

Nathaniel M. Gabor

JET Distinguished Associate Professor of Physics

Gabor Research Laboratories
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Education

Massachusetts Institute of Technology	Postdoctoral Fellow	Physics	2011 - 2013
Cornell University	Ph.D., M.S.	Physics	2012
Pennsylvania State University	B.S. (Highest Distinction)	Physics	2004

Selected National and International Awards and Honors

- Research Corporation for Science Advancement Scialog Fellow 2021-22 – ‘Bringing together promising early career scientists to gain fundamental understanding of habitability on exoplanets.’
- Presidential Early Career Award for Scientists and Engineers PECASE 2019 – ‘The PECASE award is the highest honor bestowed by the United States government to outstanding scientists and engineers.’
- Department of the Navy HBCU/MI Award 2019 – ‘Supports Navy-relevant research while increasing the engagement of students, including underrepresented minorities, in STEM fields.’
- National Academy of Sciences Kavli Frontiers Fellow 2019 – ‘The Kavli Frontiers of Science symposium is the Academy’s premiere activity for distinguished young scientists.’
- Research Corporation for Science Advancement Scialog Fellow 2017-18 – ‘Bringing together promising early career investigators to accelerate fundamental discovery in advanced energy storage.’
- CIFAR Azrieli Global Scholar Award 2017 – ‘CIFAR invites outstanding early career investigators into research programs addressing some of the most complex challenges facing the world today.’
- NSF CAREER Award 2017 – ‘The National Science Foundation’s most prestigious awards in support of early-career faculty who serve as academic role models in research and education.’
- Cottrell Scholar Award 2017 – ‘Honors outstanding teacher-scholars who are recognized by their scientific communities for the quality and innovation of their research programs and academic leadership skills.’
- AFOSR YIP Award 2016 – ‘Supports scientists and engineers demonstrating exceptional ability and promise for conducting basic research with relevance to the Air Force mission.’
- UCR Junior Faculty Excellence in Teaching (JET) Award 2015 – ‘Awarded to teachers whose record shows that they have vibrancy, passion, and devotion to the University of California’s teaching mission.’
- SPIE International Society for Optics and Photonics Best Paper Award 2014 – ‘Given based on originality, depth of research, significance of findings and historical interest.’
- MIT School of Science Excellence Award 2011 – ‘Acknowledging extraordinary efforts toward fulfilling the goals, values and mission of the Institute. This is among the highest honors awarded by MIT.’
- Clark-Russell Award Cornell Physics – ‘For extraordinary dedication to undergraduate education. This award honors outstanding teaching and scholarship.’
- Spanson Award Cornell Nanoscale Science and Technology Facility (CNF) 2007 – ‘Recognizes the demonstration of novel techniques in nanofabrication and device engineering.’
- John and Elizabeth Holmes Teas Scholarship 2004 – ‘Recognizes and supports excellence in research within the physical sciences and engineering.’
- Jean Bennet Physics Award 2004 – ‘Acknowledging excellence and leadership among undergraduate students in the Eberly College of Science at the Pennsylvania State University.’

Research Interests

At atomic and molecular scales, quantum mechanics describes reality. The theory of quantum mechanics is among the most successful scientific theories, exhibiting not one single contradiction in nearly a century since its inception. Yet, when atoms are combined to form highly complex structures - such as synthetic quantum materials or biological macro-molecules - the connection between microscopic phenomena and emergent macroscopic behaviors is lost. Indeed, hierarchical complexity defies a unified physical description. Gabor Research Laboratories aim to discover new phenomena - both quantum and classical - that may arise within and at the interface between quantum condensed matter and complex biological systems. As scientists at the boundary of physics and biology, we have a unique opportunity to unite our understanding of quantum mechanics with the complex and diverse biophysical properties and behaviors of life.

Scientific Employment: Investigative Roles and Research Activity

Principal Investigator: UCR Physics, Materials Science and Engineering 2013 - present

Designed and constructed low temperature magnetoelectronic and optoelectronic spectroscopy laboratory for investigations of interacting excitons and electron-hole excitations in transition metal dichalcogenides, graphene, bilayer graphene, and topological insulators, leading to the development of two significant experimental techniques to observe the space-time dynamics of energy flow in quantum materials. Developing extensive fabrication of complex nanoscale device structures based on graphene, molybdenum ditelluride, tungsten disulphide, and molybdenum disulphide. Developing new data-intensive techniques to measure and assess photosynthetic efficiency in microbial phototrophs including the well-studied purple bacterium *rhodobacter sphaeroides*. Currently supervising 8 laboratory researchers.

