Spin excitations for microwave generation and information processing

Dr. Alexandre Hamadeh

Fachbereich Physik, AG Magnetismus, Rheinland-Pfälzische Technische Universität, Kaiserslautern, Germany

Institut de Chimie Physique et Matériaux (ICPM) – Technopôle, 1 Bd. Arago, 57078 Metz
Séminaire du laboratoire LCP-A2MC – Salle de réunion de Chimie
Vendredi 8 mars 2024 – 14h

This seminar will present two areas of study focusing on the potential and methods for exciting spin for microwave generation and data processing.

The first part of the seminar will delve into the field of spintronics, emphasizing the recent developments in the use of spintronics for microwave devices. Our research has led to the experimental observation of simultaneous multimode emission of incommensurate microwave oscillations in spin-transfer oscillators. This achievement is significant because of the oscillators' DC-to-GHz conversion capabilities, which are based on spin transport and magnetoresistance effects at nanoscale dimensions. In addition, their nonlinear dynamics and compatibility with CMOS technology are remarkable. I will present the microscopic processes behind this observation, such as parametric four-magnon scattering and hybridization of eigenmodes in magnetic multilayers, which provide insights into frequency co-generation and mode-splitting manipulation [1].

The second part of the seminar will focus on magnon-phonon coupling. The generation of magnons by phonons has been studied extensively in recent years, mainly because of the potential to add reconfigurability and non-reciprocity to phononic systems, such as surface acoustic wave filters, through their hybridization with magnons. First, I will show how phonons can enhance magnonic circuits by creating amplifiers and frequency converters for magnons, as well as by exciting the nonlinearity of magnons [2,3]. In addition, I will discuss how these excitations lead to the accumulation of phonons in YIG (yttrium iron garnet) structures at a comparatively low power threshold. Finally, I will explain how phonons can excite non-uniform magnetization, i.e. vortex configurations [4].

[1] Science Advances 9 (50), eadk1430(2023); [2] IEEE Transactions on Nanotechnology 22, 806-810 (2023); [3] Adv. Electron. Mater. 9, 230052 (2023), [4] Applied Physics Letters 123 (13) (2023)