# Christophe De Beule

*Dr. Sc. Physics*

✉ christophe.debeule@gmail.com
cdebeule.github.io
0000-0002-6214-7150

## Overview

My broad research interests concern the electronic properties of two-dimensional materials such as graphene and van der Waals heterostructures. I am particularly interested in the engineering of quantum geometry and band topology through strain or by combining different materials. My current research focuses on the structural and electronic properties of moiré materials such as twisted transition-metal dichalcogenide bilayers, and the effect of electron-electron interactions on the low-energy moiré bands.

## Research Highlight

**Christophe De Beule**, Robin Smeyers, Wilson Nieto Luna, E. J. Mele, and Lucian Covaci, *Elastic screening of pseudo gauge fields in graphene*, Phys. Rev. Lett. **134**, 046404 (2025). 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

05.2025 – present **Researcher**, *University of Antwerp (Belgium)*, CMT group.

03.2022 – 04.2025 **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

- 16 first-author publications;
- 4 papers published in PRL (one featured on the cover), 1 paper published in PNAS, and 2 currently under review in PRL.

## Preprints

[26] Alina Mreńca-Kolasińska*, **Christophe De Beule***, Jia-Tong Shi, Aitor Garcia-Ruiz, Denis Kochan, Klaus Richter, and Ming-Hao Liu. *Pseudomagnetotransport in Strained Graphene*, arXiv: 2505.21056.

[25] **Christophe De Beule**, Gayani N. Pallewela, Mohammed M. Al Ezzi, Liangtao Peng, E. J. Mele, and Shaffique Adam. *Theory for Lattice Relaxation in Marginal Twist Moirés*, Under review in Phys. Rev. Lett. arXiv: 2503.19162.

[24] Liangtao Peng, **Christophe De Beule**, Du Li, Li Yang, E. J. Mele, and Shaffique Adam. *Magnetism in Twisted Bilayer $WSe_2$*, Under review in Phys. Rev. Lett. arXiv: 2503.09689.

[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*, Accepted in Phys. Rev. B. arXiv: 2409.16602.

## Peer-reviewed Articles

[22] **Christophe De Beule**, Robin Smeyers, Wilson Nieto Luna, E. J. Mele, and Lucian Covaci. *Elastic Screening of Pseudogauge Fields in Graphene*, Phys. Rev. Lett. 134, 046404 (2025). doi: 10.1103/PhysRevLett.134.046404.

[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*, Phys. Rev. Lett. 133, 266201 (2024). doi: 10.1103/PhysRevLett.133.266201.

[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 (2024). 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 (2023). 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, e2306384120 (2023). 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 (2023). 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 (2023). 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 (2023). 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 (2023). 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 (2022). 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 (2021). 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 (2021). 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 (2021). 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 (2020). 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 (2020). 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 (2018). 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 (2017). 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 (2016). 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, 035015 (2016). 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 (2014). 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, 113031 (2013). 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 (2013). DOI: 10.1103/PhysRevB.87.115113.

## Invited talks

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| Jun 2025 | Institute of Physics, Academia Sinica (Taiwan), *Invited by Chen-Hsuan Hsu.*<br>Lattice relaxation, soliton networks, and domain-wall modes in bilayer moirés |
| Apr 2025 | Washington University in St. Louis (USA), *Invited by Shaffique Adam.*<br>Lattice relaxation, soliton networks, and pseudogauge fields in bilayer moirés |
| Apr 2025 | Rutgers University (USA), *Invited by Eva Y. Andrei.*<br>Lattice relaxation, soliton networks, and pseudogauge fields in bilayer moirés |
| March 2025 | Flatiron Institute (USA), *Invited by Valentin Crépel and Nicolás Morales-Durán.*<br>Lattice relaxation in homobilayer twist moirés |
| Jan 2025 | Cheng Kung University (Taiwan), *Invited by Ming-Hao Liu.*<br>Lattice relaxation in homobilayer twist moirés |
| Aug 2024 | Drexel University (USA), *Invited by Jörn Venderbos.*<br>Current state-of-the art in moiré transition metal dichalcogenides |

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

## Teaching Experience

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| 2020 and 2024 | **Introduction to Wolfram Mathematica**, *Theory and exercises*, Course written and initiated by me, TU Braunschweig (2020) and UPenn (2024). |
| 2020 | **Topological Systems and Quantum Computation**, *Exercises*, Prof. Patrik Recher, TU Braunschweig. |
| 2019 | **Dynamics of Fermi liquids in one dimension**, *Exercises*, Prof. Patrik Recher, TU Braunschweig. |
| 2014 – 2015 | **Advanced Quantum Mechanics**, *Exercises and contributed to theory course*, Prof. Bart Partoens, University of Antwerp. |
| 2014 | **Analytical Mechanics**, *Exercises and co-developed theory course*, Prof. Bart Partoens, University of Antwerp. |
| 2013 – 2014 | **Computer Practicum**, *Tutoring and managing of student programming projects in* MATLAB, University of Antwerp. |

## Supervision and mentoring

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| 2024 | **Mohammed M. Al Ezzi**, *PhD student*, Group of Prof. Shaffique Adam, National University of Singapore (Now postdoc in Harvard). |
| 2024 – present | **Robin Smeyers**, *PhD student*, CMT group, University of Antwerp. |
| 2023 – present | **Steven Gassner**, *PhD student*, University of Pennsylvania. |
| 2018 – 2021 | **Patrick Wittig**, *PhD student*, University of Braunschweig. |
| 2018 – 2020 | **Lena Bittermann**, *PhD student*, University of Braunschweig. |
| 2015 | **Timo Kerremans**, *Bachelor student*, University of Antwerp. |

## Institutional responsibilities

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| 2012 – 2016 | **Organization of Physics Colloquia (EPS Young Minds)**, *University of Antwerp.* |
| 2024 – 2025 | **Organization of weekly group meetings and invited talks**, *UPenn.* |