Zheng Sun

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Personal Description

I'm a postdoctoral researcher in physics and my interest field can be best summarized as exploration of light-matter interaction at the nanoscale. The main research focus areas are development of: photonic structures that confine light and artificially engineered optical materials such as metamaterials, optical micro-cavities and hybrid excitonic materials display optical properties that surpass naturally occurring materials. These focus areas are motivated by the quest to develop next generation computing technologies including those that exploit the quantum property of light, ultrasensitive sensors for chemical and biological detection, and high efficiency energy transfer systems.

Education

Ph.D. Physics, The Graduate Center, City University of New York, 2017.

M.A. Physics, Fudan University, 2012.

B.S. Applied Physics, Zhejiang Normal University, 2008.

Employment

Postdoc Fellow University of Pittsburgh 2017/11/01– Now.

Research Interest

Excitons in two-dimensional Semiconductors of transition metal dichalchogenides (TMDs)

Cavity quantum electrodynamics using inorganic and hybrid microcavities

Engineered nonlinear optical materials based on hybrid nanocomposites

Optical electro control of the polaritons and related applications

Quantum optics using metamaterials

Transportation of polaritons in GaAs quantum wells based microcavity

Selected Rewards and Honors

2020	RECOGNIZES for peer review (OSA Publishing), USA
2016	Nanophotonics Technical Group Outstanding Student Poster Award at CLEO, USA
2012	CUNY Science Scholarship, USA
2011	Graduation with Highest Honor, Shanghai, China
2010	First Academic Scholarship, Fudan University, China
2008	Graduation with Highest Honor, Zhejiang Normal University, Zhejiang, China

Research skills and Expertise

Spectroscopy and Optical Measurements

1. Built complete spectroscopy setup for quantum optics measurement such as k-space and confocal microscope spectroscopy

2. Performed various quantum optics measurements including static photoluminescence, photoluminescence excitation, k-space excitation and collection, single photon time correlated measurements and fluorescent imaging

3. Performed streak camera, confocal microscope Raman system, various semiconductor lasers and cryogenic spectroscopy

Nano-fabrication and Semiconductor Processing

1. Fabricated photonic microcavity devices through the entire process

2. Fabricated a field effect transistor through the entire process

3. Familiar with general processes for semiconductor nano-fabrication: lithography, etching and deposition

4. Frequently used an e-beam lithography, e-beam evaporation, scanning electron microscope and atomic force microscope

Low Dimensional Materials Preparation and Transferring

1. Designed and built up a microscope incorporated translation stage specific for exfoliated low dimensional materials

2. Low dimensional materials can be transferred to the specific area on the various substrates by using different methods

Microcavity Device Design and Simulation

1. Designed photonic microcavity using transfer matrix solution simulation (MATLAB, COMSOL, ANSYS)

Data Acquisition, Analysis, and Presentation

1. Performed numerical fitting and data analysis using MATLAB

2. Familiar with ORIGIN and Adobe Illustrator for data presentations

Research Accomplishment

Postdoctoral Research Nov 2017 - Now

Research advisor: **Prof. David Snoke** Condensed Matter Optics Group, **University of Pittsburgh**

• One of the main efforts at present in the study of polariton condensates in microcavities. The polaritons are essentially photons dressed with an effective mass and strong interactions due to the special design of the solid-state microcavity structures we use. These interacting photons can undergo Bose-Einstein condensation, which is a state of matter with spontaneous coherence. We can see superfluid flow of the polariton condensate over millimeter distances; we can also trap the condensate in various potentials; and we can see interference due to the coherence of the condensate.

Several fundamental questions are connected to the work. One topic is how coherence can occur spontaneously ("enphasing") in systems like lasers and condensates and how coherence is lost ("dephasing") in standard quantum systems. This, in turn, relates to the deep question of why there is irreversibility in nature, that is, the arrow of time. Another topic is how phase transitions can occur in nonequilibrium systems.

