Victor Watson Brar

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EDUCATION

- Ph.D., Physics, December 2010
  University of California, Berkeley. Berkeley, CA.
  Thesis: "Scanning Tunneling Spectroscopy of Graphene and Magnetic Nanostructures"
  Advisor: Prof. Michael Crommie

- B.S., Mathematics; B.S., Physics; Minor in Political Science, June 2004
  Massachusetts Institute of Technology (MIT). Cambridge, MA.
  Undergraduate Thesis: "Evaluations of Single Walled Carbon Nanotubes Using Resonance Raman Spectroscopy"
  Thesis Advisor: Prof. Mildred Dresselhaus

- Part II/Part III Courses in Physics and Math, Sept. 2002 – June 2003
  University of Cambridge, Fitzwilliam College. Cambridge, U.K.
  Undergraduate Research in Computational Protein Folding
  Research Advisor: Prof. Cait MacPhee

PROFESSIONAL RESEARCH EXPERIENCE

University of Wisconsin-Madison, Department of Physics
Van Vleck Assistant Professor, June, 2016 - Present

California Institute of Technology
Kavli Nanoscience Fellow, Nov. 2011-2013
Postdoctoral Fellow, 2013 – June 2016
Advisor: Prof. Harry Atwater

- Fabricated and measured tunable graphene plasmonic resonators in the Mid-IR with optical mode volumes 10^7 times smaller than free-space.
- Coupled graphene plasmonic resonances to single monolayer boron nitride phonons to create composite surface-phonon-plasmon-polariton modes.
- Utilized graphene plasmons to dynamically control the thermal emissivity of a surface.

University of California, Berkeley, Department of Physics
Graduate Student Researcher, 2005 –2011
Advisor: Prof. Michael Crommie

- Carried out the first scanning tunneling microscopy (STM) experiment on an electrostatically gated surface (graphene).
- Used STM to study the atomic scale properties of Coulomb impurities on graphene, which lead to a direct measurement of graphene's intrinsic dielectric constant and the first observation of the 'Atomic Collapse' effect.
- Discovered several many-body phenomena in the tunneling spectra of graphene.
- Used spin-polarized STM to probe the energy-dependent magnetic structure of individual magnetic atoms on metal and magnetic surfaces.

Massachusetts Institute of Technology, Department of Physics
Undergraduate Researcher, 2000 – 2002; 2003 – 2004
Advisors: Prof. Mildred Dresselhaus and Prof. Ado Jorio

- Conducted Raman Spectroscopy experiments and analysis on single-walled carbon nanotubes (SWNTs).
- Studied combination Raman modes resulting from double-resonant Raman phenomena.

University of Cambridge, **Department of Physics**
Undergraduate Researcher, 2002 - 2003
Advisor: Prof. Cait MacPhee

- Performed protein folding computer simulations on prion proteins in order to understand their role in causing prion-based diseases. Calculated several candidate structures for the prion chains responsible for Fatal Familial Insomnia.

Intel Corporation
Research Intern, Summer 2004
Supervisor: Dr. Yuegang Zhang

- Performed index of refraction calculations to support experiments studying the interaction of light with carbon nanotubes. The experiments were aimed at using optical tweezers to separate different species of carbon nanotubes.

University of Wisconsin-Madison, Department of Physics
Research Assistant, Summer 2000
Supervisor: Prof. Darren Craig

- Provided programming support and helped construct equipment for the Madison Symmetric Torus, a reversed-field pinch plasma confinement device.

