Joint CQSE and CASTS Seminar

Weekly Seminar
Dec. 29, 2017 (Friday)

TIME Dec. 29, 2017, 14:30 ~ 15:30
TITLE Gauge Theory in Modern Applications & Electronic
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Abstract

Gauge concept had evolved **[1]** from Faraday's electrotonic state of matter, Maxwell's gauge freedom, Weyl's gauge invariance, to Yang and Mills' non-commutative symmetry in the standard model. In condensed matter, gauge theory is studied in superconductivity and quantum Hall effects. Recently (21st century), gauge concepts emerged with interesting physical significance in the technologies of electronics, spintronics, and photonics, on the meso/nanoscale as well as the quantum-info scale. These technologies can be realized in solid state materials from metal, semiconductor, carbon (graphene), to insulators (topological). In this talk, we will describe the non-Abelian gauge physics **[2, 3]** that exists in a wide range of material system with spin orbit coupling. We discuss its relation to the classical notion of forces and velocities, and its measurement in technologically relevant parameters of conductivity and voltage. We will give a specific introduction to the spin orbit torque, which is gaining popularity in the engineering physics community working on magnetic non-volatile memory. We first derived a concise formula for the field-like spin orbit torque in 2007 **[4]** based on the gauge theory, and the formula was experimentally confirmed recently **[5]**. Today research is ongoing in using the physics of spin orbit torque to switch the binary states of magnetic memory. We will also introduce the significance of gauge theory in the spin Hall effect (SHE), the spin version of the classical Hall effect. We also describe a full treatment of SHE using the gauge theoretic approach, and show the need for corrections to the results of SHE conductivity previously derived in many well-known material systems.

[1] CN Yang, Phys. Today 67, 45 (2014).

[2] Takashi Fujita, MBA Jalil, SG Tan, Shuichi Murakami, J. Appl. Phys. (Appl. Phys. Rev.) 110, 121301 (2011); Seng Ghee Tan, Mansoor BA Jalil, J. Phys. Soc. Japan 82, 094714 (2013).

[3] Seng Ghee Tan, Mansoor BA Jalil, Introduction to the Physics of Nanoelectronics, Woodhead Publishing (2012).

[4] SG Tan, MBA. Jalil, and X.-J. Liu, arXiv:0705.3502 (2007); SG Tan, MBA Jalil, X.-J. Liu, and T. Fujita, Ann. Phys. 326, 207 (2011).

[5] Ioan Mihai Miron et al. Nature Materials 9, 230 (2010); JunYeon Kim et al., Nature Materials 12, 240 (2013); JunYeon Kim et al., Phys. Rev. B 89, 174424 (2014).