Total Research Funding (including start-up, through 2024): \$4,494,957

1. AFOSR YIP Award Biosystems; sole PI (2016-2019): \$379,987
2. DoE EFRC SHINES; center seed co-PI (2014-2019): \$480,000
3. NASA/JPL FIELDS Data Science; center co-PI (2015-2018): \$240,000
4. UC Office of the President LCFF+; sole PI (2017): \$51,241
5. Cottrell Scholar Award; sole PI (2017-2020): \$100,000 discretionary
6. NSF CAREER Award DMR; sole PI (2017-2022): \$541,794
7. UC Innovative Learning Tech Award; co-PI (2017-2019): \$340,000 (\$55,000)
8. CIFAR Global Scholar Award; sole PI (2017-2019): \$85,000 discretionary
9. GAANN Materials Science; co-PI (2018-2021): \$895,500 (\$111,937)
10. DoN HBCU/MI Award; sole PI (2019-2022): \$449,998
11. PECASE Award; sole PI (2020-2025): \$1,000,000

Selected Experimental Project Descriptions:

1. National Science Foundation CAREER Award
Title: Optoelectronic probes of interlayer electron-hole pair multiplication in atomic layer semiconductor heterostructures
Description: This proposal aims to develop advanced experiments that measure the optoelectronic response of transition metal dichalcogenide (TMD) materials and their heterostructures. Moreover, this proposal funds an integrated program of data science education and outreach throughout southern California.
2. Air Force Office of Scientific Research YIP Award
Title: Atomic layer semiconductors as biological analog photocells for intrinsically regulated light harvesting
Description: This proposal integrates ideas from biological light harvesting and semiconductor physics of ultra-small materials to explore the optoelectronic response of

transition metal dichalcogenides, whose excitonic behavior lies at the boundary between bulk semiconductors and molecular scale systems.

3. Department of the Navy HBCU/MI Award
Title: VIPER 2D: Vertically integrated photocells based on echeloned responsivities in two-dimensional (2D) heterostructures
Description: We propose to demonstrate fast and ultra-sensitive mid infrared photocells that mimic pit viper vision. Based on emerging fundamental physics, our approach sets a new paradigm for neuro-inspired infrared photosensor design and engineering.
4. DoD Presidential Early Career Award for Scientists and Engineers (PECASE)
Title: Microfluidic Photobiology Microscopy of Light Harvesting Bacteria at the Single Cell Limit
Description: This proposal aims to dramatically increase the information throughput of microbial light harvesting experiments and probes the fundamental role that specific absorption spectra play in fine-tuning photosynthetic efficiency.

Research and Development Consultant: Apsidal, LLC.

2018 - present

Developed longstanding technical relationships with Apsidal, LLC research and development, leading to successful NASA funding through Phase I and Phase II small business innovation research (SBIR) grants. Proposal content and research protected by non-disclosure agreement.

Postdoctoral Fellow: Massachusetts Institute of Technology Physics

2011 - 2013

Mentor: Pablo Jarillo-Herrero

Designed and constructed a low temperature optoelectronic spectroscopy laboratory for investigations of interacting electrons in graphene, bilayer graphene, graphene nanoribbons, and topological insulators leading to the discovery of hot-carrier assisted intrinsic photoresponse in graphene, phonon drag in graphene, and photon-assisted tunneling in graphene heterostructures. Co-authored U.S. Air Force grant for the nanofabrication of graphene-based optoelectronic devices, MIT MISTI grant for collaboration with ICFO Spain, MIT S³TEC seed grant for solar thermoelectric energy harvesting, DOD MIT seed grant for the Inst. of Soldier Nanotechnologies. Supervised 2 graduate and 3 undergraduate students as the leader of the optoelectronics team in the Jarillo-Herrero lab.

Graduate Research Scholar: Cornell University Physics

2004 – 2011

Mentor: Paul McEuen

Designed and constructed quantum electronic and optoelectronic experiments that combine ultrafast lasers, supercontinuum light sources, and high-power laser sources in a low temperature cryostat for the investigation of graphene interface junctions, nanotube PN junctions, and THz frequency nanotube FETs. Developed extensive fabrication of complex nanoscale device structures based on graphene and carbon nanotubes. Demonstrated strongly interacting Dirac fermions in carbon nanotubes and graphene contributing to the discovery of extremely efficient generation of multiple electron-hole pairs, real-time probe of ballistic motion of electrons, and photo-thermoelectric effect in graphene.

