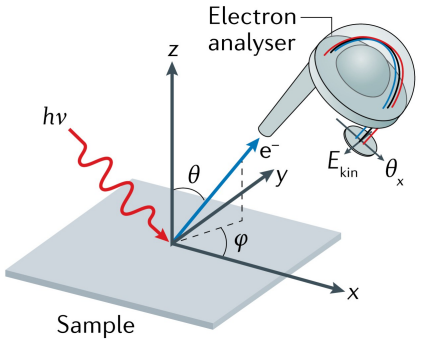
Seminar topics **12.10.2026**

1. ARPES

- *Nature Rev. Phys.* **1**, 609 (2019)
- *Rev. Mod. Phys.* **93**, 025006 (2021)

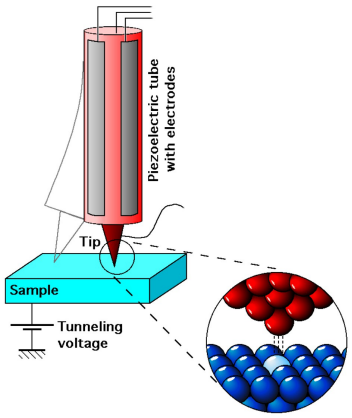
Angle-resolved photoemission spectroscopy, better known as ARPES, is the main workhorse for studying electronic structures of solids. In this talk, you will explain how the method works, discuss its current limitations and resolution, and present examples of the recent ARPES work, such as the identification of Dirac and Weyl points in topological materials.



2. Scanning tunneling experiments

- *Nature Rev. Phys.* **3**, 249 (2021)
- *Adv. Mater.* **30**, 1707628 (2018)

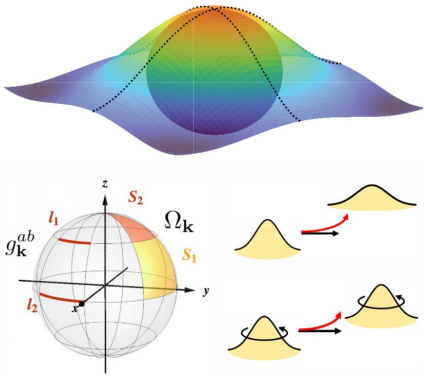
Scanning tunneling microscopy and spectroscopy (STM and STS, respectively) hold a prominent position among experimental methods for studying solid-state quantum materials. In this talk, you will explain the difference between STM and STS, and their use for identifying topological states in solids, as well as quantifying Berry curvatures in real materials.



3. Quantum metric and quantum geometry

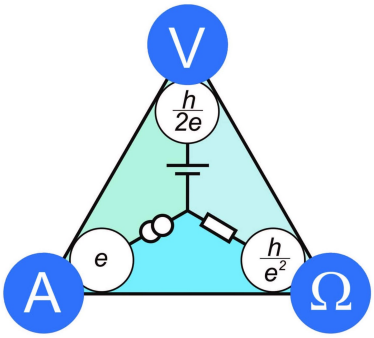
- arXiv:2504.07173
- *Rep. Prog. Phys.* **88**, 076502 (2025)

Beyond Berry curvature and Berry phase, the emerging concept of quantum metric describes evolution of electronic wavefunctions in the momentum space and its effect on electronic properties of the crystal. In this talk, you will explain what quantum geometry is, how it is related to the familiar Berry curvature, and how it can give rise to nonlinear responses in Hall conductivity and other transport properties.



4. Quantum metrology

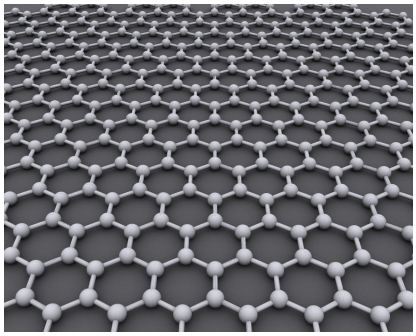
- *Ann. Rev. Condens. Matter Phys.* **8**, 13 (2017)
- *Rep. Prog. Phys.* **64**, 1603 (2001)



Accurate measurements are important. Reproducible measurements are indispensable. Quantum metrology makes sure that stable, reliable, and highly accurate resistivity and voltage standards are available to industry as well as academic community. In this presentation, you will explain how quantum Hall effect and Josephson effect are used to this end, and which solid-state devices currently serve as standards for electronics.

