

Dr Matthew J. Duff

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RESEARCH INTERESTS

The focus of my research career to date has been intense laser-matter interactions, specifically, the influence of quantum electrodynamics (QED) effects in laser-solid interactions. My research has involved a combination of experimental, computational and theoretical investigations. An achievement of my experimental work is the discovery of a novel method for generating complex modes of light via laser-solid interactions. My theoretical work has led to improved understanding of radiation generation in laser-plasma interactions, and has been published in the form of two first author, peer-reviewed articles in leading journals.

EDUCATION

PhD in ultra-intense laser-plasma interactions (10/2015-03/2019)

University of Strathclyde

Research topic: High-fields physics effects in ultra-intense laser-plasma interactions

MSc Fusion Energy (09/2014-09/2015)

University of York

Subjects read: Plasma physics, computational methods, nuclear physics

BSc (Hons) Mathematical Physics (09/2010-05/2014)

University of Edinburgh

Subjects read: Quantum physics (perturbation theory, Bell's theorem), quantum theory (path integrals, relativistic quantum theory), electrodynamics, computational physics, symmetries of quantum mechanics (including representation theory of finite groups, theory of angular momentum)

RESEARCH EXPERIENCE

Theoretical modelling: Strong theoretical background in quantum physics, as a result of my BSc (Hons) in Mathematical Physics. Achievements include developing a model which incorporates QED effects in radiation pressure acceleration of thin foils, which has been published in a leading journal.

Computer languages: Extensive experience in the use of Matlab for developing theoretical models, data analysis and visualisation, and analysing experimental images. Appreciable experience in Python and in the use of Linux operating systems.

International experience: Highly skilled at delivering oral and poster presentations as a result of presenting my own research at a number of national and international conferences, including; SPIE Opto-electronics in Prague (2016) and EPS High Fields in Belfast (2016).

Communication skills: Demonstrated excellent oral communication skills by supporting PhD students; this includes explaining complex physical phenomena and progressing their work via one-on-one discussions. I also have excellent written communication skills, evidenced by my publication record.

Collaboration skills: Developed and maintained an effective working relationship with the University of York, which has resulted in four publications to date in leading journals. Significantly contributed to eight experimental campaigns at national and international high power laser facilities, in collaboration with academic and industrial partners.

Experimental experience: Experience in planning experimental campaigns at high power laser facilities. Designed, implemented and analysed results from a novel polarimeter diagnostic, leading to a first author experimental publication (currently under peer-review). Developed robust data analysis codes which are routinely used within the group.

Organisational skills: Excellent organisation and prioritisation skills, evidenced by the fact that I split my time between multiple projects during my PhD. This demonstrates resilience and the ability to work to deadlines, given that I completed these projects, and my thesis, on time.

Numerical experience: Highly skilled in the design, running and interpretation of results from numerical simulations covering a wide range of physical phenomena. Knowledge of numerical methods and modifying source code to incorporate new physical features.

Access to supercomputing facilities: Significant experience running simulations, compiling code and visualising data on the ARCHER and Archie-WeSt supercomputers. Also experienced in the secure back up and transfer of large quantities of data from supercomputing facilities.

Project management: Experienced in using the waterfall and Agile project management approaches to effectively manage projects with diverse teams. Specifically, I am effective in employing the 'scrum' Agile methodology, in which daily meetings are held to keep teams up to date, identify problems, and drive research towards completion.

Personal development: Obtained a Postgraduate Certificate in Researcher Professional Development from the University of Strathclyde. This is formal recognition of the traits inherent in a highly skilled researcher, and which can be transferred to other fields of science and to professional work places.

FORMAL TRAINING

SUPA courses: Completed multiple courses through the Scottish Universities Physics Alliance (SUPA) which developed my research knowledge base and core skills. These include Advanced Data Analysis and 'Hands On Writing' which offered practical advice on scientific writing for articles, grants and theses.

Grant / proposal writing: Attended a workshop providing advice on grant writing and significantly contributed to the development of a successful proposal for experimental beam time at the Central Laser Facility, Oxfordshire.

