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Christophe De Beule

Dr. Sc. Physics

Overview

I work on the topological and quantum geometric properties of electrons in low-dimensional materials. Specifically, I use effective continuum theories constrained by symmetry to investigate structural and electronic properties of twisted bilayer graphene and other moiré materials.

Research Highlight

Christophe De Beule, Robin Smeyers, Wilson Nieto Luna, E. J. Mele, and Lucian Covaci, *Elastic screening of pseudo gauge fields in graphene*, arXiv:2409.02250 (under review at PRL). Awarded best poster on fundamentals at Graphene Week 2024.

Pseudo magnetic fields in strained 2D materials are "screened" by optical lattice displacements. Our theory resolves puzzling discrepancies between continuum elasticity and molecular dynamics, and shows that elastic screening drastically changes the electronic properties of corrugated graphene.

Education

2012 – 2017	**PhD Physics**, *Felicitations of the jury*, Condensed Matter Theory group at the University of Antwerp (Belgium), Award date: 23 Nov 2017.
2010 – 2012	**MSc Physics**, *Greatest distinction*, University of Antwerp (Belgium).
2007 – 2010	**BSc Physics**, *Great distinction*, University of Antwerp (Belgium).

Research Experience

03.2022 – present	**Postdoc**, *University of Pennsylvania (USA)*, Group of Eugene Mele, First year supported by an INTER Mobility grant of the Luxembourg National Research Fund.
10.2020 – 02.2022	**Postdoc**, *University of Luxembourg (Luxembourg)*, Group of Thomas Schmidt.
04.2018 – 09.2020	**Postdoc**, *Technical University of Braunschweig (Germany)*, Group of Patrick Recher.
2012 – 2017	**PhD Student**, *University of Antwerp (Belgium)*, CMT group, Supported by PhD fellowship of Research Foundation Flanders. Most prestigious PhD fellowship in Flanders.

Publications

- Fifteen first-author publications;
- Two papers published in PRL (one featured on the cover), one paper published in PNAS, and two currently under review at PRL.

Preprints

[23] Vo Tien Phong, Kason Kunkelmann, **Christophe De Beule**, Mohammed M. Al Ezzi, Robert-Jan Slager, Shaffique Adam, and E. J. Mele. *Squeezing Quantum States in Three-Dimensional Twisted Crystals*, Submitted to Nature. arXiv: 2409.16602.

[22] **Christophe De Beule**, Robin Smeyers, Wilson Nieto Luna, E. J. Mele, and Lucian Covaci. *Elastic screening of pseudo gauge fields in graphene*, Under review at PRL. arXiv: 2409.02250.

[21] Mohammed M. Al Ezzi, Gayani N. Pallewela, **Christophe De Beule**, E. J. Mele, and Shaffique Adam. *Analytical Model for Atomic Relaxation in Twisted Moiré Materials*, Under review at PRL. arXiv: 2401.00498.

Peer-reviewed Articles

[20] **Christophe De Beule**, Steven Gassner, Spenser Talkington, and E. J. Mele. *Floquet-Bloch theory for nonperturbative response to a static drive*. Phys. Rev. B 109, 235421. DOI: 10.1103/PhysRevB.109.235421.

[19] **Christophe De Beule** and E. J. Mele. *Berry Curvature Spectroscopy from Bloch Oscillations*. Phys. Rev. Lett. 131, 196603. DOI: 10.1103/PhysRevLett.131.196603.

[18] **Christophe De Beule**, Võ Tién Phong, and E. J. Mele. *Roses in the nonperturbative current response of artificial crystals*. Proc. Natl. Acad. Sci. U.S.A. 120.43, e2306384120. DOI: 10.1073/pnas.2306384120.

[17] Patrick Wittig, Fernando Dominguez, **Christophe De Beule**, and Patrik Recher. *Localized states coupled to a network of chiral modes in minimally twisted bilayer graphene*. Phys. Rev. B 108, 085431. DOI: 10.1103/PhysRevB.108.085431.

[16] Pok Man Tam*, **Christophe De Beule***, and Charles L. Kane. *Topological Andreev rectification*. Phys. Rev. B 107, 245422. Editors' Suggestion. DOI: 10.1103/PhysRevB.107.245422.

[15] Andreas Haller, Suraj Hegde, Chen Xu, **Christophe De Beule**, Thomas L. Schmidt, and Tobias Meng. *Black hole mirages: Electron lensing and Berry curvature effects in inhomogeneously tilted Weyl semimetals*. SciPost Phys. 14, 119. DOI: 10.21468/SciPostPhys.14.5.119.

[14] **Christophe De Beule**, Võ Tién Phong, and E. J. Mele. *Network model for periodically strained graphene*. Phys. Rev. B 107, 045405. DOI: 10.1103/PhysRevB.107.045405.

[13] Lena Bittermann, **Christophe De Beule**, Daniel Frombach, and Patrik Recher. *Probing Majorana bound states via a pn junction containing a quantum dot*. Phys. Rev. B 106, 075305. DOI: 10.1103/PhysRevB.106.075305.

[12] **Christophe De Beule**, Solofo Groenendijk, Tobias Meng, and Thomas L. Schmidt. *Artificial event horizons in Weyl semimetal heterostructures and their non-equilibrium signatures*. SciPost Phys. 11, 095. DOI: 10.21468/SciPostPhys.11.5.095.

[11] **Christophe De Beule**, Fernando Dominguez, and Patrik Recher. *Network model and four-terminal transport in minimally twisted bilayer graphene*. Phys. Rev. B 104, 195410. DOI: 10.1103/PhysRevB.104.195410.

