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Topic:

Topological Matter and Dirac Fermions : from fractional quantum Hall systems to graphene and topological insulators.

Abstract:

An exciting new development in condensed matter physics over the last decade is the beautiful realization of topological field theories in strongly correlated electronic systems, where topological field theories are shown to provide a classification of order due to macroscopic entanglement that is independently of symmetry breaking. The fractional quantum Hall (FQH) state is the first known example of such a quantum state that exhibits no spontaneous broken symmetry, and its properties depend only on its topology rather than geometry, which is topologically distinct from all other quantum states classified by broken symmetry. Recently, the quantum spin Hall (QSH) states and the topological insulators (TIs) have emerged as a new class of topological matter and have stimulated intense research activities. One of the novel properties associated with these topological states is the presence of a Dirac spectrum of chiral low-energy excitations, which is a salient feature of the "Dirac materials". More generally, the Dirac materials are a new class of matter that exploits the mapping of electronic band structures and an embedded spin or pseudo-spin degree of freedom onto the relativistic Dirac equation. These materials have provided an arena in condensed matter for investigating the topological phases of massless and massive Dirac fermions.

This talk will begin with an overview of the properties of two exemplifying Dirac materials: graphene and the surface state (SS) of three-dimensional (3D) TIs, followed by discussion of our new findings from scanning tunnelling spectroscopic (STS) studies of Dirac fermions in graphene and the SS of a strong topological insulator (STI), Bi_2Se_3. For mono-layer graphene grown on Cu by chemical vapor deposition (CVD), we observe evidence for strain-induced scalar and gauge potentials. Additionally, spontaneous time-reversal symmetry breaking is manifested locally at the two sublattices of graphene while global time-reversal symmetry is preserved under the presence of pseudo-magnetic fields. For Bi_2Se_3 epitaxial films grown by molecular beam epitaxy (MBE), spatially localized unitary impurity resonances are observed, which are characteristic of the SS of a 3D-STI and are consequences of the strong topological protection of the SS against impurities. Finally, new possibilities of exploring the topological phases of Dirac materials for a range of applications will be discussed, which include *strain engineering* of graphene, quantum computation based on the *Majorana fermions* at the interface of 3D-STIs and *s*-wave superconductors, and sensitive magnetometers based on the *axion effect* of TIs.

Education:

* B.Sc. degree in Physics from National Taiwan University in 1983.
* Ph.D. degree in Physics from MIT in January 1988.

Experience & Current Position:

From January 1988 to August 1989,Prof. Yeh was a visiting scientist at IBM, Thomas J. Watson Research Center , and she joined the Caltech faculty in August 1989. Prof. Yeh has been a Professor of Physics at California Institute of Technology (Caltech) since 1997.

Research interests:

Prof. Yeh's principal research field is experimental condensed matter physics. Her current research interests include superconductivity, magnetism, spintronics, graphene and related nano-structures, topological insulators, and nano-science and nano-technology.

Honors:

*Fellow, American Association for the Advancement of Science.
*Fellow, American Physical Society.
*Distinguished Alumni Award, Department of Physics, National Taiwan University.
*Fellow, The Institute of Physics, UK.
*Achievement Awards, Southern California Chinese-American Faculty Association.
*Outstanding Young Researcher Award, Overseas Chinese Physics Association.
*Packard Fellowship for Science and Engineering.
*Sloan Research Fellowship.
*Luise Meyer-Schutzmeister Memorial Award.

Sponsor:

*行政院國家科學委員會 National Science Council
*國立台灣大學物理系 Department of Physics, National Taiwan University
*美國物理學會 American Physical Society