EMPLOYMENT HISTORY

University of Strathclyde, Research Assistant (04/2019-09/2019)

Roles included:

- Participating in multiple projects employing the Agile management methodology, including the use of kanban boards and daily 'scrum' meetings to report progress
- Supporting PhD students via the development of data analysis codes in Matlab, and progressing their work through one-on-one discussions
- Continuing theoretical and computational research into QED phenomena in ultra-intense laser-plasma interactions
- Planning and participating in experimental campaigns and collaborating with the experimental science group at the Central Laser Facility

University of York, Teaching Assistant (09/2014-03/2015)

- Marked assessments and provided feedback for undergraduate physics courses, including Methods of Mathematical Physics and Statistical Mechanics

Culham Centre for Fusion Energy, Summer Research Student (06/2014-08/2014)

- Ran simulations of plasma instabilities, summarised my results in a written report and delivered an oral presentation for the research group at Culham

PUBLICATIONS **Leading author publications:**

1. **M. J. Duff**, R. Capdessus, D. Del Sorbo, C. P. Ridgers, M. King and P. McKenna. ‘Modelling the effects of the radiation reaction force on the interaction of thin foils with ultra-intense laser fields’
Plasma Physics and Controlled Fusion **60**, 064006 (2018)
2. **M. J. Duff**, R. Capdessus, C. P. Ridgers and P. McKenna. ‘Multi-stage scheme for non-linear Breit-Wheeler pair-production utilising ultra-intense laser-solid interactions’
Plasma Physics and Controlled Fusion **61**, 094001 (2019)

Other notable publications:

3. J. M. Cole, K. T. Behm, E. Gerstmayr, T. G. Blackburn, J. C. Wood, C. D. Baird, **M. J. Duff**, C. Harvey, A. Ilderton, A. S. Joglekar, K. Krushelnick, S. Kuschel, M. Marklund, P. McKenna, C. D. Murphy, K. Poder, C. P. Ridgers, G. M. Samarin, G. Sarri, D. R. Symes, A. G. R. Thomas, J. Warwick, M. Zepf, Z. Najmudin and S. P. D. Mangles. ‘Experimental Evidence of Radiation Reaction in the Collision of a High-Intensity Laser Pulse with a Laser-Wakefield Accelerated Electron Beam’
Physical Review X **8**, 011020 (2018)
4. K. Poder, M. Tamburini, G. Sarri, A. Di Piazza, S. Kuschel, C. D. Baird, K. Behm, S. Bohlen, J. M. Cole, D. J. Corvan, **M. Duff**, E. Gerstmayr, C. H. Keitel, K. Krushelnick, S. P. D. Mangles, P. McKenna, C. D. Murphy, Z. Najmudin, C. P. Ridgers, G. M. Samarin, D. R. Symes, A. G. R. Thomas, J. Warwick and M. Zepf. ‘Experimental Signatures of the Quantum Nature of Radiation Reaction in the Field of an Ultraintense Laser’
Physical Review X **8**, 031004 (2018)
5. R. Capdessus, M. King, D. Del Sorbo, **M. J. Duff**, C. P. Ridgers and P. McKenna. ‘Relativistic Doppler-boosted γ -rays in High Fields’
Scientific Reports **8**, 9155 (2018)
6. D. Del Sorbo, D. R. Blackman, R. Capdessus, K. Small, C. Slade-Lowther, W. Luo, **M. J. Duff**, A. P. L. Robinson, P. McKenna, Z. M. Sheng, J. Pasley and C. P. Ridgers. ‘Efficient ion acceleration and dense electron-positron plasma creation in ultra-high intensity laser-solid interactions’
New Journal of Physics **20**, 033014 (2018)
7. K. T. Behm, J. M. Cole, A. S. Joglekar, E. Gerstmayr, J. C. Wood, C. D. Baird, T. G. Blackburn, **M. Duff**, C. Harvey, A. Ilderton, S. Kuschel, S. P. D. Mangles, M. Marklund, P. McKenna, C. D. Murphy, Z. Najmudin, K. Poder, C. P. Ridgers, G. Sarri, G. M. Samarin, D. Symes, J. Warwick, M. Zepf, K. Krushelnick and A. G. R. Thomas. ‘A spectrometer for ultrashort gamma-ray pulses with photon energies greater than 10 MeV’
Review of Scientific Instruments **89**, 113303 (2018)

FORTHCOMING PUBLICATIONS

1. **M. J. Duff**, R. Wilson, M. King, B. Gonzalez-Izquierdo, R. Gray, A. Higginson, S. D. R. Williamson, Z. E. Davidson, R. Capdessus, N. Booth, S. Hawkes, D. Neely and P. McKenna. ‘High power light emission with tunable modes and polarization via a laser-driven relativistic aperture’
Submitted 2019

CONFERENCE PROCEEDINGS

1. **M. J. Duff**, R. Capdessus, D. Del Sorbo, C. P. Ridgers, M. King and P. McKenna
Proceedings of SPIE, 10241 (2017)
2. D. Del Sorbo, D. R. Blackman, R. Capdessus, K. Small, C. Slade-Lowther, W. Luo, **M. J. Duff**, A. P. L. Robinson, P. McKenna, Z. M. Sheng, J. Pasley and C. P. Ridgers
Proceedings of SPIE, 10241 (2017)