Dr. Joshua J "Shua" Sanchez

Postdoctoral Fellow, NSF MPS-Ascend Fellowship

Department of Physics, Massachusetts Institute of Technology

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Academics

2021: Ph.D. Physics, **University of Washington.**

2017: M.S. Physics, **University of Washington.**

2013: B.S. Physics, **University of Wisconsin**.

Research Experience & Interests

2021-present: **Massachusetts Institute of Technology,** PI: Riccardo Comin.
NSF Postdoctoral Fellow.

2016-2021: **University of Washington,** PI: Jiun-Haw Chu.
Graduate Student Researcher, Clean Energy Institute Fellow.

2017-present: **Advanced Photon Source, Argonne National Laboratory,** PI: Philip J. Ryan.
User, Resident Collaborator, Department of Energy SCGSR fellow (2019-2020).

Single crystal growth and characterization: I have experience with a variety of crystal growth techniques, including chemical vapor transport, physical vapor deposition, and flux growths. I have grown high-quality 3D crystals (6 publications) as well as bulk and monolayer van der Waals materials (ongoing work).

Strain + x-ray characterization of 3D quantum materials: At the Advanced Photon Source, I developed an experimental platform which enables simultaneous in-situ strain-tuning of quantum materials with applied magnetic field, electrical transport measurements, and diverse x-ray techniques. These include structural and magnetic diffraction (XRD/XRMS), polarized spectroscopy (XAS/XMCD/XLD), and resonant inelastic scattering (RIXS). I use this system to study diverse phenomena in strongly-correlated materials, including: nematicity, magnetism, and superconductivity in iron-based superconductors; strain-tunable charge density waves in $ErTe_3$; and spin-orbit coupling in Sr_2IrO_4.

Strain + optical characterization of 2D quantum materials: At MIT, I use photolithography to build platforms for applying strain to monolayer and few-layer flake samples and 2D electrical devices. Strain-tuning is combined with e.g. photoluminescence, birefringence, and Raman spectroscopy to probe the effects of the strain-tuning. The goal is to take advantage of the extreme elasticity of 2D materials to explore strain-induced phase transitions and strain-switchable transport phenomena.

Selected Awards & Grants

2022. University of Washington Clean Energy Institute Scientific Achievement Award (Link)
2021. NSF MPS-Ascend Fellowship (3-year, $300,000) (Link)
2020. Ford Foundation Doctoral Fellowship - *Honorable Mention* (Link)
2019. DOE Science Graduate Student Research (SCGSR) Award (Link)
2019. American Physical Society 5-Sigma Physicist Award (Link)
2018. University of Washington Physics Dehmelt Prize for Experimental Physics (Link)
2018. Seattle Science Slam, 1st Place (public science talk competition) (Link)
2017. University of Washington Clean Energy Institute Graduate Fellowship (Link)
2013. University of Wisconsin Herfurth Award (*finalist*) (Link)
2012. Senior Honors Thesis Research Grant (Link)
2009. NSF Undergraduate Research and Mentoring Fellowship (Link)
2008. University of Wisconsin Chancellor’s Scholars Award (Link)

Research Publications

***** First Author or Co-First Author Work (6)

Refereed Journal Articles

16. **Advanced Materials**, 2401534 (2024). (Link)
“Anisotropic 2D van der Waals Magnets Hosting 1D Spin Chains”.
Eugene Park, John Philbin, **Joshua J. Sanchez**, Connor Occhialini, Hang Chi, Jonathan Curtis, Zhigang Song, Alexandre Foucher, Deepika Kumawat, N. Gonzalez-Yepez, Julian P. Klein, Joachim D. Thomsen, Myung-Geun Han, Jagadeesh Modera, Riccardo Comin, Zdenek Sofer, Prineha Narang, Frances M. Ross.

*15. **Journal of Physics: Condensed Matter** 36**,** 333002 (2024). (Link)
“Perspective: Probing elasto-quantum materials with X-ray techniques and in situ anisotropic strain”.
Han Zhang*, **Joshua J. Sanchez***, Jiun-Haw Chu, and Jian Liu.

