Project title: Compact Laser-Driven Neutron Beamline for Advanced Applications in Science and Healthcare

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Helpful existing knowledge: UG degree in Physics, Plasma physics, Neutronics, Experimental skills and Python

Funding status: The studentship is awarded through Queen's Collaborative Studentship scheme for a **duration of 3.5 years**. The tuition fees and stipends will be paid as per Department for the Economy (DfE) guidelines and there will be a salary top-up of £2.5k per annum. Travel and accommodation costs during student's time at the CLF and ISIS will also be fully covered.

Project Description:

Neutrons serve as powerful tools for studying the structure and dynamics of matter, offering unique insights that cannot be achieved with charged particles or X-rays. However, traditional neutron facilities—costing billions and requiring extensive infrastructure—are limited to a few global sites. With continuous advancements in high-power laser technologies over the decades, laser-driven sources now have the potential to match the brightness of conventional accelerators while being significantly more compact and affordable, thus making them accessible to a broader research community. This PhD project provides an exciting opportunity to shape the future of neutron science by developing high-brightness beams from facilities that are orders of magnitude smaller and cheaper than existing accelerators.

Based at Queen's University Belfast (QUB) and conducted in close collaboration with the Central Laser Facility (CLF) [1] and the ISIS Neutron and Muon Source [2], this PhD will focus on developing a high-repetition-rate, laser-driven neutron beamline at the newly established Extreme Photonics Applications Centre (EPAC) [3]. EPAC is a national £80M facility at CLF, jointly funded by UKRI, the Ministry of Defence (MoD), and industry partners. It hosts a world-leading 10 Hz petawatt-class laser system designed to revolutionise laser-driven accelerator research in the UK. The beamline created through this project will be optimised for major healthcare applications such as Boron Neutron Capture Therapy (BNCT)[4], an alternative cancer treatment that could become much more accessible with compact neutron sources, as well as neutron radiography and scattering for scientific and industrial research [5,6]. These goals represent a unique intersection of fundamental physics, engineering innovation, and societal impact.

The United Kingdom has been at the forefront in developing high-intensity lasers and laser-based radiation sources. Laser-driven neutrons have been a key research focus of the supervisory teams from QUB and the CLF for over a decade, with a significant track record of high-impact publications. The student will have the opportunity to design and test the neutron beamline in stages through a well-coordinated programme, drawing on the access to world-class experimental platforms, advanced computational resources, and the expertise available at QUB, CLF, and ISIS. This integrated environment will provide excellent support, training, and supervision to the student, ensuring both their success and that of the project.

Useful references

[1] https://www.clf.stfc.ac.uk/Pages/home.aspx
[2] https://www.isis.stfc.ac.uk/Pages/home.aspx
[3] https://www.clf.stfc.ac.uk/Pages/EPAC.aspx
[4] K. Nedunchezhian et al., Boron Neutron Capture Therapy - A Literature Review, DOI: 10.7860/JCDR/2016/19890.9024
[5] CLF Highlight - https://www.clf.stfc.ac.uk/Pages/Laser-driven-moderated-neutrons-.aspx;
[6] S. R. Mirfayzi et al, Recent developments on plasma-based neutron sources from microscopic innovations to meter-scale applications, https://doi.org/10.35848/1347-4065/ad9f00