5. Graphene

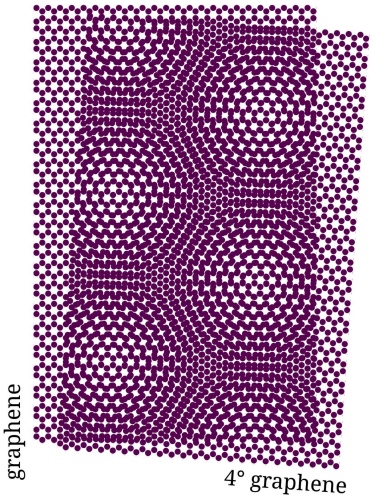
- *Nature Mater.* **6**, 183 (2007)
- *Rev. Mod. Phys.* **81**, 109 (2009)



Graphene is arguably one of the most important materials in modern solid-state physics. In this talk, you will explain how graphene is produced and investigated, and which unique properties it has – from high hardness and negative thermal expansion to quantum Hall effect and relativistic electrons.

6. Graphene bilayers with a twist

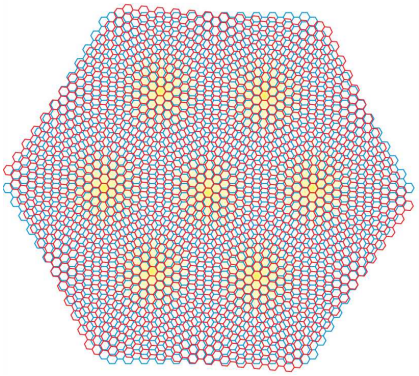
- *Physics Today*, **71**(5), 15 (2018)
- *Nature Materials*, **19**, 1265 (2020)
- Journal Club for Cond.-Mat. Physics (February 2019)



Placing two graphene sheets on top of each other leads to unexpected consequences. In this presentation, you will explain why a small twist matters and what the concept of Moiré lattices implies. Then you will present the resulting phase diagram and explain its relation to correlated electrons in solids.

7. Moiré structures

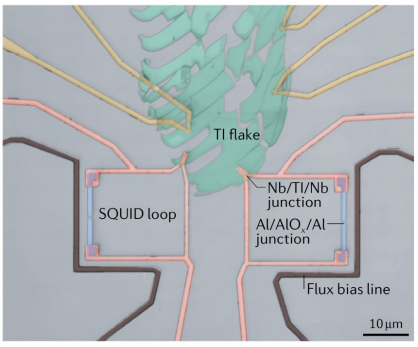
- *Nature*, **602**, 41 (2022)
- *Nature Nanotechnology*, **17**, 686 (2022)



Twisted multi-layer structures, better known as moiré materials, pushed their way into solid-state physics over the last decade and offered access to exotic phases, such as Chern insulators and fractional quantum anomalous Hall states (yes, that's quite some combination of adjectives). You will explain how these materials are fabricated and studied, what interesting prospects they offer, and which experimental difficulties they entail.

8. Topological electronics

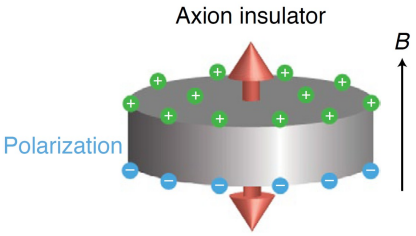
- *Comm. Phys.* **4**, 70 (2021)
- *Nature Rev. Phys.* **4**, 184 (2022)
- *Nanoscale* **15**, 12787 (2023)



Plenty of topological materials have been discovered, but what are their prospects for applications? In this presentation, you will introduce devices that can make use of topological insulators and other topologically non-trivial states, and discuss which of these devices already exist or have high chances to appear.

9. Axion electrodynamics

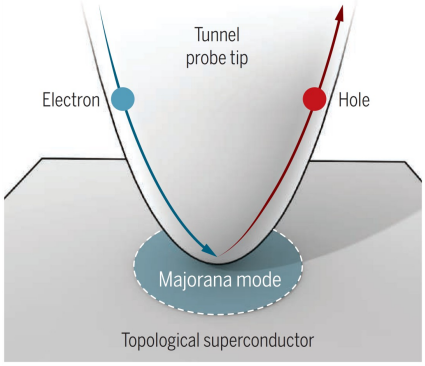
- *Nature Rev. Phys.* **1**, 126 (2019)
- *J. Appl. Phys.* **129**, 141101 (2021)



A topic for theory nerds: explain how concepts of particle physics can be relevant to solid-state materials, and whether the search for axion has been more successful in crystals than in the high-energy domain.