14. **Science Advances** 10, eadk3321 (2024). (Link)
“Emergent Tetragonality in a Fundamentally Orthorhombic Material”.
Anisha Singh, Maja Bachman, **Joshua J. Sanchez**, A. Pandey, A. Kapitulnik, Jong-Woo Kim, Philip Ryan, S.A. Kivelson, and Ian R. Fisher.

13. **Physical Review B** 109, 014403 (2024). (Link)
“Effects of Pressure on the Electronic and Magnetic Properties of Bulk NiI2”.
Jesse Kapeghian, Danila Amoroso, Connor A. Occhialini, Luiz G. P. Martins, Qian Song, Jesse S. Smith, **Joshua J. Sanchez**, Jing Kong, Riccardo Comin, Paolo Barone, Bertrand Dupé, Matthieu J. Verstraete, Antia S. Botana.

12. **Communication Physics** 6, 341, (2023). (Link)
“Possible strain-induced enhancement of the superconducting onset transition temperature in infinite-layer nickelates”.
Xiaolin Ren, Jiarui Li, Wei-Chih Chen, Qiang Gao, **Joshua J. Sanchez**, Jordyn Hales, Hailan Luo, Fanny Rodolakis, Jessica L. McChesney, Tao Xiang, Jiangping Hu, Riccardo Comin, Yao Wang, X. J. Zhou, and Zhihai Zhu.

*11. **Science Advances** 9, eadj5200 (2023). (Link)
“Strain-switchable field-induced superconductivity”.
Joshua J. Sanchez, Gilberto Fabbris, Yongseong Choi, Jonathan M. DeStefano, Elliot Rosenberg, Yue Shi, Paul Malinowski, Yina Huang, Igor I. Mazin, Jong-Woo Kim, Jiun-Haw Chu, Philip J. Ryan.

*10. **Nature Materials** 22, 985–991 (2023). (Link)
“Spontaneous orbital polarization in the nematic phase of FeSe”.
Connor A. Occhialini*, **Joshua J. Sanchez***, Qian Song, Gilberto Fabbris, Yongseong Choi, Jong-Woo Kim, Philip J. Ryan, and Riccardo Comin.

9. **Communications Physics** 6, 39 (2023). (Link)
“Nematic Fluctuations in an Orbital Selective Superconductor $Fe_{1+y}Te_{1-x}Se_x$”.
Qianni Jiang, Yue Shi, Morten H. Christensen, **Joshua J. Sanchez**, Bevin Huang, Zhong Lin, Zhaoyu Liu, Paul Malinowski, Xiaodong Xu, Rafael M. Fernandes, Jiun-Haw Chu.

8. **Physical Review Letters** 129, 027203 (2022). (Link)
“Controllable Emergent Spatial Spin Modulation in Sr2IrO4 by In Situ Shear Strain”.
Shashi Pandey, Han Zhang, Junyi Yang, Andrew F. May, **Joshua J. Sanchez**, Zhaoyu Liu, Jiun-Haw Chu, Jong-Woo Kim, Philip J. Ryan, Haidong Zhou, and Jian Liu.

*7. **Physical Review B** 105, 064513 (2022). (Link)
“Quantitative relationship between structural orthorhombicity, shear modulus, and heat capacity anomaly of the nematic transition in iron-based superconductors”.
Joshua J. Sanchez, Paul Malinowski, Jong-Woo Kim, Philip Ryan, Jiun-Haw Chu.

*6. **Physical Review B** 104, 104413 (2021). (Link)
“Strongly anisotropic antiferromagnetic coupling in EuFe2As2 revealed by stress detwinning”.
Joshua J. Sanchez, Gilberto Fabbris, Yongseong Choi, Yue Shi, Paul Malinowski, Shashi Pandey, Jian Liu, I.I. Mazin, Jong-Woo Kim, Philip Ryan, Jiun-Haw Chu.

*5. **Nature Materials** 20, 1519–1524 (2021). (Link)
“The transport-structural correspondence across the nematic phase transition probed by elasto-x-ray diffraction”.
Joshua J. Sanchez, Paul Malinowski, Joshua Mutch, Jian Liu, J-W. Kim, Philip J. Ryan, Jiun-Haw Chu.