A new effort is looking at the effect of a polariton condensate on electronic transport. This may allow a "light-induced superconductor", in which there are dramatic effects on conduction when the polariton condensate appears. We are also looking at new material systems so that the polariton codnensate effects can be moved to room temperature.

We Proposed to create room temperature 2D vdWC-polariton system suitable for quantum manybody phenomena; Control the properties of 2D vdWC-polaritons to unravel new phenomena; Demonstrate and utilize room temperature polariton condensate and superfluidity for new types of emitters, detectors, and routers. We're pursuing these goals via a collaborative, multidisciplinary effort, combining state-of-the-art fabrication capabilities with strong experimental and theoretical expertise on four core aspects of the project: polariton physics, 2D materials, photonic devices, and many-body physics in photonic and electronic systems.

I'm under Prof. David Snoke's guidance and I designed and built a microscope incorporated translation stage for transferring TMDs, besides performing optical measurements.

Graduate Research Sep 2012 - Oct 2017

Research advisor: **Prof. Vinod Menon** Condensed Matter Optics Group, **CUNY Graduate Center**

• Experimentally observation of room-temperature strongly coupled light-matter quasiparticles (polaritons) that are valley-polarized due to the coupling of photons with specific helicity to excitons

that occupy quantum mechanically distinct valleys in momentum space. The realization of valley polaritons in two-dimensional semiconductor microcavities presents the first step towards engineering valley-polaritonic devices.

• Proposed and experimentally demonstrated broadband enhancement of spontaneous emission and increase in Raman signature from archetype two-dimensional semiconductors: molybdenum disulfide (MoS2) and tungsten disulfide (WS2) by placing the monolayers in the near field of a photonic hypercrystal (PHC) having hyperbolic dispersion. The hypercrystals are characterized by a large broadband photonic density of states (PDOS) due to this hyperbolic dispersion while having enhanced light in/out coupling by a sub-wavelength photonic crystal lattice. This dual advantage is exploited here to enhance the light emission from the two-dimensional TMDs and can be utilized for light emitters and absorbers using two-dimensional semiconductors.

• First designed and experimentally demonstrated the strong light-matter coupling and the formation of microcavity polaritons in a two-dimensional atomic crystal of molybdenum disulphide (MoS2) embedded inside a dielectric microcavity at room temperature. A Rabi splitting of 46 ± 3 meV is observed in angle-resolved reflectivity and photoluminescence spectra owing to the coupling between the two-dimensional excitons and the cavity photons. Realizing strong coupling at room temperature in two-dimensional materials that offer disorder-free potential landscape provides an attractive route for the development of practical polaritonic devices.

• Proposed and experimentally demonstrated the preferential emission from ZnO nanoparticles into an epsilon near zero metamaterial. The structure was designed to have the parallel component of its dielectric constant approach zero at the maximum emission wavelength of ZnO.

Master Research Sep 2008 - June 2011

Research advisor: **Prof. Zhanghai Chen** & **Prof. Xuechu Shen**
The State Key Laboratory of Surface Physics, **Fudan University**, Shanghai, China

• Experimentally observation of the polarization dependence of the Raman spectra of a single ultra-wide β-Ga_2O_3 nanobelt. The spectra were found to strongly depend on the relative angle between the polarization of the incident light and the axis of the β-Ga_2O_3 nanobelt. Such behavior was ascribed to the large length to width ratio of the nanostructure and its small dielectric constant. The ultra-wide β-Ga_2O_3 nanobelt was fabricated using catalyst-free thermal chemical vapor deposition.

• Experimentally demonstrated the spin selective coupling of the exciton state with cavity mode in a single quantum dot (QD)–micropillar cavity system. By tuning an external magnetic field, each spin polarized exciton state can be selectively coupled with the cavity mode due to the Zeeman effect. A significant enhancement of spontaneous emission rate of each spin state is achieved. A four-level rate equation model is developed. In addition, the coupling between photon mode and each exciton spin state is also achieved by varying temperature, the full manipulation over the spin states in the QD-cavity system.