Undergraduate Research Scholar: Pennsylvania State University

2002 - 2004

Mentors: Jay Maynard, Vincent Crespi

Designed and constructed the magnetic cactus for the investigation of phyllotactic ground states in physical systems leading to the first observation (in over 4 centuries of study) of dynamic phyllotaxis and the annealing of phyllotactic ground states.

Teaching Experience

Faculty Lecturer: University of California Riverside Physics Department **2013 - present**

Organized course recitations, weekly laboratory sections, developed lecture notes, quizzes and exams for the following courses:

Physics 150B: Solid State Physics, Modern Concepts (Winter 2014, 2016, 2018, 2019)

Physics 133: Statistical Mechanics (Spring 2014-2018)

Physics 2A: Intro Mechanics for non-physics Majors (Fall 2014, 2015, 2016, 2019)

Teaching Assistant: Cornell University Physics Department **2004 - 2008**

Facilitated course recitations, weekly laboratory sections, worked with course faculty to develop lecture notes, quizzes and exams for the following courses:

Physics I: Mechanics for scientists and engineers (Fall 2004)

Physics II: Electricity and Magnetism for scientists and engineers (Spring 2005)

Physics II: Honors Electricity and Magnetism for physicists (Fall 2005, 2006)

Physics II: Honors electricity and magnetism laboratory (Fall 2006, Spring 2007, 2008)

Designed, developed, facilitated, and lead an intensive workshop that instructs new first year faculty and graduate students on various techniques of leading lectures, recitations, laboratory courses, and office hours.

Outreach and Integration at the University of California

1. I am an active member of UCR's College of Natural and Agricultural Sciences excellent outreach programs including the STEM (Science, Technology, Engineering and Math) Pathway Program. For 3 years, I served as judge and award presenter in the Riverside Unified school district STEM science fair, which features the work of a large majority of students from underrepresented communities. In the near future, I look forward to continuing and increasing participation in this program through high school on-site visits and speaking engagements.
2. Along with Prof. Xiaoyang Zhu from Columbia University, I co-organized an energy-related symposium at the American Physical Society March Meeting 2016. Hosted by the Division of Chemical Physics, the title of the symposium was "New Materials for Charge and Energy Transfer." During the symposium, numerous distinguished speakers, who are also collaborators, gave scientific talks focused on quantum materials such as graphene, boron nitride, and molybdenum disulfide.
3. In Summers 2014-19, as part of the Physics Teacher Academy at UCR, I provided teachers with a half-day laboratory experience of building and operating a simple scanning confocal microscope, a technology that is prevalent in numerous fields from molecular spectroscopy to semiconductor testing. The components for this experiment were very basic: the laser source was obtained from the head of a DVD drive, while the microscope was used to image a cleaved processor chip. I am developing more substantive laboratory experiences for 2020 and beyond that illustrate the variety of research conducted at UCR including condensed matter and nanoscience.
4. Since the Fall of 2013, I have been the sole organizer of the Southern California Atomic Layer (SoCAL) Materials Meetings at UCR. SoCAL Materials is a monthly meeting that brings together scientists at the forefront of multi-disciplinary research focusing on atomic layer materials. Speakers from Caltech, UCLA, UCSD, UCR, and USC have contributed to the meeting, resulting in a strong local community in this exciting research area.
5. I am developing ongoing art exhibitions for the "Long Night of Arts and Innovation", which takes place each year in the city of Riverside, CA, and have been featured in an exhibition "Wonder Materials: Graphene and Beyond" at the Museum of Science and Industry in Manchester, UK. My artwork, which combines highly abstract scientific concepts with traditional art media, has been displayed throughout New York, Boston, and southern California, as well as Manchester, UK, and has also been featured in the APS March Meeting invited talk announcements. The aim of the exhibition is to make challenging physical concepts accessible to non-scientists.

Personal and Professional Interests in Diversity, Equity, and Access

I am committed to facilitating scientific exposure to underrepresented groups and to supporting these colleagues - to the limits of my ability - while they pursue professional scientific careers. I have already established a very diverse research group, with emphasis in integrating women, minorities, and first-generation student members. I have worked closely with POWUR (Physics Organization for Women and the Under Represented) to assure that underrepresented students are aware of opportunities in my lab and others across campus. As a first-generation college student, I am naturally inclined to establish and develop connections between other first-generation students and myself. At UCR, I have incorporated several undergraduates into my lab, *all* of whom were first-generation students, and many of whom were from underrepresented groups. UCR maintains very high ranking for social mobility (5th, *Washington Monthly*) and is the 3rd best college for Hispanic students, who are also generally first-generation students. I have a strong sense of pride in the socioeconomic diversity at UCR, having come from a family without means for college education, and will commit all available resources to supporting diversity, equity, and access in the Sciences.

