Project Title: **Creating Twisted Electric Fields to Manipulate Chiral Matter**

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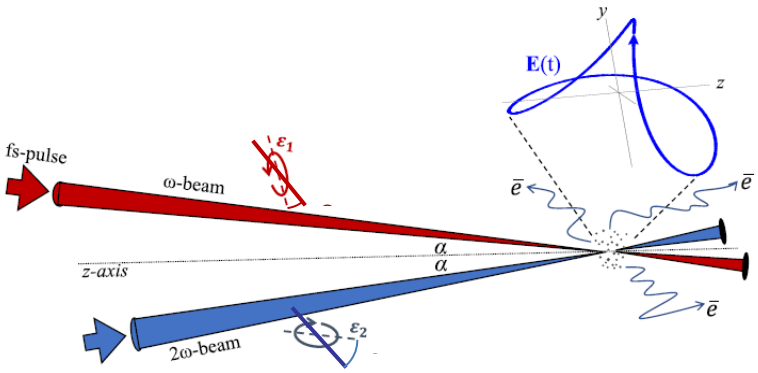

Project

A chiral object has no internal plane of symmetry and its mirror image cannot be superimposed on itself. An example is a pair of hands which look almost identical but their difference is evident when you interact with another chiral object, e.g. a handshake. In biology, the building blocks of life such as sugars, amino acids, and DNA are chiral and exist ~~as~~ only in one-handed form. The origin of this homochirality in Nature is one of the great unanswered questions in Science. As a result, chirality is very important to the pharmaceutical industry as the interaction drugs have with the body critically depends on the handedness of the molecule.

Being able to preferentially manipulate or even distinguish a chiral molecule from its mirror image is difficult, typically requiring interaction with another chiral object. The electric field vector of circularly polarised light, which maps out a spiral as it propagates, can be used in this way but the chiral interaction is very weak as the length of the spiral is much longer than the size of the molecule, i.e. it is not manifested in the dipole approximation. Effectively, it does not have much of a twisting effect on the electrons in the molecule.

In this project, by overlapping multiple laser pulses, exotic polarization states of light will be created so that the electric field maps out twisting 3D shapes in space. This will enable the laser pulse to couple more strongly with a chiral molecule relative to its mirror image. Such a tool could be used to sensitively identify which of the mirror pair is present or even be used as optical tweezers to physically separate molecules of different handedness. Such a tool would be invaluable for chiral drug discovery and manufacturing.

Skills/knowledge gained

Ultrafast femtosecond laser technology, non-linear optics, light polarization and light-matter interactions, electron spsectroscopy. Skills include coding in Matlab/Python/Labview, 3D visualisation techniques, vacuum technology, particle detectors.

References

Strong chiral dichroism and enantiopurification in above-threshold ionization with locally chiral light, O Neufeld et al., Physical Review Research, **3**, L032006 (2021)

Determining Molecular Chirality with Femtosecond Lasers, C. Bond, PhD thesis (2021) - https://pure.qub.ac.uk/files/238774588/CaoimheBond_Thesis.pdf