

Petr Stepanov

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Professional Appointments

- Jan 2023** – Assistant Professor of Physics and Astronomy. Quantum Materials Nano-
Current Optoelectronics laboratory. Stavropoulos Center for Complex Quantum Matter.
University of Notre Dame, Notre Dame, IN, USA. [Lab webpage](#).
- Sep 2018** – Marie Skłodowska-Curie PostDoctoral Fellow (PROBIST). **ICFO, Barcelona,**
Dec 2022 **Spain.** Supervised by Prof. Frank H.L. Koppens and Prof. Dmitri K. Efetov.
Optics and electronic transport studies of strongly correlated phenomena in 2D
moiré materials.
- Superconductivity and orbital magnetism (magic angle twisted bilayer
graphene).
- Photocurrent nanoscopy and near-field optics.
- Jan 2017** – Graduate Research Associate, Department of Physics, **The Ohio State**
Aug 2018 **University, Columbus, OH, USA.** Supervised by Prof. Jeanie CN Lau.
Electronic transport studies of 2D materials and their applications.
- Long-distance spin transport in graphene anti-ferromagnets.
- Layered magnetic materials.
- Sep 2012** – Graduate Student Researcher, Department of Physics and Astronomy, **University**
Dec 2016 **of California, Riverside, CA, USA.** Supervised by Prof. Jeanie CN Lau.
Electronic transport studies of 2D materials and their applications.
- Quantum Hall Effect in 2D multi-band heterostructures.
- Phase diagrams in 2D multi-band heterostructures.
- Transport properties of 2D semiconductor materials (TMDs, InSe, CrI₃ etc.).
- Sep 2011** – Exchange Master Thesis Student, Department of Physics, **Arizona State**
Dec 2011 **University, Tempe, AZ, USA.** Supervised by Prof. Robert J. Nemanich.
Experimental studies of thickness dependence of photo and
thermionic emission from nitrogen-doped diamond thin films.

Sep 2009 – Bachelor and Master Thesis Student, Junior Researcher. **Technological Institute for Superhard and Novel Carbon Materials, Troitsk, RU**. Supervised by Prof. Mikhail Y. Popov.
Jun 2012 Experimental studies of nanocomposite materials and their applications.
- Successful improvement of thermoelectric properties of $\text{Bi}_{2-x}\text{Sb}_x\text{Te}_3$ -based nanocomposite materials.

Education

Sep 2012 – **PhD in Physics, Ohio State University, Columbus, OH, USA**
Aug 2018 Research under Prof. Jeanie CN Lau's supervision.
Thesis "Spin and Charge Transport in Monolayer and Trilayer graphene in the Quantum Hall Regime".

Sep 2006 – **Diploma (BSc and MSc) in Applied Physics and Mathematics, Moscow**
Jun 2012 **Institute of Physics and Technology, Moscow, RU**
Research under Prof. Mikhail Y. Popov's supervision.
Thesis "Investigations of Nanostructured and Modified by C_{60} Thermoelectric Materials Based on Bi_2Te_3 " at Technological Institute for Superhard and Novel Carbon Materials. Troitsk, RU.

Publication Summary

25 publications with citations >2000 (Google Scholar) including papers in **Nature (x2)**, **Nature Physics (x4)**, **Nature Materials (x1)**, **PRL (x5)**, **PNAS (x1)**, **Science Advances (x1)**, **NanoLetters (x4)** highlighted by JCCMs, the New York Times, Le Monde, Spektrum, Physics Today, Physics World and more.

Teaching

Spring 2023 – Laser and Modern Optics PHYS30432. Laboratory and lectures.

Fall 2023 – Classical Mechanics PHYS70005. Graduate level course.

Spring 2024 – Quantum Mechanics II PHYS40454. Undergraduate advanced course.

Supervising graduate students and postdoctoral researchers

2023 – Currently QMNO lab hosts 1 postdoctoral researcher (Dr. Bogdan Borodin), 2 graduate students (Mr. Xuanpu Zhang, Mr. Som Subhra Guria) and 1 undergraduate student (Mr. Owen Nettles).

