

Dr. Joshua J “Shua” Sanchez
Postdoctoral Fellow, NSF MPS-Ascend Fellowship
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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).

Big Goals -- Strain-tuning strongly-correlated and topological materials: My main research interests are **(1)** growing high-quality crystals of novel 2D and 3D quantum materials, **(2)** using strain combined with transport, x-ray and optics techniques to discover the origin of strongly-correlated phases of matter, and **(3)** tuning correlated and topological phases to realize new phase-switchable device modalities, such as strain-control of dissipationless currents and magnetic states.

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. Department of Energy 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](#))

Publications

Refereed Journal Articles

11. **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. “Strain-switchable field-induced superconductivity”. **Science Advances**, accepted (2023).
<https://arxiv.org/abs/2306.12492>
10. Connor A. Occhialini*, **Joshua J. Sanchez***, Qian Song, Gilberto Fabbris, Yongseong Choi, Jong-Woo Kim, Philip J. Ryan, and Riccardo Comin. “Spontaneous orbital polarization in the nematic phase of FeSe”. **Nature Materials** 22, 985–991 (2023).
<https://www.nature.com/articles/s41563-023-01585-2>
***This is a co-first author work**
9. 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. “Nematic Fluctuations in an Orbital Selective Superconductor $\text{Fe}_{1+y}\text{Te}_{1-x}\text{Se}_x$ ”. **Communications Physics**, 6, 39 (2023).
<https://www.nature.com/articles/s42005-023-01154-8>
8. 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. “Controllable Emergent Spatial Spin Modulation in Sr_2IrO_4 by In Situ Shear Strain”. **Physical Review Letters** 129, 027203 (2022).
<https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.129.027203>
7. **Joshua J. Sanchez**, Paul Malinowski, Jong-Woo Kim, Philip Ryan, Jiun-Haw Chu. “Quantitative relationship between structural orthorhombicity, shear modulus, and heat capacity anomaly of the nematic transition in iron-based superconductors”. **Physical Review B** 105, 064513 (2022).
<https://doi.org/10.1103/PhysRevB.105.064513>

6. **Joshua J. Sanchez**, Paul Malinowski, Joshua Mutch, Jian Liu, J-W. Kim, Philip J. Ryan, Jiun-Haw Chu. “The transport-structural correspondence across the nematic phase transition probed by elasto-x-ray diffraction”. **Nature Materials** 20, 1519–1524 (2021). <https://doi.org/10.1038/s41563-021-01082-4>
5. **Joshua J. Sanchez**, Gilberto Fabbri, Yongseong Choi, Yue Shi, Paul Malinowski, Shashi Pandey, Jian Liu, I.I. Mazin, Jong-Woo Kim, Philip Ryan, Jiun-Haw Chu. “Strongly anisotropic antiferromagnetic coupling in EuFe₂As₂ revealed by stress detwinning”. **Physical Review B** 104, 104413 (2021). <https://doi.org/10.1103/PhysRevB.104.104413>
4. Paul Malinowski, Qianni Jiang, **Joshua J. Sanchez**, Zhaoyu Liu, Joshua Mutch, Preston Went, Jian Liu, Philip Ryan, Jong-Woo Kim, Jiun-Haw Chu. “Suppression of superconductivity by anisotropic strain near a nematic quantum critical point”. **Nature Physics** 16, 1189–1193 (2020). <https://doi.org/10.1038/s41567-020-0983-9>
3. Yang, J., Hao, L., Nanney, P., Noordhoek, K., Meyers, D., Horak, L., **Sanchez, J.J.** Chu, JH., Nelson, C., Dean, M., Liu, J. (2019). “Epitaxial stabilization of Sr₃Ir₂O₇ thin films”. **Applied Physics Letters** 114, 182401 (2019). <https://doi.org/10.1063/1.5092614>
2. Lin Hao, Zhentao Wang, Junyi Yang, D Meyers, **Joshua Sanchez**, Gilberto Fabbri, Yongseong Choi, Jong-Woo Kim, Daniel Haskel, Philip J Ryan, Kipton Barros, Jiun-Haw Chu, MPM Dean, Cristian D Batista, Jian Liu. “Anomalous magnetoresistance due to longitudinal spin fluctuations in a $J_{\text{eff}} = 1/2$ Mott semiconductor”. **Nature Communications** 10, 5301 (2019). <https://doi.org/10.1038/s41467-019-13271-6>
1. 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. “Two-dimensional itinerant ferromagnetism in atomically thin Fe₃GeTe₂”. **Nature Materials** 17, 778–782 (2018). <https://doi.org/10.1038/s41563-018-0149-7>