Academic and Scientific Leadership at the University of California

1. I am the lead investigator on the development of video microtutorials to supplement the introductory physics course for biology and pre-medicine majors. This project, initially funded through the LCFF+ award, will continue as part of the ILTI award (\$340,000) that combines a team of 6 faculty. My team has documented over 50 hours of filming and over 100 hours of rehearsal for the micro tutorial videos. The UCR Physics department has graciously supported the work by allowing use of Physics lecture space and demonstration equipment. Planning, filming, and post-production will continue beyond the lifetime of this grant and will be supported using other departmental and institutional resources, including the ILTI grant, for which this grant served as a foundational element.
2. UCR currently maintains one of the largest number of active NSF Career awards in the UC system, keeping pace with Berkeley and UCLA. In 2017-18, I served as a mock panel member to evaluate NSF Career Proposals at UCR. As part of a group of award-winning junior faculty, I took part in an NSF-style peer review process to evaluate proposals from new faculty across several disciplines at UCR. The panel review was modeled exactly as an NSF panel, and included considerable extra effort to guide and assist new faculty towards a more successful proposal. The results of the panel review showed marked success, and the program will continue each year at UCR.
3. Laboratory safety in the UC, and at UCR, has been a major challenge at all levels of administration and institution population. I currently serve on the safety committee as primary liaison between the UCR Department of Physics and Astronomy and Environmental Health and Safety at UCR. My role is to advocate for student safety, advocate for faculty responsibilities and rights, and demand clarity from administrative guidelines for safety in lab spaces at UCR. My laboratory has served as a benchmark for lab safety culture, and we have begun developing ways to streamline the safety procedures to improve the processes of lab building and lab maintenance across all aspects of laboratory hazards.
4. I have actively served on greater than 10 hiring committees across several departments and a wide variety of fields including physics, biophysics, physics education, chemistry, engineering, and as part of the cluster hiring program in the 2015-2017 hiring years. All searches have resulted in the hiring of highly successful and qualified candidates. In the coming academic year, I will continue this service by being part of the quantum materials experiment search. Synergistically with this, I chaired the colloquium committee, which organized the colloquium calendar for 2017-2019 academic year. We have invited several leaders in biophysics and condensed matter physics to inform the broader faculty on the latest scientific trends.

5. UCR is currently developing an 8,000 sq.ft nanofabrication facility, for which I served on the vision committee. This facility will serve the nanotechnology community across campus and provide a state-of-the-art laboratory space for nanoscale device characterization and fabrication. Based on the vision committee recommendations, the Deans of Engineering and the College of Natural and Agricultural Sciences have dedicated several faculty lines exclusively to support the move and maintenance of the new facility on campus. Also based on the committee recommendations, several new hires are being targeted to add to the already active nanofabrication community at UCR.

Selected Departmental, College, and Campus Services List

06/2017 - 08/2017	Campus. Member. Recruitment Committee ECE Cluster Hire
06/2017 - 07/2017	Campus. Member. NSF Career Review Committee
06/2017 - 08/2017	Department. Chair. Colloquium Committee 2017-2018
01/2017 - 08/2017	Department. Member. ILTI Phys 2A Course Redesign Committee
01/2017 - 08/2017	Campus. Member. Nanofabrication Facility Vision Committee
09/2016 - Present	Department. Member. UCR-Community College Bridge Committee
09/2016 - Present	Department. Member. Display Committee
09/2016 - 08/2017	Department. Chair. Physics 2A Video Microtutorial Committee
09/2016 - 07/2017	Department. Member. Web Page Development Committee
09/2016 - Present	Department. Member. Graduate Diversity Committee.
09/2016 - Present	Department. Member. Safety and Regulations Committee.
06/2016 - 08/2017	Department. Member. Display and Web Page Committee.
01/2016 - 03/2016	Department. Member. Recruitment Committee for LSOE.
04/2015 - 06/2015	Campus. Member. VCR Confidential Committee on Cluster Hire Proposals.
01/2015 - Present	Department. Member. Graduate Advisory (CM experiment) Committee.
01/2015 - 03/2015	College. Member. Hiring Committee Chemistry Department.
05/2014 - 10/2014	Department. Chair. Visual Impact and Renovations Physics Department.
01/2014 - 12/2014	Campus. Chair. The Southern California Atomic Layer Materials Meeting.
07/2013 - 06/2014	Department. Member. Recruitment Committee for CM Physics - Junior Level.
07/2013 - 06/2014	Department. Member. Recruitment Committee for CM Physics - Open Level.