2014 –2022 Supervised >10 graduate students in groups of Prof. Jeanie CN Lau, Prof. Frank H. L. Koppens and Prof. Dmitri K. Efetov.

Fellowships and Awards

Apr 2019 – European Union’s Horizon 2020 research and innovation programme fellowship
Apr 2022 under the Marie Skłodowska- Curie grant agreement No. 754510.

2015 – Benjamin C. Shen Award for outstanding 3rd year graduate student. UCR.

2007–2010 Innovation and Development Foundation undergraduate fellowship. MIPT.

2006 Russian National High School Physics Olympiad (regional level) – 1st prize.

Invited Talks

Feb 2024 “Cryo-Near-Field Photovoltage Microscopy in the Heavy-Fermion Moiré Twisted Symmetric Trilayer Graphene”. **Invited Seminar at the Ohio State University**. Columbus, OH.

Jul 2023 “Strong Electronic Correlations in Moiré Materials”. **Invited Talk at AANL**. Yerean, Armenia.

Jul 2023 “Strong Electronic Correlations in Moiré Materials”. **Invited Talk at Optics11**. Yerean, Armenia.

Dec 2023 “Quantum Heavy Fermion Simulator in Twisted Symmetric Trilayer Graphene”. **Invited Talk at National High Magnetic Field Laboratory**. Tallahassee, FL.

Feb 2023 “Strong Electronic Correlations in Moiré Materials”. **Invited Talk at the University of Kentucky**. Lexington, KY.

Jul 2022 “Cryogenic Photovoltage Nanoscopy of Strong Electronic Correlations in Moiré Materials”. **Invited Talk at Graphene 2022**. Aachen, Germany.

Sep 2021 “Magic angles in graphene”. **Invited Seminar at ITMO University**. Saint-Petersburg, Russia. In-person.

Oct 2020 “Magic angles in graphene”. **Invited seminar at MIPT**. (In Russian). Moscow, RU. [YouTube](#).

- May 2020** “Untying the insulating and superconducting orders in magic-angle graphene”. **NGI Friday Seminar**. Manchester, UK. Online
- Jul 2019** “Superconductors, Orbital Magnets, and Correlated States in Magic Angle Bilayer Graphene”. **The challenge of Two-Dimensional Superconductivity**. Leiden, NL. Presentation slides can be found at <https://2dsuperconductivity.blogspot.com/2019/07/slides-of-presentations.html>.
- Jun 2017** “Long-Distance Spin Transport Through a Graphene Quantum Hall Antiferromagnet”. **CDT Summer Conference**, Cambridge, UK, 2017.
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Skills

Lab skills

Cryogenic scanning near-field optical microscopy (SNOM). Dilution and He³ refrigerators. High magnetic fields (up to 45T). Nanofabrication (e-beam lithography and thin film deposition, plasma etching, wet etching, sputtering, 2D layers dry and wet transfer techniques). AFM. Raman Spectroscopy. TEM. FTIR.

Computing

Igor Pro, OriginLab, MatLab, Python (Data Analysis packages: NumPy, Seaborn, SciKitLearn), C/C++, Objective-C, Swift, Blender, DesignCAD, MySQL, LabVIEW.

Languages

English (full proficiency), Russian (native), Spanish (fair), German (fair)

Referee activity

Nature, Nature Physics, Nature Comm., PRL, PRB, APL, LSA.

References

Available upon request.

Full list of publications

Selected:

1. “Cryogenic nano-imaging of second-order moiré superlattices”. Niels C.H. Hesp, Sergi Batlle-Porro, Roshan Krishna Kumar, Hitesh Agarwal, David Barcons-Ruiz, Hanan Herzig Sheinfux,

Kenji Watanabe, Takashi Taniguchi, **Petr Stepanov**[#], and Frank H.L. Koppens[#]. *Nature Materials*, in print. <https://arxiv.org/abs/2302.05487>. 2024

2."Cryo-Near-Field Photovoltage Microscopy of Heavy-Fermion Twisted Symmetric Trilayer Graphene." Sergi Batlle-Porro, Dumitru Calugaru, Roshan Krishna Kumar, Niels C.H. Hesp, Kenji Watanabe, Takashi Taniguchi, Petr Stepanov[#], and Frank H.L. Koppens[#]. <https://arxiv.org/abs/2402.12296>. 2024

3."Competing zero-field Chern insulators in Superconducting Twisted Bilayer Graphene". **Petr Stepanov**, Ming Xie, Kenji Watanabe, Takashi Taniguchi, Xiaobo Lu, Allan H MacDonald, B Andrei Bernevig, Dmitri K Efetov. *Phys. Rev. Lett.*, 127, 197701. 2021. *Editor's Suggestion*.