4. **Nature Physics** 16, 1189–1193 (2020). (Link)
   ”Suppression of superconductivity by anisotropic strain near a nematic quantum critical point”. Paul Malinowski, Qianni Jiang, **Joshua J. Sanchez**, Zhaoyu Liu, Joshua Mutch, Preston Went, Jian Liu, Philip Ryan, Jong-Woo Kim, Jiun-Haw Chu.

3. **Applied Physics Letters** 114, 182401 (2019). (Link)
   “Epitaxial stabilization of $Sr_3Ir_2O_7$ thin films”.
   Yang, J., Hao, L., Nanney, P., Noordhoek, K., Meyers, D., Horak, L., **Sanchez, J.J.** Chu, JH., Nelson, C., Dean, M., Liu, J.

2. **Nature Communications** 10, 5301 (2019). (Link)
   “Anomalous magnetoresistance due to longitudinal spin fluctuations in a J_{eff} = 1/2 Mott semiconductor”.
   Lin Hao, Zhentao Wang, Junyi Yang, D Meyers, **Joshua Sanchez**, Gilberto Fabbris, Yongseong Choi, Jong-Woo Kim, Daniel Haskel, Philip J Ryan, Kipton Barros, Jiun-Haw Chu, MPM Dean, Cristian D Batista, Jian Liu.

1. **Nature Materials** 17, 778–782 (2018). (Link)
   “Two-dimensional itinerant ferromagnetism in atomically thin Fe_3GeTe_2”.
   Zaiyao Fei, Bevin Huang, Paul Malinowski, Wenbo Wang, Tiancheng Song, **Joshua Sanchez**, Wang Yao, Di Xiao, Xiaoyang Zhu, Andrew F May, Weida Wu, David H Cobden, Jiun-Haw Chu, Xiaodong Xu.

In Submission

1. “Signatures of pressure-enhanced helimagnetic order in van der Waals multiferroic NiI2”. (Link)
   Connor A. Occhialini, Luiz G.P. Martins, Qian Song, Jesse S. Smith, Jesse Kapeghian, Danila Amoroso, **Joshua J. Sanchez**, Paolo Barone, Bertrand Dupé, Jing Kong, Antia S. Botana, Riccardo Comin.

In Preparation

1. “Probing Spin-Excitations in an Ultra-Thin van der Waals Helimagnet”. (Link)
   Connor A Occhialini, Qian Song, Yi Tseng, **Joshua J. Sanchez,** Luiz Gustavo Pimenta Martins, Valentina Bisogni, Jonathan Pelliciari, Riccardo Comin.

Selected Talks and Conference Presentations

Invited Talks

22. “Strain-tuned quantum materials and opportunities for ultrafast explorations”.
SLAC, DOE XFEL Workshop, 2024.

21. “Novel Device for Strain-Tuning 2D Materials”.
Advanced Photon Source, User Conference, 2024.

20. “Quantum criticality, nematicity, and field-induced superconductivity in iron-based superconductors”.
Arizona State University, 2024.

19. “Quantum criticality, nematicity, and field-induced superconductivity in iron-based superconductors”.
University of Minnesota, 2024.

18. “Quantum criticality, nematicity, and field-induced superconductivity in iron-based superconductors”.
University of Illinois - Chicago, 2024.

17. “Quantum criticality, nematicity, and field-induced superconductivity in iron-based superconductors”.
University of Maryland - Baltimore County, 2024.

16. “Origins of nematicity and field-induced superconductivity in iron-based superconductors”.
University of Texas - Austin, 2024.

15. “Origins of nematicity and field-induced superconductivity in iron-based materials”.
University of Wisconsin - Madison, Physics department colloquium, 2023.

14. “Estudio de fases fuertemente correlacionadas en materiales cuánticos mediante técnicas combinadas de deformación y rayos X”.
Universidad Nacional Autónoma de México (UNAM), 2023.

13. “Origins of nematicity and field-induced superconductivity in iron-based materials”.
UCSD, 2023.

12. “Spontaneous orbital polarization in the nematic phase of FeSe”.
Yale University, 2023.

11. “Origins of nematicity and field-induced superconductivity in iron-based materials”.
Columbia University, Programmable Quantum Materials Zeminar. 2023.

