

Marcin Mucha-Kruczyński

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I am a theoretical condensed matter physicist interested in the physical properties of two-dimensional atomic crystals, atomically thin materials like graphene or monolayers of transition metal dichalcogenides, as well as of their stacks, referred to as van der Waals heterostructures. My research achievements include, among others, (1) demonstrating the sensitivity of angle-resolved photoemission spectroscopy to electron pseudo-spin in graphene materials, (2) exposing the interplay between band topology and interaction effects in bilayer graphene and contributing to the discovery of the electron nematic phase in this crystal and (3) constructing an effective model for electrons in graphene on hexagonal boron nitride and interpreting the first observation of the fractal electronic spectrum of electrons in 2D in a magnetic field and periodic potential (so called Hofstadter's butterfly). My current work focuses on the impact of the interlayer coupling and atomic registry at the interface between two atomic crystals on the electronic properties of the heterostructure (how properties of the stack emerge from the properties of its components and how they can be tuned by stacking geometry). I study various material systems, from perfect rhombohedral and Bernal graphite to twisted interfaces in graphene, transition metal dichalcogenides, graphene/hBN and others. I am also interested in low-symmetry phases of transition metal dichalcogenides, for example the highly anisotropic rhenium compounds. I have co-authored over 35 peer reviewed articles (including publications in Science, Nature and Physical Review Letters) which have been cited over 1700 times.

Personal Information

Nationality Polish
Date of Birth 18th November 1983
Marital Status Married

Education

07/2007–01/2011 **Ph.D. in Theoretical Physics**, *Lancaster University*, Lancaster, UK.
supervisor Prof. V. I. Fal'ko
10/2002–05/2007 **M.Sc. in Material Engineering**, *Adam Mickiewicz University*, Poznań, Poland.
supervisor Prof. Dr. hab. J. Barnaś
10/2005–06/2006 Socrates/Erasmus exchange student, *Lancaster University*, Lancaster, UK.

Additional qualifications

04/2018 **Fellow of the Higher Education Academy**, *University of Bath*.

Employment and experience

Employment/appointment history

07/2019–onwards **Senior Lecturer/Associate Professor**, *Physics Department, University of Bath*, Bath, UK.
04/2016–onwards **Principal Investigator**, *Centre for Nanoscience and Nanotechnology, University of Bath*, Bath, UK.

- 03/2015–06/2019 **Lecturer/Assistant Professor**, *Physics Department, University of Bath*, Bath, UK.
- 03/2013–02/2015 **University of Bath Prize Fellow**, *Physics Department, University of Bath*, Bath, UK.
- 10/2011–02/2013 **Research Associate**, *Physics Department, Lancaster University*, Lancaster, UK.
- 10/2010–09/2011 **EPSRC PhD+ Fellow**, *Physics Department, Lancaster University*, Lancaster, UK.

Selected Publications

- B. K. Choi et al., *Visualizing Orbital Content of Electronic Bands in Anisotropic 2D Semiconductor ReSe₂*, *ACS Nano* **14**, 7880 (2020).
- J. J. P. Thompson et al., *Determination of interatomic coupling between two-dimensional crystals using angle-resolved photoemission spectroscopy*, *Nature Commun.* **11**, 3582 (2020).
- C. Chen et al., *Emergence of interfacial polarons from electron-phonon coupling in graphene/h-BN van der Waals heterostructures*, *Nano Lett.* **18**, 1082 (2018).
- A. Varlet et al., *Anomalous Sequence of Quantum Hall Liquids Revealing a Tunable Lifshitz Transition in Bilayer Graphene*, *Phys. Rev. Lett.* **113**, 116602 (2014).
- L. A. Ponomarenko et al., *Cloning of Dirac fermions in graphene superlattices*, *Nature* **497**, 594 (2013).
- A. S. Mayorov et al., *Interaction-Driven Spectrum Reconstruction in Bilayer Graphene*, *Science* **333**, 860 (2011).