4."Untying the insulating and superconducting orders in magic-angle graphene". **Petr Stepanov**, Ipsita Das, Xiaobo Lu, Ali Fahimniya, Kenji Watanabe, Takashi Taniguchi, Frank HL Koppens, Johannes Lischner, Leonid Levitov, Dmitri K Efetov. *Nature*, 583, 375-378. 2020. Highlighted by: [Nature News and Views](#); [JCCM by T. Senthil](#); and more.

5."Superconductors, orbital magnets, and correlated states in magic angle bilayer graphene". Xiaobo Lu, **Petr Stepanov**, Wei Yang, Ming Xie, Mohammed Ali Aamir, Ipsita Das, Carles Urgell, Kenji Watanabe, Takashi Taniguchi, Guangyu Zhang, Adrian Bachtold, Allan H MacDonald, Dmitri K Efetov. *Nature*, 574, 653-657. 2019. Highlighted by: [JCCM by M. Zaletel](#); [The New York Times](#); and more.

6."Long-Distance Spin Transport Through a Graphene Quantum Hall Antiferromagnet." **Petr Stepanov**^{*}, Shi Che^{*}, Dmitry Shcherbakov, Jiawei Yang, Kevin Thilagar, Greyson Voigt, Marc W. Bockrath, Dmitry Smirnov, Kenji Watanabe, Takashi Taniguchi, Roger K. Lake, Yafis Barlas, Allan H. MacDonald, Chun Ning Lau. *Nature Physics*, 14(9), 907-911. 2018. Highlighted by: [Nature Phys. News and Views](#); [physicsworld.org](#).

7."Quantum Parity Hall effect and Topological Phases in ABA Graphene." **Petr Stepanov**, Yafis Barlas, Shi Che, Kevin Myhro, Greyson Voigt, Ziqi Pi, Kenji Watanabe, Takashi Taniguchi, Dmitry Smirnov, Maxim Kharitonov, Fan Zhang, Roger K. Lake, Allan H. MacDonald, Chun Ning Lau. *PNAS*, 116, 10286-10290. 2019

8."Tunable Symmetries of Integer and Fractional Quantum Hall Phases in Heterostructures with Multiple Dirac Bands." **Petr Stepanov**, Yafis Barlas, Tim Espiritu, Shi Che, Kenji Watanabe, Takashi Taniguchi, Dmitry Smirnov, and Chun Ning Lau. *Phys. Rev. Lett.*, 117, 076807. 2016

9."Tuning Spin Transport in a Graphene Antiferromagnetic Insulator." **Petr Stepanov**, Dmitry L. Shcherbakov, Shi Che, Marc W. Bockrath, Yafis Barlas, Dmitry Smirnov, Kenji Watanabe, Takashi Taniguchi, Roger K. Lake, Chun Ning Lau. *Phys. Rev. Applied.*, 18, 014031. 2022

Other (listed chronologically):

10."Infrared Spectroscopy for Diagnosing Superlattice Minibands in Magic-angle Twisted

Bilayer Graphene". Geng Li, Roshan Krishna Kumar#, **Petr Stepanov**, Pierre A. Pantaleón, Zhen Zhan, Hitesh Agarwal, Adrien Bercher, Julien Barrier, Kenji Watanabe, Takashi Taniguchi, Alexey B. Kuzmenko, Francisco Guinea, Iacopo Torre, and Frank H.L. Koppens#. <https://arxiv.org/abs/2404.05716>. 2024