Scientific Manuscript and Grant Proposal Reviewing Activities

Manuscripts

07/2016 - present	<i>Science Advances</i> . 3 Manuscripts Reviewed.
07/2015 - present	<i>Applied Physics Letters</i> . 3 Manuscripts Reviewed.
07/2015 - present	<i>Nature Physics</i> . 6 Manuscripts Reviewed.
03/2015 - present	<i>Nature Photonics</i> . 13 Manuscripts Reviewed.
01/2015 - present	<i>Nano Letters</i> . 21 Manuscripts Reviewed.
01/2015 - present	<i>Physical Review Letters</i> . 6 Manuscripts Reviewed.
09/2013 - present	<i>Nature Communication</i> . 6 Manuscripts Reviewed.
09/2013 - present	<i>Nature Nanotechnology</i> . 17 Manuscripts Reviewed.

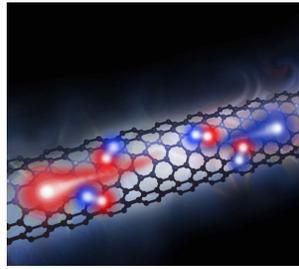
Grant Proposals

01/2017 - 08/2019	National Research Council of Canada. 3 Grants Reviewed.
01/2017 - 08/2019	European Research Council. 3 Grants Reviewed.
01/2017 - 08/2018	M. J. Murdock Charitable Trust. 1 Grants Reviewed.
12/2015 - 08/2018	National Science Foundation. 3 Grants Reviewed, 1 panel served
12/2014 - 08/2018	Department of Energy. 1 Grants Reviewed.
12/2018 - 03/2019	AAAS RDO Review. 6 Grants Reviewed.

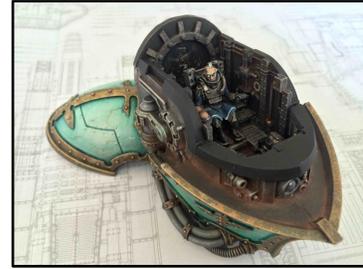
Selected Public Art Exhibitions and Published Artworks



2012 – ‘imprinted’ photography exhibition Cambridge, MA USA



2016 – ‘Wonder Materials’ multimedia exhibition Manchester, UK



2017 – ‘Ira Deorum’ multimedia exhibition. Los Angeles, CA USA

Selected Recent Invited Talks

8. “Imaging electronic droplets in ultrathin heterostructure devices,”
APS March Meeting, Denver CO (2020).
7. “From heat engines to green leaves: a physicist’s perspective on photosynthesis,”
Cal State Long Beach Physics Colloquium, Long Beach, CA (2020). *University of California Davis Chemistry Colloquium*, Davis, CA (2019). *Penn State Physics Colloquium*, State College, PA (2018). *LASSP Seminar Cornell University*, Ithaca, NY (2018). *CEPCEB Noel T. Keen Award Symposium Plant Biology and Physiology*, Riverside, CA (2017).
6. “Nanoscience in the Age of Big Data,”
RCSA Cottrell Conference, Tucson, AZ (2017).
5. “Room temperature 2D condensate of electrons and holes in ultrathin MoTe₂ photocells,”
National Academy of Sciences Kavli Frontiers, Irvine, CA (2019). *Stanford AMO Seminar*, Palo Alto, CA (2019), *Caltech Materials Science and Applied Physics Seminar* (2018), *N2D Spain, Workshop on Nanophotonics in 2D Materials*, San Sebastian, Spain (2017), *QCM Workshop Enduring Problems in Quantum Condensed Matter, A Symposium Honoring Chandra Varma*, Riverside, CA (2017).
4. “Three-body electronic interactions in 2D semiconductor heterostructures,”
UT Austin Condensed Matter Seminar, Austin, TX (2017),
SPIE Defense + Commercial Sensing, Anaheim CA (2017).
3. “Why are plants green? And other essential questions about emerging quantum optoelectronic technologies,”
TU Delft Quantum Nanosciences Seminar, TU Delft Netherlands (2017).
University of California Santa Cruz Condensed Matter Seminar, Santa Cruz, CA (2017).
2. “Nonlinear Photoresponse Microscopy of 2D Heterostructures,”
IEEE Photonics, Waikaloa, Hawaii (2016).
1. “Natural Regulation in a Green Quantum Photocell,”
University of California San Diego Condensed Matter Seminar, San Diego, CA (2015),
University of California Santa Barbara Condensed Matter Seminar, Santa Barbara, CA (2016).