Teaching

- 02/2016–onwards **Lecturer/Senior Lecturer**, *University of Bath*.
 Taught the following physics courses:
 - PH40084 Advanced Quantum Theory (Spring 2019, Spring 2020, Spring 2021).
 - PH30099 Communicating Physics (mentored group of undergraduates in designing outreach/public engagement activities related to my research, Autumn 2017, Autumn 2018, Autumn 2019)
 - PH20105 Experimental Physics and Computing 2 (responsible for MATLAB programming sessions, Spring 2017, Spring 2018, Autumn 2018, Autumn 2019).
 - PH30030 Quantum Mechanics (Autumn 2016, Autumn 2017).
 - PH20014 Electromagnetism I (Spring 2016, Spring 2017, Spring 2018, Spring 2019, Spring 2020, Spring 2021).
- 10/2015–onwards **Undergraduate Tutor**, *University of Bath*.
 Conducted weekly meetings with two small groups of undergraduate students (one group of 1st and 2nd-year students each) during the academic year to facilitate the understanding of lecture material and provide pastoral support.
- 02/2014–onwards **Lecturer**, *Bristol/Bath Centre for Doctoral Training in Condensed Matter Physics*.
 - Taught half of the *Low-dimensional semiconductors* module every February to the new cohort of CDT PhD students.
 - Regularly supervised Exploratory Training Projects - few-week projects designed to introduce students to various aspects of contemporary condensed matter physics.
- 10/2011–12/2012 **Undergraduate Tutor**, *Physics Department, Lancaster University*.
 - Taught the 1st year one-term Maths Clinic - extra classes to improve students' mathematical abilities (10/2012–12/2012).
 - Conducted fortnightly meetings with first-year students during whole academic year to facilitate the understanding of lecture material (10/2011–06/2012).
- 10/2007–06/2010 **Postgraduate Teaching Assistant**, *Physics Department, Lancaster University*.
 Marked homework assignments and provided help in problem-solving during lecture-related workshops.

Administrative duties

- 07/2018–onwards **Head of Theoretical and Computational Physics Group**, *Physics Department, University of Bath.*
- 10/2016–06/2017 **Learning & Teaching Co-ordinator**, *Physics Department, University of Bath.*
Member of 2-person team reviewing departmental learning and teaching practices
- 10/2016–onwards **Industrial placement assessor**, *Physics Department, University of Bath.*
Visiting students on 10-month-long industrial placements and assessing placement reports
- 10/2015–onwards **Assessor of final year projects**, *Physics Department, University of Bath.*
Final viva voce examiner on B.Sc. and M.Sc. programmes and assessor of final project presentations
- 10/2013–06/2014 **Director of Postgraduate Lecture Series in Nanoscience**, *Physics Department, University of Bath.*
Organization and supervision of nanoscience lectures for PhD students in the department

PhD student supervision

- 10/2019–onwards **Matthew Tomlinson**, *PhD in Physics.*
- 05/2019–onwards **William Luckin**, *PhD in Physics.*
- 05/2017–onwards **Surani Gunasekera**, *PhD in Physics.*
thesis title *Electronic properties of layered rhenium dichalcogenides*
- 05/2016–12/2019 **Aitor Garcia-Ruiz Fuentes**, *PhD in Physics.*
thesis title *Signatures of electronic excitations in Raman spectra of graphene materials*
- 10/2015–06/2019 **Joshua Thompson**, *PhD in Physics.*
thesis title *Electronic phenomena in graphene-based van der Waals heterostructures*
- 10/2014–08/2018 **Damien Leech**, *PhD in Physics.*
thesis title *Theoretical modelling of electronic properties of bilayer graphene-based van der Waals heterostructures*

Selected Invited talks

- *Physics at van der Waals interfaces: Twists, incommensurability and emergent phenomena*, University of Birmingham (Birmingham, UK, 30/01/2020).
- *Physics at van der Waals interfaces: Twists, incommensurability and emergent phenomena* at the Mathematical Institute, University of Oxford (Oxford, UK, 22/05/2019).
- *Modelling band structure and ARPES spectra of van der Waals heterostructures: Impact of incommensurate interfaces and interlayer twists* at the Elettra Synchrotrone (Trieste, Italy, 20/09/2018).
- *Physics at Van der Waals interfaces* at the Lancaster University (Lancaster, UK, 16/02/2018).
- *Moving from two to three dimensions: physics of Van der Waals heterostructures* at the University of Brasília (Brasília, Brazil, 20/11/2017).
- *Angle-resolved photoemission of graphene/hexagonal boron nitride heterostructures* at the National Graphene Institute (Manchester, UK, 07/01/2016).
- *In the land of van der Waals heterostructures: Electronic properties of graphene on hexagonal boron nitride* at the Adam Mickiewicz University (Poznań, Poland, 19/11/2015).