11. "Terahertz photocurrent probe of quantum geometry and interactions in magic-angle twisted bilayer graphene". Roshan Krishna Kumar##, Geng Li*, Riccardo Bertini*, Swati Chaudhary*, Krystian Nowakowski, Jeong Min Park, Sebastian Castilla, Zhen Zhan, Pierre A Pantaleón, Hitesh Agarwal, Sergi Battle-Porro, Eike Icking, Matteo Ceccanti, Antoine Reserbat-Plantey, Giulia Piccinini, Julien Barrier, Ekaterina Khestanova, Takashi Taniguchi, Kenji Watanabe, Christoph Stampfer, Gil Refael, Francisco Guinea, Pablo Jarillo-Herrero, Justin CW Song, **Petr Stepanov**, Cyprian Lewandowski, Frank HL Koppens#. <https://arxiv.org/abs/2406.16532>. 2024

12. "Imaging Chern mosaic and Berry-curvature magnetism in magic angle graphene". Sameer Grover , Matan Bocarsly , Aviram Uri , **Petr Stepanov** , Giorgio Di Battista , Indranil Roy , Jiewen Xiao , Alexander Meltzer , Yuri Myasoedov , Keshav Pareek , Kenji Watanabe , Takashi Taniguchi , Binghai Yan , Ady Stern , Erez Berg , Dmitri K. Efetov and Eli Zeldov. *Nature Physics*. <https://doi.org/10.1038/s41567-022-01635-7>. 2022

13. "Collective excitations in twisted bilayer graphene close to the magic angle". Niels CH Hesp, Iacopo Torre, Daniel Rodan-Legrain, Pietro Novelli, Yuan Cao, Stephen Carr, Shiang Fang, **Petr Stepanov**, David Barcons-Ruiz, Hanan Herzig-Sheinfux, Kenji Watanabe, Takashi Taniguchi, Dmitri K Efetov, Efthimios Kaxiras, Pablo Jarillo-Herrero, Marco Polini, Frank HL Koppens. *Nature Physics*, 17, pp. 1162-1168. 2021. Highlighted by: phys.org

14. "Layer- and gate-tunable spin-orbit coupling in a high-mobility few-layer semiconductor". Dmitry Shcherbakov, **Petr Stepanov**, Shahriar Memaran, Yaxian Wang, Yan Xin, Jiawei Yang, Kaya Wei, Ryan Baumbach, Wenkai Zheng, Kenji Watanabe, Takashi Taniguchi, Marc Bockrath, Dmitry Smirnov, Theo Sigrist, Wolfgang Windl, Luis Balicas, Chun Ning Lau. *Science Advances*, 7(5), eabe2892. 2021

15. "Direct evidence for flat bands in twisted bilayer graphene from nano-ARPES". Simone Lisi*, Xiaobo Lu*, Tjerk Benschop*, Tobias A de Jong*, **Petr Stepanov**, Jose R Duran, Florian Margot, Irène Cucchi, Edoardo Cappelli, Andrew Hunter, Anna Tamai, Viktor Kandyba, Alessio Giampietri, Alexei Barinov, Johannes Jobst, Vincent Stalman, Maarten Leeuwenhoek, Kenji Watanabe, Takashi Taniguchi, Louk Rademaker, Sense Jan van der Molen, Milan Allan, Dmitri K Efetov, Felix Baumberger. *Nature Physics*, 17(2), pp. 189-193. 2021

16. "Mapping local heterogeneity in open twisted bilayer graphene devices". Tjerk Benschop*, Tobias A. de Jong*, **Petr Stepanov***, Xiaobo Lu , Vincent Stalman, Sense Jan van der Molen, Dmitri K. Efetov, Milan P. Allan. *Physical Review Research*, 3(1), 013153. 2021

17. "Substrate-Dependent Band Structures in Trilayer Graphene/hBN Heterostructures". Shi Che*, **Petr Stepanov***, Supeng Ge, Menglin Zhu, Dongying Wang, Yongjin Lee, Kevin Myhro,

Yanmeng Shi, Ruoyu Chen, Ziqi Pi, Cheng Pan, Bin Cheng, Takashi Taniguchi, Kenji Watanabe, Yafis Barlas, Roger K. Lake, Marc Bockrath, Jinwoo Hwang, and Chun Ning Lau. *Phys. Rev. Lett.*, 125, 246401. 2020

