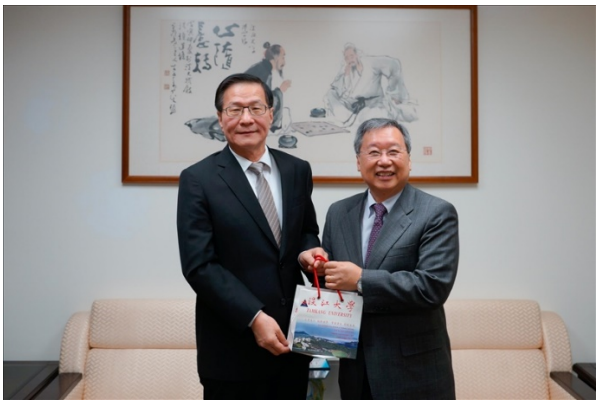
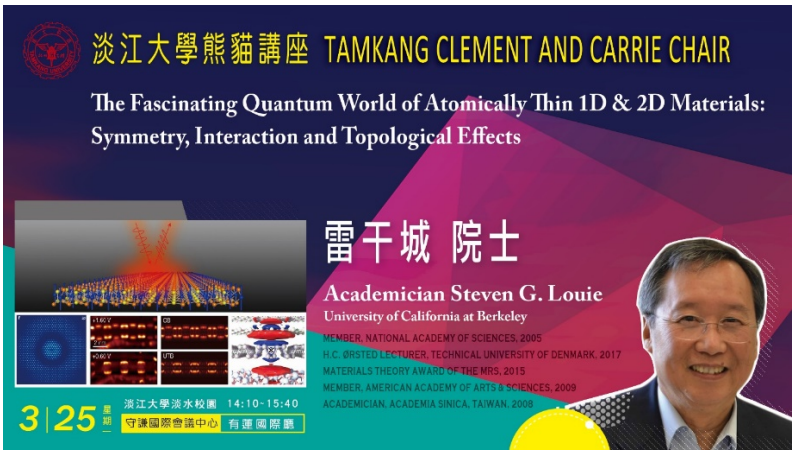
LECTURE 6



Dr. Steven G. Louie

- **Member, National Academy of Sciences, USA, 2005**
- **Fellow, Materials Research Society, 2019**
- **H.C. Ørsted Lecturer, Tech. U. of Denmark, 2017**
- **Materials Theory Award of the MRS, 2015**
- **Member, American Academy of Arts & Sciences, 2009**
- **Academician, Academia Sinica, Taiwan, 2008**

Date: 2019.03.25

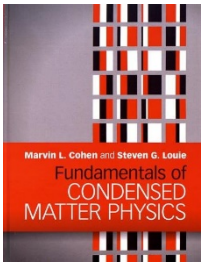


INTRODUCTION

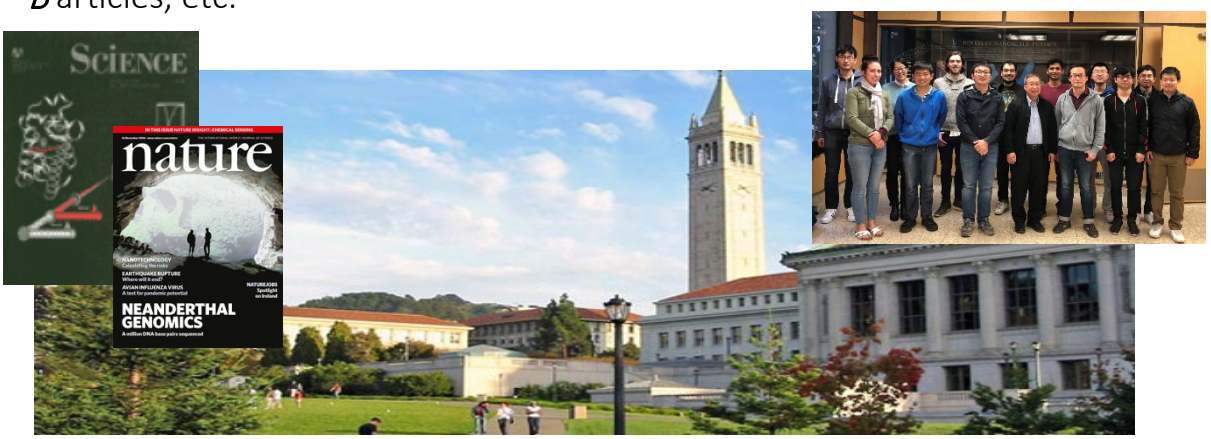
- Professor Louie received his Ph.D. in physics from the University of California at Berkeley (UC Berkeley) in 1976.
- After having worked at the IBM Watson Research Center, Bell Labs, and U of Penn, he joined the UC Berkeley faculty in 1980, where he is professor of physics and concurrently a faculty senior scientist at the Lawrence Berkeley National Lab.
- He is a member of the National Academy of Sciences, the American Academy of Arts & Sciences, and the Academia Sinica (Taiwan), as well as a fellow of the American Physical Society (APS) and the American Association for the Advancement of Science.
- Among his many honors, he is recipient of the APS Aneesur Rahman Prize for Computational Physics, the APS Davisson-Germer Prize in Surface Physics, the Materials Theory Award of the Materials Research Society, the Foresight Institute Richard P. Feynman Prize in Nanotechnology, the U.S. Department of Energy Award for Sustained Outstanding Research in Solid State Physics, as well as Jubilee Professor of the Chalmers University of Technology in Sweden and H. C. Ørsted Lecturer of the Technical University of Denmark.
- Professor Louie's research spans a broad spectrum of topics in theoretical condensed matter physics and nanoscience. He is known for his groundbreaking work on the ab initio quasiparticle excitation method and for his seminal works on: electronic and structural properties of solids, surfaces, and interfaces; quasiparticle and optical excitations; many-body effects in bulk and reduced-dimensional systems;