10. Hunt for Majoranas

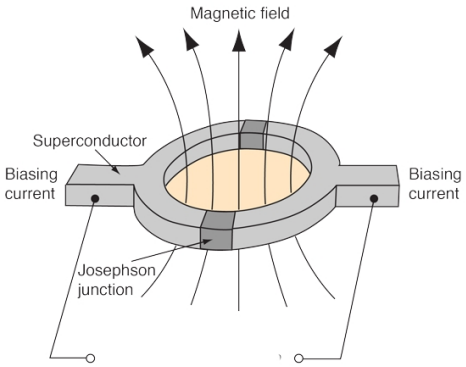
- *Nature Phys.* **16**, 718 (2020)
- *Nature Rev. Mater.* **6**, 944 (2021)
- *Nature*, **592**, 350 (2021)



A thrilling story from modern solid-state physics: the search for fictitious Majorana particles that could be used to produce topological qubits and best-ever quantum computers. Hoax, fraud, and fierce scientific battles. In your talk, you can cover any of those aspects and share your own opinion on whether elusive Majoranas have been found and tamed.

11. Superconductors and quantum interference

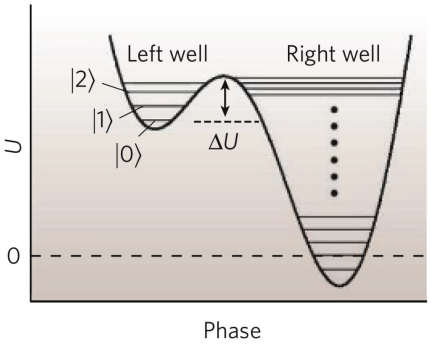
- *Amer. J. Phys.* **38**, 1071 (1970)
- *Rev. Sci. Instrum.* **77**, 101101 (2006)



Some of the most interesting applications of superconductors are related not to superconductivity itself (the property of zero-resistance current), but to the interference of superconducting wavefunctions across thin insulating barriers, the so-called Josephson junctions. In this presentation, you will discuss basics of the Josephson effect and explain how it can be used in voltage-frequency conversion. You can also touch on the aspect of SQUIDs (superconducting quantum interference devices) and their modern applications in research and industry.

12. Superconducting qubits

- *Physics Today* **58**(11), 42 (2005)
- *Nature* **453**, 1031 (2008)



Recognized by the latest Nobel prize in physics, superconducting qubits are essential building blocks of present-day quantum computers. In this talk, you will explain the key features of electrical circuits containing Josephson junctions as nonlinear elements, introduce different types of qubits, and explain their performance.

13. Room-temperature superconductors

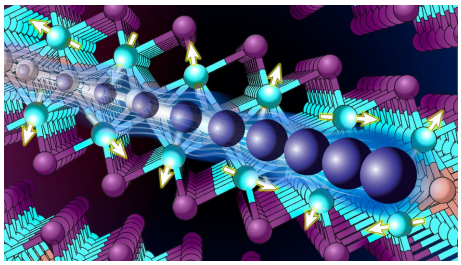
- *Ann. Rev. Condens. Matter Phys.* **11**, 57 (2020)
- *Science* **373**, eabm1133 (2021)



Superconductivity at room temperature is a long-standing physicists' dream. Long considered impossible, in recent years it almost became a reality, but only at megabar pressures that are as high as pressures inside Earth. In this presentation, you will explain why superconductivity is favored by high pressures and how these high pressures can be created in the lab. Then you can outline latest findings in the field and discuss controversies regarding the observation of superconductivity at and above room temperature, touching on the problems of reproducibility and fraud in research publications.

14. Heavy fermions

- *Proc. Nat. Acad. Sci.* **92**, 6663 (1995)
- *Nature Phys.* **4**, 196 (2008)



How heavy can a fermion be? Quite hefty, according to the latest knowledge in solid-state physics. In this talk, you will cover the peculiar compounds of lanthanides and actinides featuring highly localized f electrons that impart conduction electrons with an unusually high effective mass. You will also explain what peculiar physics arises from this heaviness, with the focus on the so-called quantum criticality.

Image credits: cited papers, as well as

- STM: Michael Schmid (CC-BY-SA)
- quantum metric: MIT
- metrology triangle: Physikalisch-Technische Bundesanstalt
- graphene: AlexanderAlUS (CC-BY-SA)
- TI device: Nature Rev. Phys. 4, 184 (2022)
- Majorana mode: Science 367, 145 (2020)
- SQUID: HyperPhysics
- Room-temperature superconductor: J. Adam Fenster, University of Rochester
- Heavy fermions: Columbia Quantum Initiative