Project title: Ultrafast interaction of ionising radiation in matter: tracking material damage and breakdown.

Supervisor(s): Prof Brendan Dromey, Dr Mark Yeung

Email contact: b.dromey@qub.ac.uk, m.yeung@qub.ac.uk

Helpful existing knowledge: Secondary radiation source generation from relativistic laser plasmas.

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Project Description:

This project will focus on the emerging use of ultrafast pulses of laser driven ions to initiate damage cascades in technologically and biologically relevant materials [1]. For decades pulsed ion interactions have been limited to the > 100 ps regime due the inherently long pulse duration from hot cathode radiofrequency cavity ion sources. This prohibits the study of interactions in the critical transition regime from ultrafast free carrier transport to diffusive excited species propagation governed by Fourier dynamics. This requires ~ picosecond (10^{-12} s) ion pulses to observe the resulting excitation dynamics. The recent confirmation of few picosecond proton pulses generated using the Taranis laser system in the Centre for Light Matter Interactions provides a solid platform to advance these studies to a wide range of materials [1-4].

In addition, this project will extend this work to investigate optical modification of matter, tracking excitation dynamics and the measuring the factors underpinning Laser Induced Breakdown.

The successful applicant will work in tandem with experienced researchers in the Centre for Light Matter Interactions designing and implementing experiments on the Taranis laser system. New techniques will be developed to study the transient spectroscopic features of ion induced damage in condensed matter as well as working on improving the efficiency and spectral characteristics of the ultrafast ion pulses. This project will also provide exceptional grounding in cutting edge ultrafast laser technology and the opportunity to travel to major large laser facilities around the world (i.e. lasers at the Central Laser Facility, and in Jena and Munich in Germany) with an emphasis on a results driven program. There will also be emphasis on working with cutting edge particle in cell code simulations to develop and theoretical understanding of the mechanisms underlying these processes

[1] A. Prasselsperger, *Phys. Rev. Lett.* **127**, 186001 (2021) link

[2] M Coughlan *et al* *New J. Phys.* **22** 103023 (2020) link

[3] B. Dromey et al., *Nature Communications* **7**, 10642 (2016) link

[4] J. P. Kennedy, *et al., Phys. Rev. Lett.* **133**, 135001 (2024) link

Eligibility criteria for applicants:

- **Nationality:** Any nationality is eligible to apply for this project.
- **Doctoral degree:** Must not hold a doctoral degree at the time of recruitment.
- **Enrolment:** Must be enrolled in a doctoral program in Queen's University Belfast during the project.
- **Mobility rule:** Must not have resided or carried out their main activity (work, studies, etc.) in the United Kingdom for more than 12 months in the 36 months immediately before the recruitment date.
- **Visa:** Where applicable, the applicant must meet the Immigration Rules of the United Kingdom to qualify for a 'long-stay' visa.