Coherent ultrafast magnetism induced by femtosecond laser pulses

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The quest for ultrafast magnetic processes has triggered a new field of research—femtomagnetism: using femtosecond laser pulses to demagnetize ferromagnetic metallic thin films. Despite being the subject of intense research for over a decade, the underlying mechanisms that govern the demagnetization remain unclear. Here, we investigate how an ultrashort laser pulse couples to the spin of electrons in ferromagnetic metals. It is shown that a single 50-fs laser pulse couples efficiently to a ferromagnetic film during its own propagation. This result indicates that the material polarization induced by the photon field interacts coherently with the spins. The corresponding mechanism has its origin in relativistic quantum electrodynamics, beyond the spin–orbit interaction involving the ionic potential. In addition, this coherent interaction is clearly distinguished from the incoherent ultrafast demagnetization associated with the thermalization of the spins. We forecast that the corresponding coherent self-induced processes are the dawn of a new era for future research in magnetism.