graphene and graphene nanoribbons; carbon and BN nanotubes; quasi-2D materials; superconductivity; topological phases; electron transport through nanostructures; correlated multi-particle excitations; ultrafast dynamics.

- Professor Louie's significant scholar contributions:
  1. More than **635** scientific publications, with over **69,000** ISI Web of Science citations and an **h-index** of **125**, as of May 2019 (over **92,000** citations and **h-index** of **146** on Google Scholar). Yearly WofS citations is currently at >**5,100**/year.
  2. Identified by the ISI Web of Science as one of the most highly cited researchers in physics, and one of the **25** most highly cited authors in nanoscience.
  3. Publications include: 12 ***Nature***, 8 ***Science***, 130 ***Phys. Rev. Lett.***, 23 "Nature family" (***Nat. Phys.***, ***Nat. Materials***, ***Nat. Nanotech.***, ***Nat. Commun.***, etc), 31 ***Nano Lett.***, 5 ***PNAS***, 6 ***ACS Nano***, 234 ***Phys. Rev. B*** articles, etc.
  4. Awarded **7** U.S. patents
  5. Authored the textbook (with M.L. Cohen): *Fundamentals of Condensed Matter Physics* (Cambridge University, 2016). Co-editor of 3 additional books: *Quantum Theory of Real Materials* (Kluwer, 1996); The *Optical Properties of Materials*, MRS Symp. Proceed. Vol. 579 (MRS, 2000); *Conceptual Foundations of Materials: A Standard Model for Ground- and Excited-State Properties* (Elsevier, 2006).



  6. Originator of **3** widely-use ab initio computational materials software packages: density functional theory code "**PARATEC**", many-electron excited-state properties code "**BerkeleyGW**", and Wannier functions electron-phonon coupling code "**EPW**". All are available freely to users.
  7. More than **550** invited talks at conferences, universities and research institutions.



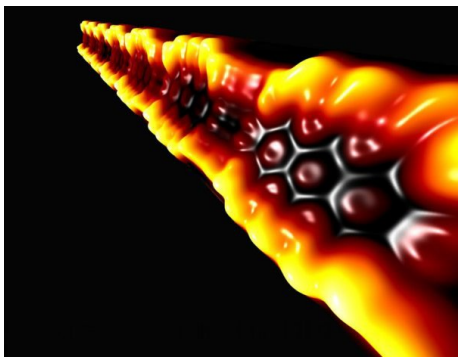
Topic：The Fascinating Quantum World of Atomically Thin 1D & 2D Materials: Symmetry, Interaction and Topological Effects