In submission

4. Anisha Singh, Maja Bachman, **Joshua J. Sanchez**, A. Pandey, A. Kapitulnik, Jong-Woo Kim, Philip Ryan, S.A. Kivelson, and Ian R. Fisher. “Emergent Tetragonality in a Fundamentally Orthorhombic Material”. <https://arxiv.org/abs/2306.14755>
(To review, **Science Advances**)
3. 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. “Signatures of pressure-enhanced helimagnetic order in van der Waals multiferroic NiI₂”. <https://arxiv.org/abs/2306.11720>.

2. 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. “Effects of Pressure on the Electronic and Magnetic Properties of Bulk NiI₂”. <https://arxiv.org/abs/2306.04729>
1. 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. “Strain-induced enhancement of T_c in infinite-layer Pr_{0.8}Sr_{0.2}NiO₂ films”. <https://arxiv.org/abs/2109.05761>
(Under review, **Communication Physics**)

In Preparation

4. Han Zhang*, **Joshua J. Sanchez***, Jiun-Haw Chu, and Jian Liu. “Probing Emergent Phenomenon under Anisotropic Strain with in-situ X-ray Techniques: A Perspective”. Invited review paper.
***This is a co-first author work**
3. **Joshua J. Sanchez***, Raagya Arora*, Efthimos Kaxiras, and Riccardo Comin. “Strain-switchable topological edge currents”.
***This is a co-first author work**
2. Eugene Park, John Philbin, **Joshua J. Sanchez**, Connor Occhialini, Hang Chi, Jonathan Curtis, Zhigang Song, Alexandre Foucher, Deepika Kumawat, N. Gonzalez-Yepe, Julian P. Klein, Joachim D. Thomsen, Myung-Geun Han, Jagadeesh Modera, Riccardo Comin, Zdenek Sofer, Prineha Narang, Frances M. Ross*. “2D van der Waals Magnets with 1D Noncollinear Spin Chains”.
1. Connor A Occhialini, Qian Song, Yi Tseng, **Joshua J. Sanchez**, Luiz Gustavo Pimenta Martins, Valentina Bisogni, Jonathan Pellicciari, Riccardo Comin. “Probing Spin-Excitations in an Ultra-Thin van der Waals Helimagnet”. <https://meetings.aps.org/Meeting/MAR23/Session/A55.8>

Selected Talks and Conference Presentations

Invited Talks

13. “Estudio de fases fuertemente correlacionadas en materiales cuánticos mediante técnicas combinadas de deformación y rayos X”. **Universidad Nacional Autónoma de México (UNAM)**, 2023.
12. “Origins of nematicity and field-induced superconductivity in iron-based materials”. **UCSD**, 2023.
11. “Spontaneous orbital polarization in the nematic phase of FeSe”. **Yale University**, 2023.
10. “Origins of nematicity and field-induced superconductivity in iron-based materials”. **Columbia University**, Programmable Quantum Materials Zeminar. 2023.
9. “Spontaneous orbital polarization in the nematic phase of FeSe”. **Rice University**, FCMP Seminar. 2023. <https://www.youtube.com/watch?v=kqjqdtqfw-4>
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

