# X-ray Beams from Laser-driven Plasma Mirrors

**Supervisor:** Dr Mark Yeung (m.yeung@qub.ac.uk), Centre for Light Matter Interactions

**Overview**

Intense laser pulses irradiating solid targets will ionise the surface, turning it into a plasma state. The resulting high density of free electrons means that this surface not only acts like a mirror (reflecting light like a conductor) but also moves under the influence of the intense electromagnetic fields which drive it to speeds approaching the speed of light. The reflected laser therefore undergoes a huge Doppler shift that can reach X-ray wavelengths while preserving the coherent beam properties of the incident laser. These X-ray beams are also compressed in time down to attosecond scale (10-18s) durations similar to the sources that underpinned the recent Nobel prize in physics for attosecond science <https://www.nobelprize.org/prizes/physics/2023/summary/>. In addition to attosecond science, these beams have applications in ultrafast biological imaging, probing warm dense matter states and even exploring the quantum vacuum.

A major challenge in this research area is the sensitivity of the conversion efficiency to the initial plasma conditions and laser properties. Many of the applications need high efficiencies to maximise the energy and intensity of the X-ray pulses.

This project will explore the use of machine learning techniques to determine optimal parameter ranges and uncover the key differences in the microscopic dynamics that determine the efficiency of the mechanism. This will be applied to particle-in-cell (PIC) simulations that numerically model the interaction with the intention that these will also inform future experiments.

**Required Background**

Some basic programming experience in Matlab or Python would be beneficial. The main physics topics are electromagnetism, optics and relativity.

**Further Reading**

The following webpage has some animations of PIC simulation results that illustrate the mechanism.

<https://loa.ensta-paris.fr/research/pco-research-group/attosecond-physics-on-relativistic-plasma-mirrors/>