ABSTRACT

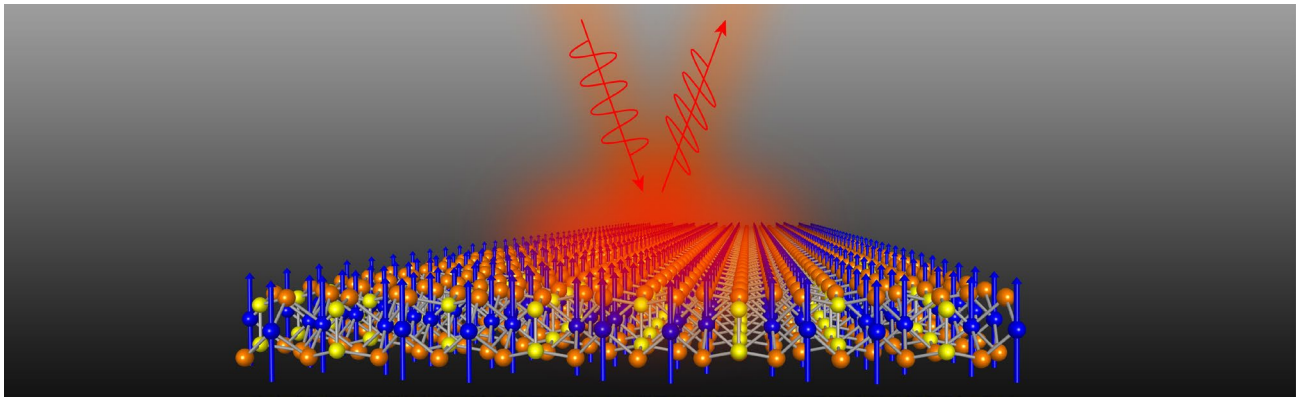
Symmetry, interaction and topological effects, as well as environmental screening, dominate many of the quantum properties of reduced-dimensional systems and nanostructures.

These effects often lead to manifestation of counter-intuitive concepts and phenomena that may not be so prominent or have not been seen in bulk materials.

In this talk, I present some fascinating physical phenomena we discovered in recent studies of atomically thin one-dimensional (1D) and two-dimensional (2D) materials. A number of interesting and unexpected behaviors have been



found – e.g., strongly bound excitons (electron-hole pairs) with unusual energy level structures and new topology-dictated optical selection rules; tunable magnetism and plasmonic properties; novel topological phases; correlated multi-particle excitations; etc. – adding to the promise of 1D and 2D materials for exploration of new science and valuable applications.

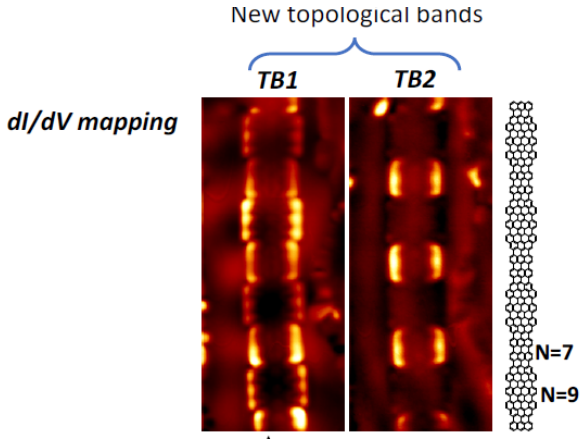


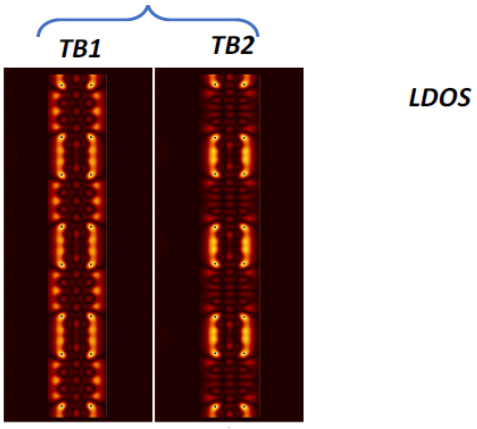
Introduction

The unique electronic and optical properties of quasi 1D and 2D systems can be attributed to their spatial size and restricted geometries yielding quantum confinement, enhanced many-electron interaction, topological, and symmetry effects. Meanwhile, such characters can be significant manipulated and tunable by gating and environmental screening. Therefore, these effects pave a new path to a whole zoo of novel properties and phenomena and make the prospects for developing versatile useful applications e.g., optoelectronics, energy conversion/generation, etc. from these low-dimensional nano-systems.

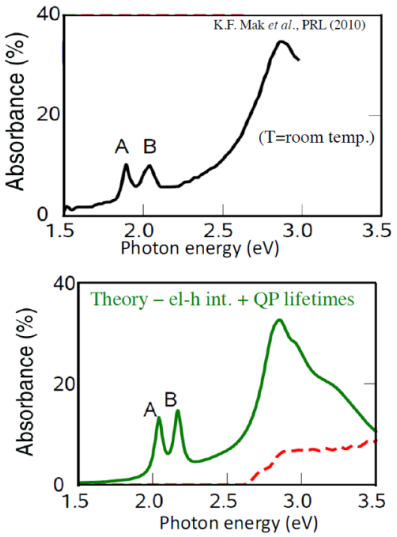
Three main topics of Prof. Louie's talk included: 1) electronic topological phases in graphene nanoribbons (GNR), 2) interaction, topology and screening effects in atomically thin 2D and 1D crystals, and 3) intrinsic and tunable 2D magnetism.