[10] **Christophe De Beule**, Fernando Dominguez, and Patrik Recher. *Effective Floquet model for minimally twisted bilayer graphene*. Phys. Rev. B 103, 195432. DOI: 10.1103/PhysRevB.103.195432.

[9] **Christophe De Beule**, Peter G. Silvestrov, Ming-Hao Liu, and Patrik Recher. *Valley splitter and transverse valley focusing in twisted bilayer graphene*. Phys. Rev. Res. 2, 043151. DOI: 10.1103/PhysRevResearch.2.043151.

[8] **Christophe De Beule**, Fernando Dominguez, and Patrik Recher. *Aharonov-Bohm Oscillations in Minimally Twisted Bilayer Graphene*. Phys. Rev. Lett. 125, 096402. Featured on cover. DOI: 10.1103/PhysRevLett.125.096402.

[7] **Christophe De Beule**, Rolando Saniz, and Partoens Bart. *Crystalline topological states at a topological insulator junction*. J. Phys. Chem. Solids 128, 144–151. DOI: https://doi.org/10.1016/j.jpcs.2017.12.027.

[6] **Christophe De Beule**, Mohammad Zarenia, and Bart Partoens. *Transmission in graphene–topological insulator heterostructures*. Phys. Rev. B 95, 115424. DOI: 10.1103/PhysRevB.95.115424.

[5] **Christophe De Beule**, Niccolò Traverso Ziani, Mohammad Zarenia, Bart Partoens, and Björn Trauzettel. *Correlation and current anomalies in helical quantum dots*. Phys. Rev. B 94, 155111. DOI: 10.1103/PhysRevB.94.155111.

[4] Matthias Van der Donck, **Christophe De Beule**, Bart Partoens, François M. Peeters, and Ben Van Duppen. *Piezoelectricity in asymmetrically strained bilayer graphene*. 2D Mater. 3.3, 035015. DOI: 10.1088/2053-1583/3/3/035015.

[3] Kirsten Govaerts, Kyungwha Park, **Christophe De Beule**, Bart Partoens, and Dirk Lamoen. *Effect of Bi bilayers on the topological states of* Bi_2Se_3*: A first-principles study*. Phys. Rev. B 90, 155124. DOI: 10.1103/PhysRevB.90.155124.

[2] Kyungwha Park, **Christophe De Beule**, and Bart Partoens. *The ageing effect in topological insulators: evolution of the surface electronic structure of Bi2Se3 upon K adsorption*. New J. Phys. 15.11, 113031. DOI: 10.1088/1367-2630/15/11/113031.

[1] **Christophe De Beule** and Bart Partoens. *Gapless interface states at the junction between two topological insulators*. Phys. Rev. B 87, 115113. DOI: 10.1103/PhysRevB.87.115113.

Invited talks

Aug 2023	Drexel University (USA), *Invited by Prof. Jörn Venderbos.* Current state-of-the art in moiré transition metal dichalcogenides
Aug 2023	University of Antwerp (Belgium), *Invited by Prof. Bart Partoens.* Topological Andreev rectification
Aug 2023	University of Luxembourg (Luxembourg), *Invited by Prof. Thomas Schmidt.* Berry curvature spectroscopy from Bloch oscillations
May 2020	University of Luxembourg (Luxembourg), *Invited by Prof. Thomas Schmidt.* Valley chiral networks in minimally twisted bilayer graphene
Jan 2020	Cheng Kung University (Taiwan), *Invited by Prof. Ming-Hao Liu.* Electronic transport in twisted bilayer graphene
Aug 2019	KU Leuven (Belgium), *Invited by Dr. Kristof Moors.* Valley splitter and transverse valley focusing in twisted bilayer graphene
Feb 2018	TU Dresden (Germany), *Invited by Dr. Tobias Meng.* Topological crystalline states at the interface of two topological insulators
Feb 2018	TU Braunschweig (Germany), *Invited by Prof. Patrik Recher.* Topological crystalline states at the interface of two topological insulators

Teaching Experience

2020	**Introduction to Wolfram Mathematica**, *Theory and exercises*, Course written and initiated by me, TU Braunschweig (Germany).

2020 **Topological Systems and Quantum Computation**, *Exercises*, Prof. Patrik Recher, TU Braunschweig (Germany).

2019 **Dynamics of Fermi liquids in one dimension**, *Exercises*, Prof. Patrik Recher, TU Braunschweig (Germany).

2014 – 2015 **Advanced Quantum Mechanics**, *Exercises and contributed to theory course*, Prof. Bart Partoens, UA (Belgium).

2014 **Analytical Mechanics**, *Exercises and co-developed theory course*, Prof. Bart Partoens, University of Antwerp (Belgium).

2013 – 2014 **Computer Practicum**, *Tutoring and managing of student programming projects in* MATLAB, University of Antwerp (Belgium).

Supervision and mentoring

2024 **Mohammed M. Al Ezzi**, *PhD student*, Group of Prof. Shaffique Adam, National University of Singapore.

2024 – present **Robin Smeyers**, *PhD student*, CMT group, University of Antwerp (Belgium).

2023 – present **Steven Gassner**, *PhD student*, University of Pennsylvania (USA).

2018 – 2021 **Patrick Wittig**, *PhD student*, University of Braunschweig (Germany).

2018 – 2020 **Lena Bittermann**, *PhD student*, University of Braunschweig (Germany).

2015 **Timo Kerremans**, *Bachelor student*, University of Antwerp (Belgium).

Institutional responsibilities

2012 – 2016 **Organization of Physics Colloquia (EPS Young Minds)**, *UA (Belgium).*

2024 – present **Organization of weekly group meetings and invited talks**, *UPenn (USA).*