Understanding and controlling antiferromagnetic metals; towards ultrafast computing

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Antiferromagnets offer ultrafast spin dynamics driven by uniquely strong atomic-scale exchange interactions. The versatile spin couplings can be technologically exploited in devices for ultrafast spintronics, potentially overcoming the frequency limitations of current ferromagnetism-based technologies.

Our project aims at the theoretical understanding of ultrafast spin dynamics in antiferromagnetic materials thereby quantifying and controlling basic mechanisms and parameters. The long term goal is to fully describe the fundamental processes occurring in antiferromagnets which requires the implementation of complementary theoretical techniques covering both atomic scale modeling with extreme temporal resolution and micromagnetic simulations for slower, long-range emergent phenomena. We will develop novel theoretical tools to unveil the role of exchange-driven spin interactions that are at the basis of the useful yet often still puzzling dynamics in antiferromagnets.

We plan to study prototypical antiferromagnetic materials with distinct microscopic properties, including helical spin structures, collinear antiferromagnets with two-dimensional electronic surface states, and spintronic semi-metals. For these promising materials we will address spin dynamics driven by impulsive photoexcitation spanning all relevant timescales from few hundred femtoseconds to nanoseconds.