10. “Spontaneous orbital polarization in the nematic phase of FeSe”.
Rice University, FCMP Seminar. 2023. https://www.youtube.com/watch?v=kqjqdtqfw-4

9. “Longitudinal Support for Generational Change”.
Brookhaven National Laboratory, RHIC AGS Users Meeting (invited DEI talk). 2023.

8. “Probing strong correlations and topology in 2D and 3D materials with strain and x-ray techniques”.
Advanced Photon Source, POLAR 4-ID Workshop (session talk). 2023.

7. “Probing nematicity and magnetism with combined tunable strain and x-ray techniques”.
APS March Meeting (session talk). 2022.

6. “Probing nematicity and magnetism with combined tunable strain and x-ray techniques”.
Iowa State University-Ames, Pressure and Strain in Quantum Materials Workshop. 2022.

5. “Probing nematicity and magnetism with combined tunable strain and X-ray scattering/fluorescence techniques”.
Northwestern University, Spring Future Leaders Seminar. 2022.

4. “Probing nematicity and magnetism with combined tunable strain and X-ray scattering/ fluorescence techniques”.
ELASTO-Q-MAT Initiative, Germany. 2022.

3. “Probing the Symmetry-Breaking Phases in Iron-based Superconductors with Combined Strain, Transport and X-ray Techniques”.
Massachusetts Institute of Technology, Chez Pierre Seminar. 2021.

2. “Probing the Symmetry-Breaking Phases in Iron-based Superconductors with Combined Strain, Transport and X-ray Techniques”.
California Institute of Technology, Research University Alliance/AGEP seminar. 2021.

1. “Strain and Magnetic Field Tuning of Quantum Phase Transitions in $EuFe_2As_2$”.
Argonne National Laboratory, Chicago IL. 2019.

Conference & Other Talks

15. “Strain-Tunable Raman Spectra in a Quasi-1D Antiferromagnet”.
APS March Meeting. 2024.

14. “Strain-Switchable Field-Induced Superconductivity”.
APS March Meeting. 2023.

13. “Probing the Symmetry-Breaking Phases in Iron-based Superconductors with Combined Strain, Transport and X-ray Techniques”.
University of Washington, PhD Thesis Defense Talk. 2021.

12. “Strongly Anisotropic Antiferromagnetic Coupling in $EuFe_2As_2$ Revealed by Stress Detwinning”.
APS March Meeting, Virtual. 2021.

11. “Strain and Field Tuning Magnetism and Superconductivity in $Eu(Fe_{1-x}Co_x)_2As_2$”.
Argonne National Laboratory, 2020.

10. “Strain and Field Tuning Magnetism and Superconductivity in $Eu(Fe_{1-x}Co_x)_2As_2$”.
University of Washington, MRSEC collaboration. 2020.

9. “Enhancing Superconductivity in $Eu(Fe_{.85}Co_{.15})_2As_2$ with Strain And Magnetic Field”.
University of Wisconsin - Milwaukee, 2020.

8. “Precision Controlled Detwinning of Orthorhombic Twin Domains in Underdoped $BaFe_2As_2$”.
Argonne National Laboratory. 2019.

7. “Precision Controlled Detwinning of Orthorhombic Twin Domains in Underdoped $BaFe_2As_2$”.
APS March Meeting. 2019.

6. “Strong Field Behavior of Broken Rotational Symmetry Phases in Solids”.
Doctoral Candidacy Exam,
University of Washington, 2018.

5. “X-ray Diffraction and Transport Study on Single Crystals $Ba(Fe_{1-x}Co_x)_2As_2$ Under In-situ Tunable Uniaxial Stress”.
APS March Meeting, 2018.

4. “X-ray Diffraction To Probe Orthorhombic Domain Detwinning And Elastoresistance On Single Crystal $Ba(Fe_{0.975}Co_{0.025})_2As_2$ Under In-situ Tunable Uniaxial Stress”.
Argonne Advanced Photon Source User Meeting, 2018.

3. “Storing information in Antimagnets”.
Seattle Science Slam (public science talk competition, 1st place). WA. 2018.

2. “Wake and Sleep Dissociation”
University of Wisconsin, Senior Honors Thesis Symposium. 2013.