TEACHING EXPERIENCE

University of Wisconsin - Madison, Department of Physics
Physics 551 - Solid State Physics, Fall 2016, Spring 2017

University of California, Berkeley, Department of Physics
Graduate Student Instructor
Basic Semiconductor Circuits, Fall 2004
Thermodynamics and Electricity & Magnetism, Spring 2005

California Institute of Technology, Department of Applied Physics
Guest Lecturer,
APh 114 – Solid State Physics, Fall 2011, Fall 2012 & Winter 2014

AWARDS AND PATENTS

Lars Commins Memorial Award in Experimental Physics
University of California, Berkeley, May 2011

Kavli Nanoscience Institute Postdoctoral Fellowship Award
California Institute of Technology, Nov. 2011 – Nov. 2013

"Holographic, Sub-Wavelength Reflectarray based on Tunable Graphene Optical Elements for Phase and Intensity Light Control"
Victor Brar, Michelle Sherrott, Harry Atwater (Caltech)
Luke Sweatlock (Northrup Gruman)
(Provisional Patent, 3/11/2014, CIT File No.: CIT-6845-P)

"Electronically Controlled Backbody Emission from Graphene Plasmonic Resonators as a Fast Incandescent Light Source with Tunable Spectral Signature"
Victor Brar, Harry Atwater (Caltech)
Luke Sweatlock (Northrup Gruman)
(Provisional Patent, 3/13/2014, CIT File No.: CIT-6850-P)

INVITED TALKS

"Probing Sub-Critical and Super-Critical Impurities in Graphene" **Victor Brar, Invited Colloquium** at University of Oregon. Host: Benjamín Alemán, April 2017

"Controlling Mid-IR Emission with Plasmonic Resonances in Graphene" **Victor Brar, Invited Talk, META16, the 7th International Conference on Metamaterials, Photonic Crystals and Plasmonics** in Torremolinos -- Malaga, Spain, July 2016

"Controlling Mid-IR Emission with Plasmonic Resonances in Graphene" **Victor Brar, Invited Talk, 229th meeting of The Electrochemical Society** in San Diego, California May 2016

"Surface Plasmons and Impurity States in Graphene" **Victor Brar, Invited Seminar** at Fudan University, Shanghai, China. Host Yuanbo Zhang, May 2016

"Electrostatically Tunable Metasurfaces for Controlling Optical Wavefronts and Thermal Emission", **Victor Brar, CeNS Workshop - "Channels and Bridges to the**

Nanoworld" hosted by Ludwig Maximilians University-Munich, in Venice, Italy, September 2015

"Active Control of Mid-IR Absorption and Emission Using Plasmonic Modes in Graphene Metasurfaces ", **Victor Brar, 6th International Workshop on Electromagnetic Metamaterials**, Santa Fe, September 2014

"Graphene Plasmonics: Gate-Tunable Resonators with Extreme Light Confinement", **Victor Brar, Invited Colloquium** at CSU – Long Beach. Host: Andreas Bill, October 2012

"Probing and Modifying Coulomb Impurities on Graphene at the Atomic Scale", **Victor Brar, Invited Seminar** at Tsinghua University, Beijing, China. Host: Yayu Wang, October 2011

"Probing and Modifying Coulomb Impurities on Graphene at the Atomic Scale", **Victor Brar, Invited Seminar** at Fudan University, Shanghai, China. Host: Yuanbo Zhang, October 2011

"Gate-Controlled Ionizations and Screening of Cobalt Adatoms on a Graphene Surface", **Victor Brar, Invited Talk** at the APS March Meeting, March 2011

"Gate-controlled Ionization and Screening in Co Adatoms on Graphene", **Victor Brar, Invited Seminar** at the IBM Almaden Research Center. Host: Andreas Heinrich, May 2010

"Many-body Effects in Tunneling Spectroscopy of Graphene", **Victor Brar, Graphene Tokyo 2009** at the University of Tokyo, July 2009

"Probing Plasmons, Phonons, and Quasiparticle Lifetime in Graphene Using Scanning Tunneling Spectroscopy", **Victor Brar, Invited Seminar** at Los Alamos National Laboratory, Center for Integrated Nanotechnologies. Host: Alexander Balatsky, March 2009

"Studying Exchange Coupling Behavior of Individual Magnetic Adatoms with Spin-polarized STM", **Victor Brar, NCSS5 – SPSTM2 Joint International Conference** at Ohio University, Athens, Ohio, July 2008

VOLUNTEER EXPERIENCE

Prison University Project, San Quentin Prison
Math Tutor, Fall 2004 – Spring 2005.
Project Coordinator: Jody Lewen

- Tutored prison inmates once a week in math topics ranging from geometry to calculus.

