Ultrafast Light to Steer Electroncs and Switch Magnetic Moments

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The enormous electric field strength of ultrafast laser waveforms allows to steer electronic motion and control electronic excitation so fast, that secondary processes disrupting coherence and striving for an equilibrium have hard time catching up – even in condensed phase systems.

We investigate the opportunities this temporal segregation offers to transfer coherent control ideas in atomic and molecular ensembles to solids. I will discuss two experiments demonstrating that single cycle optical fields allow manipulating electronic and spin degrees of freedom in solid state systems at optical clock rates faster than de-coherence. Sub-femtosecond carrier injection in the band-structure of dielectrics interfaced to electronic circuitry demonstrate the feasibility of ultrafast, coherent optoelectronic applications up to 1 Petahertz frequencies[1]. As a corollary of this ultrafast coherent modification of the electronic system, in suitably chosen hetero-structures also the spin system can be manipulated coherently. Optically induced spin transfer is demonstrated as a route to the direct, all-optical manipulation of macroscopic magnetic moments on previously inaccessible attosecond timescales[2] and a path to arrange magnetic domain patterns with light.

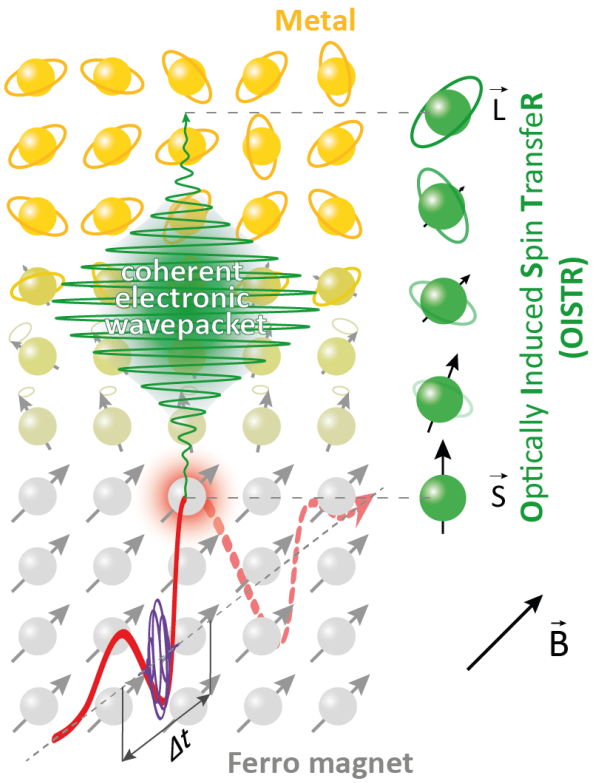

Figure 1: Control of magnetism through light-field driven charge transfer

Could this provide a pathway to turn something more magnetic via illumination? As an outlook of the talk I will discuss our recent activities targeted at inducing magnetic order via light in ferromagnetic/dielectric hetero-structures.

References

[1] M Ossiander, K Golyari, K Scharl *et al.*, Nat. Commun. **13**, 1620 (2022)

[2] F Siegrist, J A Gessner, M Ossiander *et al.*, Nature **571**, 240 (2019)