex when addressing large-scale systems. This limits direct access to bulk phase behavior and motivates the development of simplified but physically grounded models.

To address this challenge, we develop a mean-field description of effective electrostatic interactions, extending the well-known and widely used DLVO theory to heterogeneously charged particles [1]. This provides a reference framework to construct highly simplified models that retain only a few key parameters encoding charge anisotropy and net charge, enabling efficient simulations of collective behavior [2]. Using this minimal representation, we investigate liquid–liquid phase separation and show how charge heterogeneity controls the propensity of the system to undergo condensation [3].

Our results establish a consistent route from first-principles electrostatics to minimal models of protein condensation, providing insight into how microscopic charge heterogeneity translates into macroscopic phase behavior.

[1] A. Gnidovec, E. Locatelli, S. Čopar, A. Božič, and E. Bianchi, Anisotropic DLVO-like interaction for charge patchiness in colloids and proteins, Nature Communications 16, 4277 (2025).
[2] D. Notarmuzi, S. Ferrari, E. Locatelli, and E. Bianchi, Simulating inverse patchy colloid models, Journal of Chemical Physics 162, 144902 (2025).
[3] D. Notarmuzi and E. Bianchi, Liquid-liquid phase separation driven by charge heterogeneity, Communications Physics 7, 412 (2024).

Andrej Pustogow studied physics at LMU Munich and ETH Zurich, where he already focused on electronic transport and the Seebeck effect. After completing his PhD with distinction Summa Cum Laude at the University of Stuttgart, he conducted postdoctoral research at the University of Stuttgart and later at the University of California, Los Angeles, supported by a Feodor Lynen Fellowship of the Alexander von Humboldt Foundation. His research ranges from quantum magnetism and unconventional superconductivity to electronic correlations and modern thermoelectric materials.

Pustogow has received substantial international recognition, including publications in Nature, Science, and PNAS. Since 2020 he has been a professor at TU Wien, where he completed his habilitation in Experimental Physics in 2025 and holds an Associate Professor position since then. His research program is dedicated to developing novel pathways toward a comprehensive understanding and control of electronic properties in solid-state systems.

New Spin on Electrons in Frustrated Mott Systems, Superconductors and Thermoelectrics

Understanding and controlling the behavior of electrons in solids constitute the core of fundamental condensed-matter science. Yet, the controlled variation of electronic properties requires to identify the proper tuning knob and the ability to apply it to existing materials.
Here we solve several longstanding puzzles, that remained hotly debated for decades, in the fields of correlated electron systems and thermoelectricity. This is achieved through the powerful combination of solid-state spectroscopy and electronic bandwidth tuning in systems with unconventional band structures and/or gemetrical frustration by applying pressure and strain

- By means of NMR under uniaxial strain we overturned the widespread belief in spin-triplet superconductivity in the paradigmatic compound Sr2RuO4 and provided evidence for even-parity unconventional superconductivity [1].
- Using magnetic resonance and strain we solved a decades old mystery and ruled out a *gapless* spin-liquid state in the organic Mott system κ-(BEDT-TTF)2Cu2(CN)3 [2,3]. Moreover, we achieved the first controlled tuning of geometrical frustration by *in situ* uniaxial strain in an inorganic kagome antiferromagnet [4].
- Our recent spectacular findings triggered the advent of the *Metal Age of Thermoelectricity* [5]. In particular, we introduced the novel paradigm of scattering-tuned *metallic thermoelectrics* in diverse materials ranging from cubic nickel-gold alloys, where we realized world-record power factors, to Ni_3Ge and the kagome system Ni_3In with topological flat bands [5].

[1] A. Pustogow *et al.*, *Nature* **574**, 72–75 (2019); *PNAS* **118**, e2025313118 (2021)
[2] A. Pustogow *et al.*, *Nat. Commun.* **14**, 1960 (2023); *Science* **372**, 276-279 (2021)
[3] A. Pustogow, *Solids* **3**, 93–110 (2022)
[4] J. Wang, … and A. Pustogow, *Phys. Rev. Lett.* **131**, 256501 (2023)
[5] F. Garmroudi, … and A. Pustogow, *Sci. Adv.* **9**, eadj1611 (2023); *Phys. Rev. X* **15**, 021054 (2025); *Sci. Adv.* **11**, eadv7113 (2025)

Eva Sevcsik develops micro- and nanostructured biointerfaces to study cell- and immunobiological phenomena. She studied Technical Chemistry at Graz University of Technology and pursued her doctoral research in biophysics at the Austrian Academy of Sciences in Graz. Following postdoctoral work at Yale University, she joined the Biophysics research unit at TU Wien as a postdoctoral associate. Eva is now an Associate Professor at the Institute of Applied Physics at TU Wien.

Her research focuses on designing and applying micro- and nanostructured biointerfaces to control the spatial organization of membrane proteins in living cells. By combining these engineered surfaces with single-molecule microscopy, she investigates the fundamental principles of plasma membrane organization and function, with a particular interest in the molecular mechanisms underlying early T cell signaling.

Engineering Biointerfaces to Dissect Cell–Cell Interactions at the Nanoscale

Reconstituting biological phenomena in model systems with defined components and properties is a powerful strategy to dissect molecular mechanisms. My research focuses on developing such systems to enable the reconstitution, observation, and physical manipulation of cellular processes down to the single-molecule level. In particular, I use micro- and nanostructured biointerfaces to achieve a quantitative and mechanistic understanding of plasma membrane organization and associated signaling processes.

In this talk, I will highlight our recent efforts to investigate the nanoscale organization of ligands and receptors at cell–cell interfaces—an essential determinant of cellular communication that remains challenging to resolve experimentally. To address this, we have developed a biomimetic interface based on DNA origami nanostructures that allows precise control of protein spacing with nanometer resolution, enabling us to systematically modulate receptor signaling (1, 2). At the same time, this platform remains fully compatible with dynamic receptor rearrangements on the cell surface upon ligand engagement, as observed in immune, neuronal, and cancer-related processes. I will present recent advances combining these biointerfaces with single-molecule fluorescence microscopy to elucidate the molecular mechanisms underlying early T cell antigen recognition.

[1] J. Hellmeier, *et al.*, DNA origami demonstrate the unique stimulatory power of single pMHCs as T-cell antigens. *Proc. Natl. Acad. Sci. U. S. A.* **118**, e2016857118 (2021).
[2] J. Hellmeier, *et al.*, Strategies for the site-specific decoration of DNA origami nanostructures with functionally intact proteins. *ACS Nano* **15**, 15057–15068 (2021).