

Femtosecond dynamics of quantum materials

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From the outset of research into femtomagnetism, the field in which spins are manipulated by light on femtosecond or faster time scales, several questions have arisen and remain highly debated: How does the light interact with spin moments? How is the angular momentum conserved between the nuclei, spin, and angular momentum during this interaction? What causes the ultrafast optical switching of magnetic structures? What is the ultimate time limit on the speed of spin manipulation? What is the impact of nuclear dynamics on the light-spin interaction?

In my talk I will advocate a parameter free *ab-initio* approach to treating ultrafast light-matter interactions, and discuss how this approach has led both to new answers to these old questions but also to the uncovering of novel and hitherto unsuspected spin dynamics phenomena [1,2]. In particular I will highlight following aspects of ultrafast dynamics:

- (a) Femto- phono- magnetism: an extra degree of control over spin dynamics can be obtained by selective excitation of phonon modes [3].
- (b) Pulse design: control of spin- valley- tronics via pulse shaping [4,5].
- (c) Spin vacuum switching: full reversible switching using spin-currents[6].
- (e) Exciton dynamics: strong correlations between excitons and free carriers.

References

- [1] Dewhurst et al., *Nano Lett.* **18**, 1842 (2018).
- [2] Siegrist et al. *Nature* 571, **240** (2019)

[3] Sharma et al. *Sci. Advs.* 8, **eaq2021** (2022)

[4] Sharma et al. *Optica* 9 (8), 947-952 (2022)

[5] Sharma et al. *Sci. Advs.* 9, **eadf3673** (2023)

[6] Harris-Lee et al. *Sci. Advs.* (2024)