

# Nikhil Tilak, Ph.D.

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## PROFESSIONAL EXPERIENCE

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**Postdoctoral Associate, Rutgers University, New Jersey, USA.**                      **07/2023 - present**  
My research focuses on correlated phases in two-dimensional heterostructures and moire materials.  
**Physics Faculty, Bakliwal Tutorials, Pune, India.**                                      **06/2014 - 05/2015**  
Taught calculus-based physics for the highly selective Indian institutes of technology joint entrance exam (IIT-JEE). 1200+ hours of teaching experience to over 550 high school juniors and seniors.

## EDUCATION

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**Ph.D. in Physics, Rutgers University, New Jersey, USA.**                                      **09/2015 - 06/2023**  
**B.Tech. in Engineering Physics, I.I.T. Guwahati, Assam, India.**                                      **08/2010 - 05/2014**

## RESEARCH PROJECTS

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**Structure and electronic properties of marginally twisted MoS<sub>2</sub>.**  
Studied lattice-relaxation, moire potentials and interfacial ferroelectricity in marginally twisted MoS<sub>2</sub> bilayers using scanning tunneling microscopy (STM) and piezoresponse force microscopy (PFM).  
**Carrier confinement in magic-angle twisted bilayer graphene.**  
Investigated the effects of substrate potential disorder on magic-angle twisted bilayer graphene using STM/STS.  
**Proximity-induced charge density wave in graphene/1T-TaS<sub>2</sub>.**  
Investigated the incommensurate and commensurate CDW phases in 1T-TaS<sub>2</sub>. Used graphene as a cover to protect TaS<sub>2</sub> surface from degradation.  
**Design and construction of a low temperature scanning tunneling microscope.**  
Designed and constructed a dip-stick style STM and a scanner head capable of operating from 300 K to 4.2 K. System was optimized to reduce heat-load to reduce cryogen consumption.  
**Effect of strain on CVD graphene microdrums.**  
Optimized the growth of monolayer graphene on copper foils. Transferred the graphene to holey silicon nitride substrates to make suspended graphene devices for strain measurements.

## SKILLS

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**Device fabrication.**  
Expertise in making van der Waals heterostructures. Electrical contact fabrication using e-beam lithography and photolithography, thermal metal deposition, reactive ion etching, wet etching etc. Experienced in working with air-sensitive materials inside an inert gas filled glovebox.  
**Characterization techniques.**  
Scanning tunneling microscopy (STM), scanning probe microscopy (AFM, KPFM, EFM, PFM, force-distance spectroscopy), electronic transport, Raman spectroscopy, optical microscopy.  
**Vacuum and cryogenic techniques.**  
Expert at design, construction and maintenance of ultra/high vacuum chambers and cryogenic temperature measurement apparatus. Highly experienced in helium leak detection.

## Mechanical and electronics.

Soldering, Brazing, CAD, Machining (Drilling, Lathe, Milling), Arduino based circuits.

## Data analysis and programming.

Python, Origin, LabVIEW, Mathematica, C/C++. Experienced in machine learning and deep learning using scikit-learn, TensorFlow etc.

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## SELECTED PUBLICATIONS

- <sup>1</sup>N. Tilak, M. A. Altvater, S.-H. Hung, C.-J. Won, T. Kaleem, G. Li, S.-W. Cheong, C.-H. Chung, H.-T. Jeng, and E. Y. Andrei, “Revealing the charge density wave proximity effect in graphene 1t-TaS<sub>2</sub>.”, (under review at Nature materials) (2023).
- <sup>2</sup>N. Tilak, G. Li, T. Taniguchi, K. Watanabe, and E. Y. Andrei, “Moiré potential, lattice relaxation, and layer polarization in marginally twisted MoS<sub>2</sub> bilayers”, Nano Letters (2022).
- <sup>3</sup>N. Tilak, X. Lai, S. Wu, Z. Zhang, M. Xu, R. d. A. Ribeiro, P. C. Canfield, and E. Y. Andrei, “Flat band carrier confinement in magic-angle twisted bilayer graphene”, Nature communications **12**, 4180 (2021).
- <sup>4</sup>M. A. Altvater, N. Tilak, S. Rao, G. Li, C.-J. Won, S.-W. Cheong, and E. Y. Andrei, “Observation of a topological defect lattice in the charge density wave of 1t-tas<sub>2</sub>”, Applied Physics Letters **119**, 121601 (2021).
- <sup>5</sup>R. S. Bisht, J. Park, H. Yu, C. Wu, N. Tilak, S. Rangan, T. J. Park, Y. Yuan, S. Das, U. Goteti, H. T. Yi, H. Hijazi, A. Al-Mahboob, J. T. Sadowski, H. Zhou, S. Oh, E. Y. Andrei, M. T. Allen, D. Kuzum, A. Frano, R. C. Dynes, and S. Ramanathan, “Spatial interactions in hydrogenated perovskite nickelate synaptic networks”, Nano Letters (2023).
- <sup>6</sup>R. K. Biroju, N. Tilak, G. Rajender, S. Dhara, and P. Giri, “Catalyst free growth of zno nanowires on graphene and graphene oxide and its enhanced photoluminescence and photoresponse”, Nanotechnology **26**, 145601 (2015).

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## CONFERENCE TALKS AND POSTERS

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|---|-------------------------------------|
| STM studies of marginally twisted MoS <sub>2</sub> bilayers [poster]                            | Rutgers Center for Materials Theory |
| symposium, 2022   |                                     |
| Moiré bands in twisted MoS <sub>2</sub> homobilayers [talk]                                     | APS March Meeting 2022, Chicago     |
| Observation of charging peaks near the flat band in magic-angle twisted bilayer Graphene [talk] | APS                                 |
| March Meeting 2021, Virtual   |                                     |
| A method for controllably inducing ultra-high strain in suspended 2D materials [talk]           | APS March                           |
| Meeting 2018, Los Angeles   |                                     |

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## RECENT HONORS

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| <b>David C. Langreth Graduate Development Award</b>   | <b>2017</b>        |
| “Presented annually to an especially promising early-stage graduate student by the Department of Physics and Astronomy at Rutgers”                  |                    |
| <b>MITACS Globalink Research Internship</b>   | <b>Summer 2013</b> |
| Was selected for a competitive 12-week research internship at the <i>Institut national de la recherche scientifique</i> , Varennes, Quebec, Canada. |                    |

## REVIEWER FOR

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ACS Nano, ACS Nano Letters, NPJ Quantum materials

## TEACHING EXPERIENCE

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**Teaching Assistant, Rutgers University, NJ, USA.**

**Fall 2015 - Spring 2018**

TA for extended analytical physics (115), analytical physics (123 & 124), intro solid state physics (406), graduate quantum mechanics 1 (501), electromagnetism (385) and classical physics lab (276).

**Physics Faculty, Bakliwal Tutorials, Pune, India.**

**06/2014 - 05/2015**

Taught calculus-based physics for the highly selective Indian institutes of technology joint entrance exam (IIT-JEE). 1200+ hours of teaching experience to over 550 high school juniors and seniors.

## LEADERSHIP AND MENTORSHIP

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Directly mentored five undergraduate students leading to successful transitions to graduate school and industry.

Student representative on the graduate studies and life committee (AY 2018-19)

Vice President of the Physics and Astronomy Graduate Student Organization. (AY 2016-17)