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 $\text{Eu}(\text{Fe}_{1-x}\text{Co}_x)_2\text{As}_2$ ”. APS Workshop: “Multi-Modal X-Ray Techniques for Emergent Quantum Materials”. **Argonne National Laboratory**, Chicago IL. 2020.
10. “Strain and Field Tuning Magnetism and Superconductivity in $\text{Eu}(\text{Fe}_{1-x}\text{Co}_x)_2\text{As}_2$ ”. MRSEC collaboration, **University of Washington**, Seattle WA. 2020.
9. “Enhancing Superconductivity in $\text{Eu}(\text{Fe}_{.85}\text{Co}_{.15})_2\text{As}_2$ with Strain And Magnetic Field”. Condensed Matter Physics Seminar, **University of Wisconsin - Milwaukee**, Milwaukee WI. 2020.
8. “Precision Controlled Detwinning of Orthorhombic Twin Domains in Underdoped BaFe_2As_2 ”. **Argonne National Laboratory**, Chicago IL. 2019.
7. “Precision Controlled Detwinning of Orthorhombic Twin Domains in Underdoped BaFe_2As_2 ”. **APS March Meeting**, Boston MA. 2019.
6. “Strong Field Behavior of Broken Rotational Symmetry Phases in Solids”. Doctoral Candidacy oral presentation, **University of Washington**, Seattle WA. 2018.
5. “X-ray Diffraction and Transport Study on Single Crystals $\text{Ba}(\text{Fe}_{1-x}\text{Co}_x)_2\text{As}_2$ Under In-situ Tunable Uniaxial Stress”. **APS March Meeting**, Los Angeles CA. 2018.
4. “X-ray Diffraction To Probe Orthorhombic Domain Detwinning And Elastoresistance On Single Crystal $\text{Ba}(\text{Fe}_{0.975}\text{Co}_{0.025})_2\text{As}_2$ Under In-situ Tunable Uniaxial Stress”. **Argonne Advanced Photon Source User Meeting**, Lemont IL. 2018.
3. “Storing information in Antimagnets”. **Seattle Science Slam** (public science talk competition, 1st place). Seattle, WA. 2018.
2. “Wake and Sleep Dissociation” **Senior Honors Thesis Symposium**, University of Wisconsin. 2013.
1. “Impaired visuomotor learning in major depressive disorder: a high-density EEG investigation” **UQAM Cognitive Science Summer Institute**, Montreal Canada. 2012.

Mentoring

I directly mentored 9 undergraduates in lab research, all of whom are underrepresented (racial/gender) minority students. As of 2023, 5 have completed B.S. degrees in Physics and 1 in electrical engineering, and 6 are now pursuing graduate degrees in STEM, including 3 physics PhDs.

Massachusetts Institute of Technology

Desvaun Drummond (originally Howard University, now EE PhD student at UC-Berkeley)

Maria Aguiar (MIT undergraduate)

Nicholas Gonzalez-Yepey (MIT undergraduate)

Deepika Kumawat (visiting summer REU student from Mt. Holyoke College)

University of Washington

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 (Masters degree program in data science at SMU-Dallas)

Philip Stephersen (Masters degree program in Environmental Safety at Colorado State University).

Teaching

University of Washington, Physics Department

2018. TA, graduate-level solid state physics course. Gave several lectures.

2016. TA, 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

2018. **APS “PROSPER Act” campaign.** I worked with the APS Office of Government Affairs to run a grassroots campaign of physicists in opposition to the PROSPER Act, which despite the name would have severely limited access to a graduate education for scientists without significant independent wealth. We were successful in blocking this bill, and for my efforts I received the [APS 5-Sigma Physicist Award](#).

2020. **UW Clean Energy Institute Diversity Equity and Inclusion Committee Member.** In the wake of the George Floyd protests I joined a new committee formed by the UW Clean Energy Institute to address racial disparities in the field of clean energy research. We created a new award for multiyear summer research funding to give longitudinal support to STEM undergrads from underrepresented groups.

2020-2021. **Spokesperson, Physics Graduate Student Council.** Elected leader of physics graduate student council working on student issues, especially with regards to diversity initiatives.

2016-2021. **Executive Board Member, UAW4121.** I was an elected board member and leader in our union for academic student workers and postdoctoral researchers at the University of Washington. I worked to ensure a high standard of living and safe working conditions for 6000 UW workers. I was a lead negotiator for our 2018 contract in which we won the strongest anti-harassment protections for graduate workers at any university in the country.

Languages

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