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Developing terahertz radiation sources for particle acceleration: A route to future table-top accelerators

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Radio-frequency (RF) accelerating cavities used in current particle accelerators are limited to accelerating gradients of 100 MVm-1. To achieve the desired increase in acceleration gradient for future particle accelerators while enabling a reduction in the size and cost requires a fundamentally new approach. Free-space acceleration with ultrafast laser driven terahertz radiation sources offers a promising alternative. Such terahertz radiation sources can provide electromagnetic pulses with electric field strengths in excess of 100 MVm-1 and they have an oscillation period which matches the particle bunch lengths produced in RF accelerators.

The challenge in using freely propagating electromagnetic radiation for particle acceleration is in maximising the interaction length between the radiation and the particle beam. The phase slippage of the radiation with respect to the particle bunch velocity, v, can limit the effective interaction length as $v < c$. In comparison to using optical frequencies, the use of terahertz frequency radiation is attractive because the particle bunches and radiation pulses can remain in phase over longer distances.

In this talk I will present our work on developing ultrafast laser-driven terahertz radiation sources suitable for the acceleration of charged particles and our work in realizing a proof-of-principle terahertz acceleration experiment. This will include a discussion of our work on developing sources which can produce radiation with a novel polarization state aligned along the direction of beam propagation and our more recent work on developing a terahertz source with a sub-luminal phase velocity that can be tuned to match the velocity of a particle beam.

Speaker Biography

Darren Graham is a lecturer in the School of Physics and Astronomy at the University of Manchester. He uses ultrafast laser-based THz techniques to develop novel THz frequency radiation sources and exploits THz radiation to manipulate particle beams. He has published over 35 papers, with 833 citations and has a h-index of 13. He has held several international collaborative grants with researchers in Japan, Germany, and Ireland, and sits on the committee of the Institute of Physics Quantum Electronics and Photonics group.

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