Alter-fast Dynamics: Optical Studies of Engineered Altermagnetism

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We propose a study to investigate magneto-optical interactions in novel altermagnetic materials, develop tools to interrogate the newfound material class at ultrafast timescales, and realize dynamically controllable spin-polarized states. Altermagnets exhibit ferromagnetic properties such as anomalous Hall effect, spin-polarized current, and the magneto-optical Kerr effect, while also possessing fast, terahertz-range, spin excitation resonance frequencies, typically characteristic of antiferromagnets. This presents unique opportunities for ultrafast magneto-optoelectronic control of spin and angular momentum at timescales and strengths that are inaccessible to traditional magnets, pushing spintronics through a technology-limiting frequency barrier and allowing for devices with novel detection modes and readouts. We aim to identify optical signatures of altermagnetic materials using ultrafast pump-probe techniques, study the spin dynamics and spin excitations using time-domain optical spectroscopy, and engineer altermagnetism using stacked structures and study their optical properties. These techniques serve as critical tools for engineering and discovering new altermagnets that can overcome barriers associated with switching speeds and exchange interactions of traditional magnets, paving the way ultrafast magnetic memory, multiferroics, photomagnetism and neuromorphics.