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Tailoring light for efficient chiral sensing and manipulation: opportunities at FERMI

Chiral molecules exist in pairs of mirror-reflected versions: the left and right enantiomers, which behave identically unless they interact with another chiral entity. Since most biomolecules are chiral, opposite enantiomers behave differently in biochemical and pharmaceutical contexts, making chiral recognition vital. However, traditional chiroptical methods are not efficient because the rely on the (chiral) helix that circularly polarised light draws in space [1]. The pitch of this helix is orders of magnitude larger than the molecules, which leads to tiny enantiosensitivity (<0.1%). In other words, the enantiosensitive response of the molecules is typically weak because it arises beyond the electric-dipole approximation.

Here I will show how we can tailor light in time and in space to drive ultrafast chiral electronic currents inside the molecules via purely electric-dipole interactions. These light-driven currents interact with the chiral molecular skeleton (its natural "corkscrew") in a highly enantiosensitive manner, leading to efficient chiral sensing and manipulation. I will present and connect several strategies, which involve non-collinear optical setups [2-4], tightly focused laser beams [5,6], vortex light [7], TACOS [8], uniaxial molecular alignment, and optical nanofibers. I will discuss how we can bring these ideas to free-electron lasers (FEL), taking advantage of important developments in FEL science and technology that enable the generation of phase-locked two-colour radiation with controlled polarisation at FERMI.

References

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