Fully funded PhD studentship: Theoretical and Computational Attosecond Chiral Physics

Extreme Light Consortium (XLC), Quantum Optics and Laser Science, Blackett Laboratory, Imperial College London, UK

This PhD project aims to expand the emerging field of *Attosecond Chiral Physics* by developing new optical methods for efficient chiral discrimination[1-3], enantio-separation, and ultrafast imaging and control of chiral electron and nuclear dynamics, which occur at the attosecond to femtosecond timescales. The selected candidate will work closely with the XLC team combining theoretical and numerical approaches, and will have the opportunity to be involved in pioneering experiments.

Chirality is a ubiquitous property of light and matter. Chiral molecules appear in pairs of left- and right-handed enantiomers, two non-superimposable mirror twins. They behave identically, unless interacting with another chiral object. This asymmetry plays key roles in science, from particle physics to biomedicine. For instance, the chiral molecules in our bodies make our interaction with chiral drugs enantio-sensitive: one molecular enantiomer can be an effective medicine, whereas its mirror twin is less effective, not effective at all, or even poisonous. Being able to distinguish them is therefore vital, especially since more than half of the drugs currently in use are chiral.

Traditional chiro-optical methods rely on the electronic response of matter to both the electric and magnetic components of a circularly polarised wave, i.e. on the chiral molecule "feeling" the light's helix. However, the micron-scale pitch of this helix is too large compared to the angstrom-scale size of the molecules, leading to extremely weak chiro-optical signals and a justified impression that chiral discrimination is difficult, especially on ultrafast time scales. In other words, chiro-optical effects are usually weak (<0.1%) because they arise beyond the electric-dipole approximation.

We can bypass this fundamental limitation with *synthetic* chiral light[1], which is *locally* chiral (within the electric-dipole approximation): the tip of the electric field vector draws a chiral, 3D Lissajous curve in time, at each point in space, see Fig. 1a. Control over the temporal structure of the optical field enables the highest possible degree of control over the enantio-sensitive response of chiral matter: quenching it in one enantiomer while maximising it in its mirror twin, Fig. 1b.

Applicants should hold a MSc in Physics, Chemistry, or a closely related subject by the start of the studentship, and have a strong interest in theoretical and computational methods for Atomic, Molecular, and Optical Physics. Funding covers fees and a tax-free stipend of £17-18k per year, conference travel and consumables. Please contact Dr David Ayuso on d.ayuso@imperial.ac.uk for more information about the project, the team, and the application process.

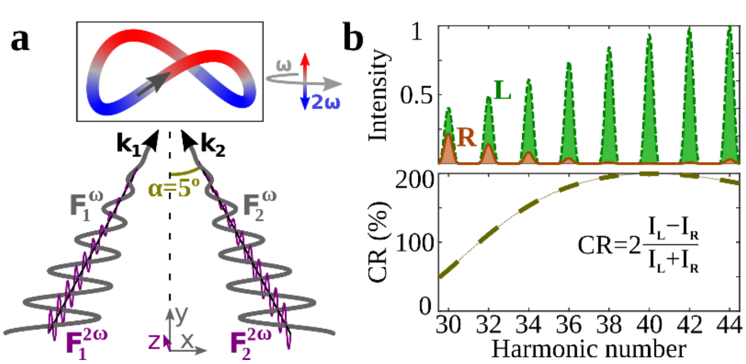

Fig. 1. a, Synthetic chiral light[1] is created with two non-collinear lasers carrying orthogonally polarised ω and 2ω colours. The total ω field is elliptical in the xy plane, the 2ω field is z-polarised, generating the chiral 3D Lissajous curve in the inset. **b**, Even harmonic intensity emitted by left- and right-handed propylene oxide and chiral response, see [1].

[1] D. Ayuso et al, *Nature Photonics* **13**, 866–871 (2019)
[2] D. Ayuso et al, arXiv:2004.05191 (2020)
[3] D. Ayuso et al, arXiv:2011.07873 (2020)