SKILLS

Extensive experience with STM, FTIR, Electron Beam lithography, Raman spectroscopy, UHV systems, ^{4}He cryogenic systems, low noise measurements, epitaxial growth of magnetic crystals, Auger spectroscopy, shadow-mask evaporation, wire-bonding, CVD growth of graphene, and SEM. Eagle Scout (Fall 1999).

List of Publications

1 Kim, S., Jang, M. S., **Brar, V. W.**, Tolstova, Y., Mauser, K. W. & Atwater, H. A., "Electronically tunable extraordinary optical transmission in graphene plasmonic ribbons coupled to subwavelength metallic slit arrays," *Nat Commun* **7** (2016**).**

2 Wong, D., Corsetti, F., Wang, Y., **Brar, V. W.**, Tsai, H. Z., Wu, Q., Kawakami, R. K., Zettl, A., Mostofi, A. A., Lischner, J. & Crommie, M. F., "Spatially resolving density-dependent screening around a single charged atom in graphene," *Physical Review B* **95** (20) (2017**).**

3 Whitney, W. S., **Brar, V. W.**, Ou, Y. B., Shao, Y. M., Davoyan, A. R., Basov, D. N., He, K., Xue, Q. K. & Atwater, H. A., "Gate-Variable Mid-Infrared Optical Transitions in a (Bi1-xSbx)(2)Te-3 Topological Insulator," *Nano Lett* **17** (1), 255-260 (2017**).**

4 Sherrott, M. C., Hon, P. W. C., Fountaine, K. T., Garcia, J. C., Ponti, S. M., **Brar, V. W.**, Sweatlock, L. A. & Atwater, H. A., "Experimental Demonstration of >230° Phase Modulation in Gate-Tunable Graphene–Gold Reconfigurable Mid-Infrared Metasurfaces," *Nano Lett* **17** (5), 3027-3034 (2017**).**

5 **Brar, V. W.**, Koltonow, A. R. & Huang, J. X., "New Discoveries and Opportunities from Two-Dimensional Materials," *Acs Photonics* **4** (3), 407-411 (2017**).**

6 Varghese, J. O., Agbo, P., Sutherland, A. M., **Brar, V. W.**, Rossman, G. R., Gray, H. B. & Heath, J. R., "2D Materials: The Influence of Water on the Optical Properties of Single-Layer Molybdenum Disulfide (Adv. Mater. 17/2015)," *Advanced Materials* **27** (17), 2733-2733 (2015**).**

7 **Brar, V. W.**, Sherrott, M. C., Jang, M. S., Kim, S., Kim, L., Choi, M., Sweatlock, L. A. & Atwater, H. A., "Electronic modulation of infrared radiation in graphene plasmonic resonators," *Nat Commun* **6** (2015**).**

8 **Brar, V. W.***, Jang, M. S.*, Sherrott, M., Kim, S., Lopez, J. J., Kim, L. B., Choi, M. & Atwater, H., "Hybrid Surface-Phonon-Plasmon Polariton Modes in Graphene/Monolayer h-BN Heterostructures," *Nano Lett* **14** (7), 3876-3880 (2014**).**

9 Jang, M. S.*, **Brar, V. W.***, Sherrott, M. C., Lopez, J. J., Kim, L., Kim, S., Choi, M. & Atwater, H. A., "Tunable large resonant absorption in a midinfrared graphene Salisbury screen," *Physical Review B* **90** (16), 165409 (2014**).**

