

# Joint CQSE and CASTS Seminar

Weekly Seminar  
Nov. 16, 2012 (Friday)

TIME Nov. 16, 14:30 ~ 15:30  
TITLE Spin pumping, spin torque transfer and spintronics  
SPEAKER Prof. Ching Ray Chang  
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PLACE Rm716, CCMS & New Physics Building, NTU

## Abstract

We study spin and charge currents pumped by precessing magnetization of a single ferromagnetic layer within the multilayer structures, ferromagnet|insulator|ferromagnet (F|I|F) and ferromagnet|insulator|normal-metal (F|I|N). These multilayer structures are in contact with two metallic probes whose bias potentials are zero. The whole pumping problem can be greatly simplified by adopting a rotation that converts the original time-dependent Hamiltonian into a time-independent one. In this rotation frame, where the magnetization is static, these junctions are mapped onto a four-terminal dc circuit whose effectively half-metallic ferromagnetic electrodes are biased by the frequency  $\hbar\omega/e$  of microwave radiation driving magnetization precession at the ferromagnetic resonance FMR conditions. Adoption of this rotation also yields a clear physical picture that can explain that when the system is spatially symmetric, the pumped spin currents are pure, namely, without charge currents concomitant. In F|I|F junctions, we show that pumped spin current, diminished behind the tunnel barrier and increased in the opposite direction, is filtered into charge current by the second F layer to generate dc pumping voltage of the order of one micro-volt (at FMR frequency 10 GHz) in an open circuit. In F|I|N junctions, several orders of magnitude smaller charge current and the corresponding dc voltage appear concomitantly with the pumped spin current due to barrier induced asymmetry in the transmission coefficients connecting the four electrodes in the rotating-frame picture of pumping.