- *Manipulating Lifshitz transition in bilayer graphene* at the University of Exeter (Exeter, UK, 04/11/2014).
- *Anomalous sequence of quantum Hall states in bilayer graphene in strong perpendicular electric fields* at the Indian Institute of Technology Bombay (Mumbai, India, 27/08/2014).
- *Modifying electronic structure of graphene with external perturbations* at the National University of Singapore Graphene Research Centre (Singapore, 31/07/2014).
- *Hofstadter's butterfly in graphene/hBN heterostructures*, Indian Institute of Science (Bangalore, India, 02/05/2014).
- *Electronic states in graphene on hexagonal substrates*, Tata Institute of Fundamental Research (Mumbai, India, 06/11/2013).
- *Dirac cone origami: Electronic structure of graphene/hBN heterostructures* at the CECAM workshop "Novel 2D materials: tuning electronic properties on the atomic scale" (Bremen, Germany, 11-14/06/2013).
- *Miniband structure of Graphene on a Hexagonal Substrate* at the University of Manchester (Manchester, UK, 07/12/2012).
- *Spectrum Reconstruction in Bilayer Graphene (due to Strain and/or electron-electron interaction)* at the American Physical Society March Meeting 2012 (Boston, US, 27/02–02/03/2012).
- *Low-energy electronic dispersion in bilayer graphene under uniaxial strain* at the workshop "Quantum phenomena in graphene, other low-dimensional materials, and optical lattices" (Erice, Sicily, 04-07/07/2011).
- *Epitaxial graphene for devices and quantum metrology* at the National Physical Laboratory (Teddington, UK, 02/02/2011).

Research visits

- 11/2017–12/2017 Universidade de Brasília (Brasília, Brazil).
- 07/2014–09/2015 National University of Singapore Graphene Research Centre (Singapore).
- 07/2014–08/2014 National University of Singapore Graphene Research Centre (Singapore).
- 02/2012–03/2012 Kavli Institute for Theoretical Physics (Santa Barbara, USA).
- 08/2008 Tokyo Institute of Technology (Tokyo, Japan), group of Prof. T. Ando.
- 09/2004 CAESAR Research Centre (Bonn, Germany), group of Prof. M. Giersig.

Conferences and workshops organized

- Electronic structure of 2D materials: theory meets experiment (Diamond Light Source, Didcot, UK, 18–19/07/2017).
- TMD-UK 2016 (Bath, UK, 01–02/09/2016).

Awards and honours

- 2018 University of Bath Excellence Award
- 2017 Institute of Physics James Clerk Maxwell Medal
- 2014 University of Bath Excellence Award
- 2012 University of Bath Prize Fellowship
- 2011 Springer Prize for Excellence in PhD Research

- 2010 EPSRC PhD+ Fellowship
- 2007 Student Poster Prize at IOP Theory of Condensed Matter Group Meeting 2007, Warwick, UK, 17/12/2007.
- 2007 EPSRC PhD scholarship
- 2006 Adam Mickiewicz University Faculty of Physics scientific scholarship
- 2005 Polish Minister of Education and Sport scholarship for outstanding academic achievements
- 2004 Adam Mickiewicz University Faculty of Physics scientific scholarship
- 2003 Adam Mickiewicz University Faculty of Physics scientific scholarship

Other professional activities

Referee for the following journals

- APS journals: Physical Review Letters, Physical Review X, Physical Review B
- NPG journals: Nature Physics, Nature Nanotechnology, Nature Communications
- IOP Publishing: 2D Materials, New Journal of Physics, Journal of Physics: Condensed Matter, Nanotechnology, Journal of Physics D: Applied Physics
- Other: Nanoscale, Solid State Communications, Physica status solidi b, Physics Letters A, Journal of Applied Physics, Physical Chemistry Chemical Physics, Journal of Physical Chemistry C

Memberships

- 2018–onwards Member of the Institute of Physics
- 2008–2013 Associate Member of the Institute of Physics

Languages

Polish	Fluent in speech and writing	<i>Mother tongue</i>
English	Fluent in speech and writing	
German	Elementary	