Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **2565** Type: **Oral (Non-Student) / Orale (non-étudiant(e))**

Cavity Spintronics: Foundations and Applications of Spin-Photon Hybridization

Wednesday, 5 June 2019 10:45 (15 minutes)

Light-matter interactions lie at the heart of condensed matter physics, providing physical insight into material behaviour while enabling the design of new devices. Perhaps this is most evident in the push to develop quantum information and spintronic technologies. On the side of quantum information, engineered light-matter interactions offer access to and control of quantum states. Meanwhile insights into spin-photon manipulation are driving the development of spintronic technologies. In this context the discovery of hybridization between ferromagnets and cavity photons has ushered in a new era of light-matter exploration at the crossroads of quantum information and spintronics. The key player in this rapidly developing field of cavity spintronics is a new quasiparticle, the cavity-magnon-polariton (CMP). In this talk I will describe the defining characteristics of the CMP and recent spintronic applications. In the last few years we have developed a comprehensive theoretical framework of spin-photon hybridization, which has revealed the electrodynamic origin of hybridization. As I will describe, this model is supported by our experimental observations and is motivated by a deeper microscopic description. Based on this foundation in depth experimental investigations of the coupled spin-photon system have been performed. For example, we have found that hybridization will influence spin current generated through the spin pumping mechanism, demonstrating a firm link between spin-photon coupling and spintronics. Furthermore, several in-situ coupling control mechanisms have been revealed and utilized to perform non local spin current manipulation over distances of several centimetres. These many recent developments represent only the first steps in this exciting frontier of condensed matter research lying at the crossroads of magnetism and cavity quantum electrodynamics.

Papers Published During Thesis Work (Selected)

M. Harder et al. PRL 121, 137203 (2018) (Editor's Suggestion)
M. Harder et al. PRB 95, 214411 (2017)
L. Bai, M. Harder et al. PRL 118, 217201 (2017)
H. Maier-Flaig, M. Harder et al. APL 110, 132401 (2017)
M. Harder et al. PRB 94, 054403 (2016)
M. Harder et al. Science China 59, 117511 (2016)
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L. Bai, M. Harder et al. PRL 114, 227201 (2015) (Editor's Suggestion)

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Session Classification: W1-8 Probing and controlling matter with light II (DCMMP) | Sonder et contrôler la matière avec de la lumière II (DPMCM)

Track Classification: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)