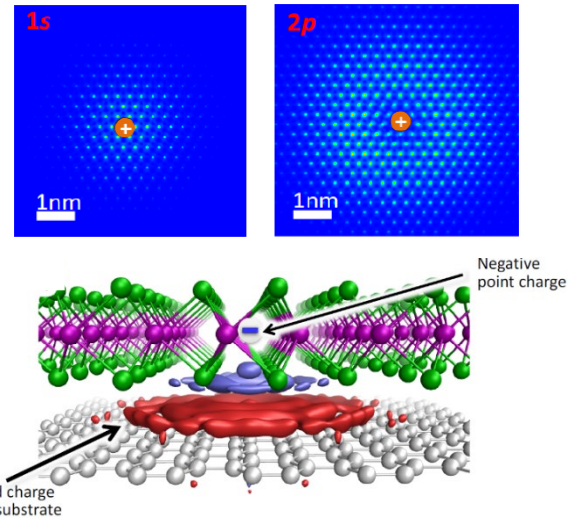
Firstly, in an excellent agreement with experimental spectroscopies, Prof. Louie successfully predicted new topological bands in GNR which can change the bandgap and bandwidth by changing the segment length.



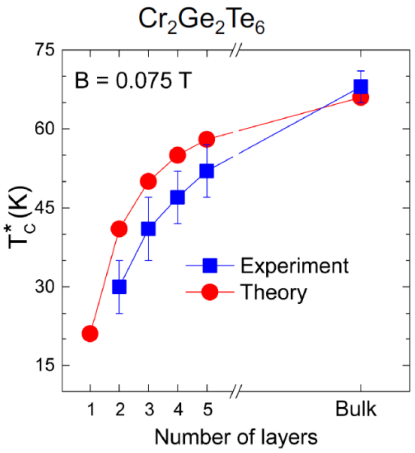


Secondly, according to unconventional electron interaction and screening in atomically thin 2D semiconductors, diverse and novel excitons and important environmental screening effects can be expected. Prof. Louie's group demonstrated theoretically unique Wannier excitons and substrate screening which had been observed from optical spectrum of monolayer MoS2 and/or on bilayer graphene. Meanwhile, dramatically new optical selection rules and multi-particle excitations has also been unveiled to dominate optical spectroscopies in 2D materials.





Finally, Prof. Louie indicated that a small applied field leads to an effective anisotropy that is much greater than the near-zero magnetocrystalline anisotropy, opening up a large spin-wave excitation gap. In fact, this phenomenon can be theory and show that the unusual field dependence of the transition temperature is a hallmark of soft, two-dimensional ferromagnetic van der Waals crystals, such as the nearly ideal two-dimensional Heisenberg ferromagnet Cr2Ge2Te6.

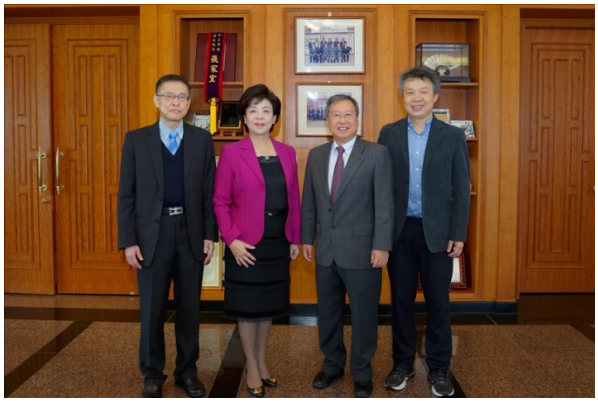


Concluding Remarks

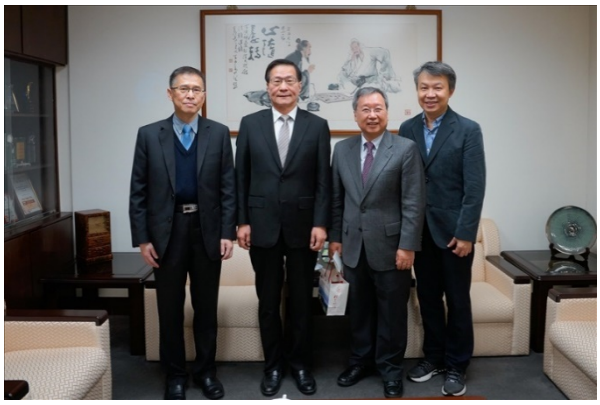
Atomically thin 1D & 2D crystals are different & potentially very useful.