1. “Impaired visuomotor learning in major depressive disorder: a high-density EEG investigation”
UQAM Cognitive Science Summer Institute, Montreal Canada. 2012.

Mentoring

I have directly mentored 10 undergraduates in lab research, all of whom are underrepresented (racial/gender) minority students. As of 2024, 6 have completed BS/BA degrees in physics and 1 in electrical engineering, and 6 have pursued graduate degrees in STEM.

Massachusetts Institute of Technology (2021-2024)

Desvaun Drummond	Electrical Engineering PhD student at UC-Berkeley
Deepika Kumawat	BA Physics 2024, Mt. Holyoke College
Maria Aguiar	MIT undergraduate
Nia Gonzalez-Yepez	MIT undergraduate
Izze Torres	MIT undergraduate

University of Washington (2016-2021)

Winnie Wang	Physics PhD student at University of Wisconsin
Anna Roche	Physics PhD student at University of Arizona
Thalya Paleologu	Physics PhD student at University of Florida
Ahmed Awadallah	M.S. 2023, Data Science at SMU-Dallas, now at NASA
Philip Stephersen	M.S. 2024, Environmental Safety at Colorado State University

Teaching

I have a strong passion for course instruction at the college level. I have tutored and TA’d courses ranging from non-major introductory physics to advanced undergraduate lab courses and one graduate-level condensed matter course. I have been a guest lecturer in several courses. I have extensive experience working with underrepresented (racial/gender) minority students.

Massachusetts Institute of Technology

2024. Taught 1 lecture on physics of photovoltaics for the MIT “Physics of Energy” course.
2022. Physics Mentor Program, mentor-tutor to 3 students, introductory electrodynamics.

University of Washington, Physics Department

2018. TA, graduate-level solid state physics course. Gave several lectures.
2016. TA, advanced undergraduate-level electronic circuits course. Gave several lectures.
2015. TA, undergraduate-level introductory physics course.

University of Wisconsin, Physics Department

2013. TA, undergraduate-level electromagnetism course.
2008-2013. Department-hired Tutor (Physics Learning Center), undergraduate-level physics courses.

Leadership & Service

Physicist Coalition for Nuclear Threat Reduction. As part of this coalition of over 1000 US physicists, I lobbied congress in Washington D.C. to reduce the use of land-based ICBM nuclear missiles. (2024) (Link)

American Physical Society Office of Government Affairs. I helped lobby congress to successfully protect funding for low-income graduate students. I won the APS 5-Sigma Physicist Award. (2018) (Link)

University of Washington Clean Energy Institute. I joined a new DEI committee formed to address racial disparities in the field of clean energy research. We reformed evaluation rubrics and created a new multiyear summer research fellowship for STEM undergrads from underrepresented groups. (2020) (Link)

Executive Board Member, UAW-4121, University of Washington. I worked to ensure a high standard of living and safe working conditions for 6000 UW workers. In 2018 I co-lead contract negotiations, winning the strongest anti-harassment protections at any university in the country. (2016-2021)

Media, Workshops, Panels, and Other Publications

8. “Global Security Training: Cultivating Relationships with Congressional Offices”.
   Panelist, Union of Concerned Scientists Workshop. (2024). (Link)
7. “Scientists reveal superconductor with on-off switches”.
   Argonne National Laboratory Press (2023). (Link)
6. “Physicists discover a new switch for superconductivity”.
   MIT News. (2023). (Link)
5. “Longitudinal Support for Generational Change”.
   Brookhaven National Laboratory, RHIC AGS Users Meeting (invited DEI talk). (2023).
4. “Balancing Science With Service”.
   Profile, University of Washington Clean Energy Institute. (2022). (Link)
3. “Two APS Student Members Lead National Petition Drive to Oppose Congressional Legislation”.
   APS News. (2018). (Link)
2. “Prosper Act would devastate graduate education and scientific advancement”.
   Op-Ed, The Spokesman- Review. (2018). (Link)
1. “Pay, sexual-harassment issues at stake as UW grad students vote to authorize strike”.
   Interview, Seattle Times. (2018). (Link)

Languages

I am proficient in English, Spanish and MATLAB. I have basic ability with Mandarin Chinese and Python.

~~Current as of 6/01/2024