Project Title: Generation of Exotically Polarised Light to Manipulate Matter

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Type of Project: EXPERIMENTAL

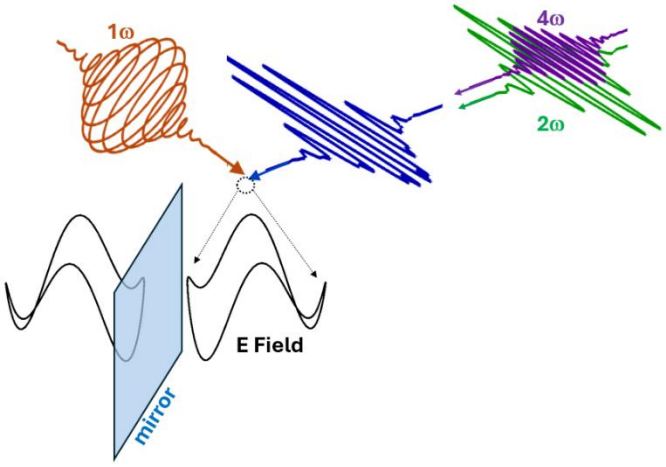
Helpful existing knowledge: Electromagnetism and optics, Python or Matlab skills

Funding status: Royal Society International Exchange – funds a collaboration with University of Bordeaux

Project Description

Light is a transverse wave and normally we think of its polarisation states as being linear, elliptical or circular. Controlling the polarisation, and hence the electric field, of light allows us to manipulate electrons in matter for scientific research and many applications (e.g. LCD displays and 3D glasses). Ultrashort, intense laser pulses are particularly interesting as the strength of electric field allows new phenomena to be investigated, such as using lasers for particle acceleration.

But what if we had more control of the electric field and its interactions? New theoretical studies suggest if lasers of different colours and polarisation states are crossed, at their intersection point the electric field will oscillate in an exotic polarisation state which could revolutionise how light can control matter. In particular, the resulting 3D field can map out a 'chiral' pattern, where there is no internal plane of symmetry and its mirror image cannot be superimposed on itself.



These chiral pulses have been predicted to preferentially manipulate or distinguish chiral molecules (such as DNA and proteins) from their mirror image. In this project, it is the aim to be the first demonstrate this experimentally and therefore unlock the potential for lasers to manipulate chiral matter. This could have profound implications in medicine and the pharmaceutical industry.

Skills gained by student

- Simulation skills using Matlab or Python
- Automated experimental control
- Machine Learning Optimisation
- Data Analysis
- Ultrashort pulse lasers and optics
- Vacuum Technology
- Mass Spectrometry

Useful references

Quantum control of photoion circular dichroism using orthogonal laser beams, J.B. Greenwood & L. Donnelly, Phys. Chem. Chem. Phys., 27, 11079 (2025) https://doi.org/10.1039/D5CP01127B

Synthetic chiral light for efficient control of chiral light–matter interaction, D. Ayuso et al., Nat. Phot., 13, 866–871 (2019) doi.org/10.1038/s41566-019-0531-2