- Novel properties which can be tuned by substrate and gating
- Enhanced electron-electron interactions
- Environment screening is central
- New topological phenomena that may be manipulated for science & technologies
- New optical selection rules in 2D with topological bands
- Intrinsic, highly tunable magnetism for ultra-compact spintronics
- Many, many more fascinating properties (e.g., highly tunable magnetism, valley dichroism, electron super-collimation by disorder, ...)

MINUTE



Met with Chairman of the Board, Dr. Flora Chia-I Chang and TKU colleagues



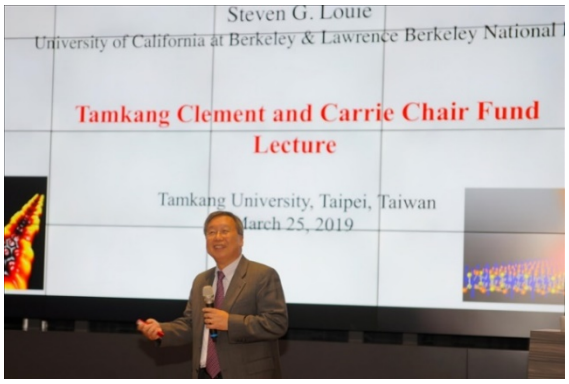
Met with President, Dr. Huan-Chao Keh and TKU colleagues

- Prof. Louie visited Tamkang University on March 23-31, 2019. Prof. Hung-Chung Hsueh at Department of Physics at TKU made receptions and accompanied him during his stay. His visit was honored by Tamkang Clement and Carrie Chair Lecture Fund and the Ministry of Science and Technology in Taiwan.

- Before the Chair Lecture at TKU, Prof. Louie visited President, Dr. Huan-Chao Keh and Chairman of the Board, Dr. Flora Chia-I Chang. Warmest welcomes were presented to The Chair Lecture.

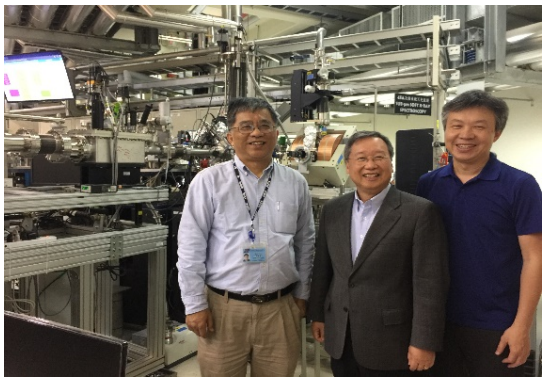
- During the Lectures, science and engineering faculty and students were crowded at the international conference center to listen to the two-hour chair speech on *The Fascinating Quantum World of Atomically Thin 1D & 2D Materials: Symmetry, Interaction and Topological Effects*. When delivering his speech, Prof. Louie received great attentions from the audience, and interacting with the audience during the Q&A session successfully.

Group photo with TKU colleagues

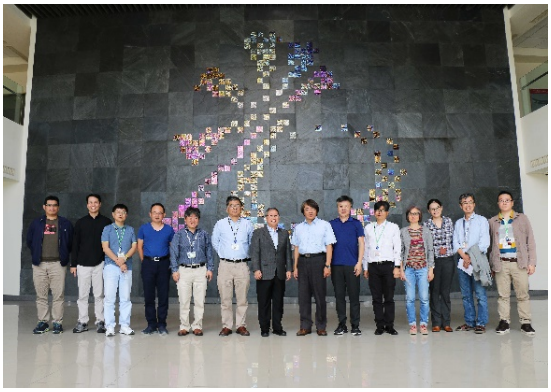


Delivering the Tamkang Clement and Carrie Chair Lecture at The International Convention Centre

- Besides TKU, during Prof. Louie's stay, he was also invited by Dr. Gwo-Huei Lou, the Director of National Sychrotron Radiation Research Center (NSRRC), to visit NSRRC and had a fruitful discussion with the experimental research teams on March 27. Especially, Prof. Louie was very impressed by the state-of-the-art facility of TPS 45 submicron soft X-ray beamline constructed by X-ray research group of the Physics Department at TKU.



Visit TPS 45 beamline with Prof. Hung-Chung Hsueh and Prof. Way-Faung Pong.



Group photo with NSRRC and TKU colleagues