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Ultrafast magnetic phenomena at the nanoscale: from all-optical switching to zero-bias anomalies

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One of the major challenges in information technology is to find new paradigms to increase computing speed and storage capacity in magnetic media. Any manipulation of the magnetization inherently involves control of its dynamical behavior, which is rich of phenomena that can spans several orders of magnitude in length and timescales. While fantastic progress has been achieved in both the experimental and theoretical arenas to address and excite magnetic moments at ultrafast scales, several questions remain unsolved. From the theory side, the underlying problems offer formidable computational challenges because of the complex interactions with the surrounding degrees of freedom.

In this talk I will address the possibility of using a single laser pulse for ultrafast all-optical switching of the magnetization of an elementary ferromagnet such as bulk Ni. I will provide the parameter space of the laser pulse enabling the magnetic reversal of Ni moments as predicted from our recently developed theoretical framework, parameterized with density functional theory calculations. I will discuss the real-time evolution of the magnetic moments up to few picoseconds and dissect various intertwined spin-dynamics regimes. Then I will switch to the dynamical behavior characterizing single atoms on surfaces, which are naturally subject to strong quantum spin-fluctuations. Combining time-dependent density functional theory and many-body perturbation theory, I will show how such fluctuations affect the magnetic stability of spin moments by renormalizing the magnetic anisotropy energy [1] as well as magnetic exchange interactions [2]. Finally, I will demonstrate that current-driven spin-state manipulation in nano-devices leads to rich transport patterns [3] with new many-body features, spinarons, with a lifetime of the order of hundreds of femtoseconds resulting from the interaction of the electrons and the spin-excitations. Some of the observed zero-bias anomalies are usually misinterpreted as being Kondo features [4].

[1] Ibanez-Azpiroz et al., Nanoletter Nanoletters 16, 4305 (2016).
[2] Bouaziz et al., PRR 2, 043357 (2020).
[3] Ibanez-Azpiroz et al., PRL Phys. Rev. Lett. 119, 017203 (2017).
[4] Bouaziz et al., Nat. Commun. 11, 6112 (2020).

Für diese Zeit steht eine Kinderbetreuung nach vorheriger Anmeldung zur Verfügung.

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