10 **Brar, V. W.***, Jang, M. S.*, Sherrott, M., Lopez, J. J. & Atwater, H. A., "Highly Confined Tunable Mid-Infrared Plasmonics in Graphene Nanoresonators," *Nano Lett* **13** (6), 2541-2547 (2013**).**
(See Review by David Pile, "Plasmonics: Graphene Shrinks Light" in *Nature Photonics* **7**, 511 (2013))

11 Wang, Y., Wong, D., Shytov, A. V., **Brar, V. W.**, Choi, S., Wu, Q., Tsai, H. Z., Regan, W., Zettl, A., Kawakami, R. K., Louie, S. G., Levitov, L. S. & Crommie, M. F., "Observing Atomic Collapse Resonances in Artificial Nuclei on Graphene," *Science* **340** (6133), 734-737 (2013**).**
(See Review by Ashley G. Smart, "Graphene yields evidence of atomic collapse", *Physics Today* **66**, 12 (2013))

12 Wang, Y.*, **Brar, V. W.***, Shytov, A. V., Wu, Q., Regan, W., Tsai, H. Z., Zettl, A., Levitov, L. S. & Crommie, M. F., "Mapping Dirac quasiparticles near a single Coulomb impurity on graphene," *Nat Phys* **8** (9), 653-657 (2012**).**

13 Decker, R., Wang, Y., **Brar, V. W.**, Regan, W., Tsai, H. Z., Wu, Q., Gannett, W., Zettl, A. & Crommie, M. F., "Local Electronic Properties of Graphene on a BN Substrate via Scanning Tunneling Microscopy," *Nano Lett* **11** (6), 2291-2295 (2011**).**

14 **Brar, V. W.***, Decker, R.*, Solowan, H. M., Wang, Y., Maserati, L., Chan, K. T., Lee, H., Girit, C. O., Zettl, A., Louie, S. G., Cohen, M. L. & Crommie, M. F., "Gate-controlled ionization and screening of cobalt adatoms on a graphene surface," *Nat Phys* **7** (1), 43-47 (2011**).**

15 **Brar, V. W.**, Wickenburg, S., Panlasigui, M., Park, C. H., Wehling, T. O., Zhang, Y. B., Decker, R., Girit, C., Balatsky, A. V., Louie, S. G., Zettl, A. & Crommie, M. F., "Observation of Carrier-Density-Dependent Many-Body Effects in Graphene via Tunneling Spectroscopy," *Physical Review Letters* **104** (3), 4 (2010**).**

16 Zhang, Y. B.*, **Brar, V. W.***, Girit, C., Zettl, A. & Crommie, M. F., "Origin of spatial charge inhomogeneity in graphene," *Nat Phys* **5** (10), 722-726 (2009**).**

17 Zhang, Y. B., **Brar, V. W.**, Wang, F., Girit, C., Yayon, Y., Panlasigui, M., Zettl, A. & Crommie, M. F., "Giant phonon-induced conductance in scanning tunnelling spectroscopy of gate-tunable graphene," *Nat Phys* **4** (8), 627-630 (2008**).**

18 Wegner, D., Yamachika, R., Wang, Y., **Brar, V. W.**, Bartlett, B. M., Long, J. R. & Crommie, M. F., "Single-molecule charge transfer and bonding at an

organic/inorganic interface: Tetracyanoethylene on noble metals," *Nano Lett* **8** (1), 131-135 (2008**).**

19 Yayon, Y., **Brar, V. W.**, Senapati, L., Erwin, S. C. & Crommie, M. F., "Observing Spin Polarization of Individual Magnetic Adatoms," *Physical Review Letters* **99** (6), 067202 (2007**).**

20 **Brar, V. W.**, Zhang, Y., Yayon, Y., Ohta, T., McChesney, J. L., Bostwick, A., Rotenberg, E., Horn, K. & Crommie, M. F., "Scanning tunneling spectroscopy of inhomogeneous electronic structure in monolayer and bilayer graphene on SiC," *Applied Physics Letters* **91** (12), 3 (2007**).**

