2023 EPS Europhysics Prize

The Condensed Matter Division of the European Physical Society (EPS CMD) is proud to announce the award of the 2023 EPS Europhysics Prize to:

Professor Claudia Felser and Professor B. Andrei Bernevig
“for seminal contributions to the classification, prediction, and discovery of novel topological quantum materials”.

Prof. Claudia Felser is a director at the Max Planck Institute for Chemical Physics of Solids in Germany, Prof. B. Andrei Bernevig is a Professor of Physics at Princeton University in the United States and Visiting Ikerbasque Professor at Donostia International Physics Center in Spain.

The Prize will be presented on Wednesday 6th September 2023, during the Awards Session of the 30th General Conference of the EPS Condensed Matter Division (CMD30), to be held in Milan (joint organization with FisMat in Italy). This prize has been awarded since 1975 (this is the 40th edition) and is one of Europe’s most prestigious prizes in the field of condensed matter physics. It is given in recognition of a prominent and well-identifiable discovery, breakthrough, or contribution to condensed matter physics, by one or more individuals, contribution that, in the opinion of the selection committee, represents scientific excellence. The award recognises research for which a significant portion of the work was carried out in Europe. A summary of all the prize editions can be found here. We thank the sponsors of the EPS Europhysics Prize: EPL and CECOM.

About the Prize
The EPS Europhysics Prize is one Europe’s most prestigious prizes in the field of condensed matter physics. It is awarded every one or two years in recognition of recent work by one or more individuals for scientific excellence in condensed matter physics. The Prize was awarded for the first time in 1975.

About the EPS
The European Physical Society (EPS) was created in 1968 to promote physics in Europe. The EPS now has around 2,500 individual members and brings together 42 national physical societies which themselves represent together over 130,000 physicists.

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Professor Claudia Felser
Claudia Felser studied chemistry and physics at the University of Cologne, completing her diploma in solid state chemistry (1989) and her doctorate in physical chemistry (1994). After postdoctoral fellowships at the Max Planck Institute in Stuttgart (Germany) and the CNRS in Nantes (France), she joined the University of Mainz in 1996 as an assistant professor (C1) becoming a full professor there in 2003 (C4). She is currently Director at the Max Planck Institute for Chemical Physics of Solids in Dresden and a honorary Professor at the Dresden University of Technology. In 2001 Felser received Order of Merit (Landesverdienstorden) of the state Rheinland Pfalz for the foundation of the first NAT-LAB at the University Mainz with a focus in female school students.
Professor B. Andrei Bernevig
After winning gold and silver in the International Physics Olympiad as a teenager, Bernevig graduated from Stanford University in 2001 where he worked under Bob Laughlin with bachelor's in physics and master's in mathematics. He received his PhD from Stanford University under Shoucheng Zhang, and continued as a postdoctoral fellow at the Center for Theoretical Physics at Princeton University, where he is now a professor. His work on topological states of matters starts with the initial prediction of Quantum Spin Hall States in HgTe; his theoretical work on classifying quantum materials based on topological principles of the electron wavefunction was achieved through the decade-long combined collaboration of a Princeton team of post-doctoral researchers and students, with Ecole Normale Superieure professor, and an essential team of senior and junior researchers at the University of the Basque country in Bilbao and crucially at the Donostia International Physics Center, where he is a Visiting Professor.

Long citation
One of the hottest topics in condensed matter physics today is topology, and in particular materials whose properties are controlled by their topology. Bernevig and Felser are international leaders in this field and are responsible for the development of general design rules, that have led to the prediction of thousands of new topological compounds, and the experimental realization of many of these. These range from the Quantum Spin Hall effect (Bernevig), new Weyl semimetals (Bernevig, Felser), non-symmorphic insulators and semimetals supporting new Fermion excitations (Bernevig, Felser), as well as the discovery of a large number of new types of magnetic topological materials, including magnetic Weyl semimetals (Bernevig, Felser).

The path forward for many current applications, from quantum computing to catalysis, thermoelectrics, superconductors, and sensing, requires the discovery of novel quantum materials. New classes of quantum materials have been found in insulators and semimetals whose properties can be indexed by the mathematical concept of nontrivial topology. Topology in physics is an area in which universal design rules can be derived by group theoretical and mathematical considerations. Realizing these rules in material compounds with specific properties requires further chemical intuition. The materials discovered by Bernevig and Felser exhibit a wide range of phenomena, from topological or dangling bond surface states, giant responses to external stimuli and non-local transport, to new quasiparticles such as Weyl, Dirac and beyond.

The unique combined work of the nominees has led to the discovery that a large number of materials possess extraordinary properties related to the topology of their electron wavefunctions: some 30% of the ~200,000 known inorganic compounds (Nature 2017, 10.1038/nature23268, and Nature 2019, 10.1038/s41586-019-0954-4). This is astounding since many of these materials were in plain sight! The results signal that topology is an
overarching concept that can classify compounds, in a similar manner that the Periodic Table classifies single elements.

