Symposium Topological Insulators: Status Quo and Future Directions (SYTI)

jointly organized by
the Low Temperature Physics Division (TT),
the Thin Films Division (DS),
the Surface Science Division (O),
the Semiconductor Physics Division (HL), and
the Magnetism Division (MA)

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Topological insulators have attracted much attention since their discovery in 2005-2007 and generated an enormous research activity of both experimentalists and theorists. This symposium aims to provide an overview of the status quo about ten years after the discovery of topological insulators presented by some of the leading experts in the field. The speakers will also discuss and speculate about the most promising and most exciting future directions this topological branch of research might possibly take.

Overview of Invited Talks and Sessions

(Lecture room H1)

Invited Talks

SYTI 1.1	Wed	9:30–10:10	H1	**Topological insulators and topological superconductors** — •Shoucheng Zhang
SYTI 1.2	Wed	10:10–10:50	H1	**Three-dimensional topological insulators and superconductors** — •Yoichi Ando
SYTI 1.3	Wed	10:50–11:30	H1	**Interplay of magnetic and electronic states in pyrochlore iridates** — •Leon Balents
SYTI 1.4	Wed	11:40–12:20	H1	**Magnetic imaging of edge states** — •Kathryn Moler
SYTI 1.5	Wed	12:20–13:00	H1	**Sub-nm wide edge states at the dark side of a weak topological insulator** — •Markus Morgenstern

Sessions

SYTI 1.1–1.5	Wed	9:30–13:00	H1	**Topological Insulators: Status Quo and Future Directions**

SYTI 1: Topological Insulators: Status Quo and Future Directions

Time: Wednesday 9:30–13:00 Location: H1

Invited Talk SYTI 1.1 Wed 9:30 H1
Topological insulators and topological superconductors — •Shoucheng Zhang — Dept of Physics, Stanford University

In this talk, I will first give a brief overview on topological insulators and superconductors. I will then discuss the recent theoretical prediction and the experimental observation of the quantum anomalous Hall effect in magnetic topological insulators. I shall present a newly predicted material called stanene, and discuss its potential applications.

Invited Talk SYTI 1.2 Wed 10:10 H1
Three-dimensional topological insulators and superconductors — •Yoichi Ando — II. Physikalisches Institut, Universität zu Köln

A topological quantum state of matter is characterized by a nontrivial topological structure of its Hilbert space. 3D topological insulators are characterized by non-trivial Z_2 topology, which is due to band inversion caused by strong spin-orbit coupling [1]. Intriguingly, when superconductivity shows up upon doping charge carriers into 3D topological insulators, the resulting superconducting state can also be topological [2], because the strong spin-orbit coupling could lead to an unconventional gap function characterized by a new Z_2 topological invariant [3]. In this talk, I will present experimental realizations of these materials and report recent efforts to address their exotic properties.

[1] Y. Ando, J. Phys. Soc. Jpn. **81**, 102001 (2013)
[2] Y. Ando and L. Fu, Ann. Rev. Cond. Mat Phys. **6**, 361 (2015)
[3] S. Sasaki, M. Kriener, K. Segawa, K. Yada, Y. Tanaka, M. Sato, and Y. Ando, PRL **107**, 217001 (2011)

Invited Talk SYTI 1.3 Wed 10:50 H1
Interplay of magnetic and electronic states in pyrochlore iridates — •Leon Balents — University of California, Santa Barbara, CA, USA

The pyrochlore iridates are a series of compounds undergoing antiferromagnetic ordering and metal-insulator transitions. They are of interest because they combine electron correlation effects and the potential for non-trivial band topology. We will discuss the theoretical picture of these materials, from electronic structure to magnetism and phase transitions, and how they may be controlled through applied fields and temperature. Comparison will be made between theory and recent experiments.

10 min. break

Invited Talk SYTI 1.4 Wed 11:40 H1
Magnetic imaging of edge states — •Kathryn Moler — Stanford University

Beautiful theoretical proposals launched the field of topological materials, followed rapidly by great initial successes in synthesizing and demonstrating several topological insulators. The challenges now are to understand and control edge and surface scattering, to find materials with no bulk states and large gaps for high-temperature operation, and most importantly, to fabricate integrated devices that include gates, superconductors, and ferromagnets. Scanning SQUID microscopy can aid this effort by imaging magnetism, superconductivity, and current flow. Images of current flow in two quantum spin hall insulators verify that currents really do flow on the edges, provide images of the developing edge states with voltage and temperature, and also help reveal the conditions for achieving topological vs. trivial edge states. Sensitive magnetic measurements characterize superconductor * topological insulator structures, and help to determine the conditions for achieving exotic Josephson junctions.

Invited Talk SYTI 1.5 Wed 12:20 H1
Sub-nm wide edge states at the dark side of a weak topological insulator — •Markus Morgenstern — II. Institute of Physics B and JARA-FIT, RWTH Aachen, 52074 Aachen

Three-dimensional insulating crystals, which respect time reversal symmetry, can be classified as trivial insulators, strong topological insulators and weak topological insulators (WTIs). Many examples of trivial or strong topological insulators are known, but WTIs have barely been probed. They offer pairs of topologically protected surface states on most surfaces, but exhibit one dark surface without such surface states. The step edges of this dark surface naturally belong to the bright surfaces such that they contain spin helical edge states with perfect e^2/h conductivity. The first WTI $Bi_{14}Rh_3I_9$ was synthesized recently [1]. Here, we show by scanning tunneling spectroscopy that the edge states indeed exist and are below 1 nm wide. They can be scratched into the surface using an atomic force microscope providing a simple tool to guide them [2]. Moreover, it is shown that the edge state can be removed by chemically dimerizing adjacent layers of the WTI. Strategies to bring the edge state to the Fermi level are discussed.

[1] B. Rasche, A. Isaeva, M. Ruck, S. Borisenko, V. Zabolotnyy, B. Büchner, K. Koepernik, C. Ortix, M. Richter, and J. van den Brink, Nature Mater. **12**, 422 (2012)
[2] C. Pauly, B. Rasche, K. Koepernik, M. Liebmann, M. Pratzer, M. Richter, J. Kellner, M. Eschbach, B. Kaufmann, L. Plucinski, C. M. Schneider, M. Ruck, J. van den Brink, and M. Morgenstern, Nature Phys. **11**, 338 (2015)