18. “Magic-Angle Bilayer Graphene Nanocalorimeters: Toward Broadband, Energy-Resolving Single Photon Detection.” Paul Seifert, Xiaobo Lu, **Petr Stepanov**, José Ramón Durán Retamal, John N Moore, Kin-Chung Fong, Alessandro Principi, Dmitri K Efetov. *NanoLetters*, 20(5). 2020

19. “Raman Spectroscopy, Photovoltaic Degradation, and Stabilization of Atomically Thin Chromium Tri-iodide.” Dmitry Shcherbakov, **Petr Stepanov**, Daniel Weber, Yaxian Wang, Jin, Hu, Yanglin Zhu, Kenji Watanabe, Takashi Taniguchi, Zhiqiang Mao, Wolfgang Windl, Joshua Goldberger, Marc Bockrath, Chun Ning Lau. *NanoLetters*, 18(7), pp. 4214-4219. 2018

20. “Integer and Fractional Quantum Hall effect in Ultrahigh Quality Few-layer Black Phosphorus Transistors.” Jiaqie Yang, Son Tran, Jason Wu, Shi Che, **Petr Stepanov**, Kenji Watanabe, Takashi Taniguchi, Hongwoo Baek, Dmitry Smirnov, Ruoyu Chen, Chun Ning Lau. *NanoLetters*, 18(1), pp. 229-234. 2018

21. “Energy Gaps and Layer Polarization of Integer and Fractional Quantum Hall States in Bilayer Graphene.” Yanmeng Shi, Yongjin Lee, Shi Che, Ziqi Pi, Timothy Espiritu, **Petr Stepanov**, Dmitry Smirnov, Chun Ning Lau, and Fan Zhang. *Phys. Rev. Lett.*, 116, 056601. 2016

22. “Ionic Liquid Gating of Suspended MoS₂ Field Effect Transistor Devices.” Fenglin Wang, **Petr Stepanov**, Mason Gray, Chun Ning Lau, Mikhail E. Itkis, Robert C. Haddon. *NanoLetters*, 15(8), pp. 5284-5288. 2015

23. “Annealing and Transport Studies of Suspended Molybdenum Disulfide Devices.” Fenglin Wang, **Petr Stepanov**, Mason Gray and Chun Ning Lau. *Nanotechnology*, 26(10). 2015

24. “Interface and interlayer barrier effects on photo-induced electron emission from low work function diamond films.” Tianyin Sun, Franz A. M. Koeck, **Petr Stepanov**, Robert J. Nemanich. *Diamond and Related Mat.*, 44, pp. 123-128. 2014

25. “Thermoelectric properties of Bi_{0.5}Sb_{1.5}Te₃/C₆₀ nanocomposites.” Vladimir Blank, Sergei Buga, Vladimir Kulbachinskii, Vladimir Kytin, Viacheslav Medvedev, Mikhail Popov, **Petr Stepanov**, Vasilii Skok. *Phys. Rev. B*, 86, 075426. 2012

26. “Composites of Bi_{2-x}Sb_xTe₃ nanocrystals and fullerene molecules for thermoelectricity.” Vladimir Kulbachinskii, Vladimir Kytin, Mikhail Popov, Sergei Buga, **Petr Stepanov**, Vladimir Blank. *Journal of Solid State Chemistry*, 193, pp. 64-70. 2012

27. “C₆₀-doping of nanostructured Bi–Sb–Te thermoelectrics.” Mikhail Popov, Sergei Buga, Phillip Vysikaylo, **Petr Stepanov**, Vasilii Skok, Viacheslav Medvedev, Evgeny Tatyani, Viktor

Denisov, Alexei Kirichenko, Viktor Aksenkov, Vladimir Blank. *Phys. Status Solidi A*, 208, pp. 2783–2789. 2011

Popular Science and News&Views Articles:

“Graphene with a twist”. Culturico.com. 2021

“[Thermopower Probes Electronic Flat Bands](#)”. *Nature Physics*, **18**, 617–618. 2022

Patents:

“High resolution superconducting nano-calorimeter”. US20210140833A1. Dmitri K Efetov, Paul Seifert, Xiaobo Lu, José Durán, **Petr Stepanov**