This scientific duo has worked closely together: Bernevig and co-workers made theoretical predictions, Felser, Bernevig and co-workers designed potential materials using analytical methods and advanced density functional theoretical techniques; finally, Felser and co-workers brought these materials to life via the growth of high-quality crystals and the characterization of their fundamental physical properties. After the prediction by Bernevig (Science 2006, 10.1126/science.1133734) and the subsequent observation of the quantum spin Hall effect in 2006 in HgTe, Felser immediately recognized that Heusler compounds, which are ternary compounds, would also this phenomenon and offer a wide range of tunable materials (Nature Materials 2010, 10.1038/NMAT2770), Felser also proposed KHgSb, a heavy graphene material as a weak topological insulator (PRL 2012, 10.1103/PhysRevLett.109.16406); this compound has subsequently become prominent for its hosting of hourglass Fermions (Nature 2016, 10.1038/nature17410), and being a new type of topological insulator. This was a starting point for a highly successful collaboration between Felser and Bernevig on new types of topological semimetals (hosting new Fermionic excitations) (Science 2016, 10.1126/science.aaf5037) which burgeoned into a theory-experimental program of discovering and classifying new insulators and metals. The experimental verification of these new Fermions took some time but in 2019 excellent crystals produced by Felser and co-workers led to the measurements of giant Fermi arcs in RhSi, CoSi (Nature 2019, 10.1038/s41586-019-1037-2), PtAl (Nature Physics 2019, 10.1038/s41567-019-0511-y), and PdGa (Science 2020, 10.1126/science.aaz3480) using angle resolved photoemission spectroscopy (ARPES).

The first non-magnetic Weyl semimetals NbP, TaP, NbAs and TaAs were predicted in January 2015 by Bernevig and Dai (PRX 2015, 10.1103/PhysRevX.5.011029). The rapid growth of high quality single crystals enabled Felser et al. to publish, jointly with several teams of excellent co-workers, including members of the high magnetic field laboratory in Rossendorf and Nijmegen, the ARPES team in Oxford, and STM teams at Weizmann and Würzburg, a series of high impact publications (Nature Physics 2015, 10.1038/NPHYS3425; Nature Materials 2016, 10.1038/NMAT4457). In another publication, Nature 2017, 10.1038/nature23005, the gravitational anomaly was reported in the Weyl semimetal NbP, a publication which was subsequently the subject of an article in the New York Times.

More recent examples are Magnetic Weyl Fermions in Heusler and Kagome compounds. Heusler compounds are well known magnetic compounds, the subject of seminal work by Felser and her team over a number of years. In the field of magnetic Weyl semimetals, two groups of Heusler compounds are prominent. Kübler and Felser predicted that Mn₃Ge and Mn₃Sn, noncollinear antiferromagnets, would display a large Berry phase (EPL 2014, 10.1209/0295-5075/120/47002). This was subsequently verified experimentally by both the Felser and Nakatsuji led teams via giant responses of the anomalous Hall effect (Science Advances 2016, 10.1126/sciadv.1501870; and Nature 2015, 10.1038/nature15723). This class of materials have high potential for antiferromagnetic spintronics and thermoelectrics. Bernevig predicted the first ferromagnetic magnetic Weyl semimetal, Co₂TiSn (PRL 2016; 10.1103/PhysRevLett.117.236401) and Felser predicted Co₂MnAl (EPL 2016; 10.1209/0295-5075/114/47005); the experimental verification by Felser and co-workers was published in...
several high impact papers (Science 2019, 10.1126/science.aav2327; and Nature 2022, 10.1038/s41586-022-04512-8). Recent years have shown that the physics of topological materials can be extended to most existing compounds, and topology is a fundamental principle in their classification.

The work of Felser and Bernevig has been previously recognized by a series of prestigious awards including for Bernevig: Guggenheim Fellowship, 2017; Simons Foundation Investigator Award, 2016; New Horizons Prize, 2015; Sackler Prize, 2014; Blavatnik Award, 2012; David and Lucile Packard Fellow, 2011; McMillan Award for outstanding contributions to condensed matter physics, 2008. And for Felser: Tsungming Tu Award from the Ministry of Science and Technology, Taiwan, 2015; Fellow of the American Physical Society, 2013; Fellow of IEEE, 2015; Fellow of Leopoldina, the German National Academy of Science, 2017; Max Born prize of the DPG and IOP, 2022; the Liebig medal of the GDCh, and the Oswald medal, 2022. Both together received the APS James C. McGroddy Prize for New Materials, 2019.

Their outstanding scientific achievements are also reflected in the high number of citations of their publications (Scopus database): Bernevig, has more than 36,000 citations and Felser, more than 46,000 citations.