21 **Brar, V. W.**, Samsonidze, G. G., Santos, A. P., Chou, S. G., Chattopadhyay, D., Kim, S. N., Papadimitrakopoulos, F., Zheng, M., Jagota, A., Onoa, G. B., Swan, A. K., Unlu, M. S., Goldberg, B. B., Dresselhaus, G. & Dresselhaus, M. S., "Resonance Raman spectroscopy characterization of single-wall carbon nanotube separation by their metallicity and diameter," *Journal of Nanoscience and Nanotechnology* **5** (2), 209-228 (2005**).**

22 Souza, M., Jorio, A., Fantini, C., Neves, B. R. A., Pimenta, M. A., Saito, R., Ismach, A., Joselevich, E., **Brar, V. W.**, Samsonidze, G. G., Dresselhaus, G. & Dresselhaus, M. S., "Single- and double-resonance Raman G -band processes in carbon nanotubes," *Physical Review B* **69** (24), 241403 (2004**).**

23 Samsonidze, G. G., Chou, S. G., Santos, A. P., **Brar, V. W.**, Dresselhaus, G., Dresselhaus, M. S., Selbst, A., Swan, A. K., Unlu, M. S., Goldberg, B. B., Chattopadhyay, D., Kim, S. N. & Papadimitrakopoulos, F., "Quantitative evaluation of the octadecylamine-assisted bulk separation of semiconducting and metallic single-wall carbon nanotubes by resonance Raman spectroscopy," *Applied Physics Letters* **85** (6), 1006-1008 (2004**).**

24 Corio, P., Santos, A. P., Santos, P. S., Temperini, M. L. A., **Brar, V. W.**, Pimenta, M. A. & Dresselhaus, M. S., "Characterization of single wall carbon nanotubes filled with silver and with chromium compounds," *Chemical Physics Letters* **383** (5-6), 475-480 (2004**).**

25 Saito, R., Gruneis, A., Samsonidze, G. G., **Brar, V. W.**, Dresselhaus, G., Dresselhaus, M. S., Jorio, A., Cancado, L. G., Fantini, C., Pimenta, M. A. & Souza, A. G., "Double resonance Raman spectroscopy of single-wall carbon nanotubes," *New Journal of Physics* **5**, 15 (2003**).**

26 Corio, P., Santos, P. S., **Brar, V. W.**, Samsonidze, G. G., Chou, S. G. & Dresselhaus, M. S., "Potential dependent surface Raman spectroscopy of single wall carbon nanotube films on platinum electrodes," *Chemical Physics Letters* **370** (5-6), 675-682 (2003**).**

27 Jorio, A., Souza Filho, A. G., **Brar, V. W.**, Swan, A. K., Unlu, M. S., Goldberg, B. B., Righi, A., Hafner, J. H., Lieber, C. M., Saito, R., Dresselhaus, G. & Dresselhaus, M. S., "Polarized resonant Raman study of isolated single-wall carbon nanotubes: Symmetry selection rules, dipolar and multipolar antenna effects," *Physical Review B* **65** (12), 121402 (2002**).**

28 Jorio, A., Fantini, C., Dantas, M. S. S., Pimenta, M. A., Souza Filho, A. G., Samsonidze, G. G., **Brar, V. W.**, Dresselhaus, G., Dresselhaus, M. S., Swan, A. K., Unlu, M. S., Goldberg, B. B. & Saito, R., "Linewidth of the Raman features of individual single-wall carbon nanotubes," *Physical Review B* **66** (11), 115411 (2002**).**

29 **Brar, V. W.**, Samsonidze, G. G., Dresselhaus, M. S., Dresselhaus, G., Saito, R., Swan, A. K., Unlu, M. S., Goldberg, B. B., Souza Filho, A. G. & Jorio, A., "Second-order harmonic and combination modes in graphite, single-wall carbon nanotube bundles, and isolated single-wall carbon nanotubes," *Physical Review B* **66** (15), 155418 (2002).