Publications

Journal Articles

Citation: **Almost 800 times** according to **My Google Scholar**

1. **Zheng Sun**, Jonathan Beaumariage, Qingrui Cao, Benjamin Hunt, Kenji Watanabe, Takashi Taniguchi, David W. Snoke, "Observation of the Interlayer Exciton Gases in WSe_2- p: WSe_2 Heterostructures," ***ACS Photonics Accepted*** (2020)(**Corresponding author**)

2. **Z. Sun**, J. Beaumariage, Q. Cao, B. Hunt, K. Watanabe, T. Taniguchi, D. W. Snoke, "Toward a room temperature Schafroth superconductor based on charged excitonic complexes," ***arXiv***:2003.05850 (2020)(**Corresponding author**)

3. D. W. Snoke, Y. Yoon, D. M. Myers, S. Mukherjee, J. Beaumariage, V. Hartwell, M. Steger, E. Estrecho, **Z. Sun**, E.A. Ostrovskaya, and K.A. Nelson, "Experimental determinations of polariton-polariton interactions in microcavities," ***Under preparation*** (2020)

4. **Zheng Sun**, Jonathan Beaumariage, Ke Xu, Jierui Liang, Shaocong Hou, Stephen R. Forrest, Susan K Fullerton-Shirey, David W. Snoke, "Electric-field-induced optical hysteresis in single-layer WSe_2," ***Appl. Phys. Lett.***, 115, 161103 (2019)(**Corresponding author**)

5. S Mukherjee, DM Myers, RG Lena, B Ozden, J Beaumariage, **Z. Sun**, M Steger, LN Pfeiffer, K West, AJ Daley, DW Snoke, "Natural Oscillations of a Polariton Condensate in a Ring," ***Phys. Rev. B***, 100 (24), 245304 (2019) (**Kaleidoscope**)

6. **Zheng Sun**, David W Snoke, "Optical switching with organics," **[Invited]**, ***Nat. Photonics***, **[News and Views]**, 13, 370-371, (2019)(**Corresponding author**)

7. **Zheng Sun**, Jonathan Beaumariage, Hema C P Movva, Sayema Chowdhury, Anupam Roy, Sanjay K Banerjee, David W Snoke, "Stress-induced bandgap renormalization in atomic crystals," ***Solid State Communications***, 288, 18-21, (2019) (**Corresponding author**)

8. Biswanath Chakraborty, Jie Gu, **Zheng Sun**, Mandeep Khatoniar, Rezlind Bushati, Alexandra L Boehmke, Rian Koots, Vinod M Menon, "Control of Strong Light-matter Interaction in Monolayer WS2 Through Electric Field Gating," ***Nano Lett.***, 18 (10), 6455-6460, (2018)

9. **Zheng Sun**, Jie Gu, Areg Ghazryan, Zav Shotan, Christopher R. Considine, Michael Dollar, Biswanath Chakraborty, Xiaoze Liu, Pouyan Ghaemi, S. Kéna-Cohen, Vinod M. Menon, "Optical Control of Room Temperature Valley Polaritons," ***Nat. Photonics***, 11, 491-496 (2017)

10. T Galfsky, **Zheng Sun***, CR Considinel, CT Chou, WC Ko, YH Lee, E Narimanov, "Broadband enhancement of light-matter interaction in 2D semiconductors by photonic hypercrystals," ***Nano Lett.*** 16 (8), 4940-4945 (2016) **(Co-first author)**

11. T. Galfsky, **Z. Sun**, Z. Jacob, V. M. Menon, "Preferential emission into epsilon-near-zero metamaterial ," **[Invited]**, ***Opt. Mater. Express***, 5(12), 2878-2883 (2015)

12. X. Liu, T. Galfsky, **Z. Sun**, F. Xia, E. Lin, Y.-H. Lee, S. Kéna-Cohen, and V. M. Menon,"Strong light–matter coupling in two-dimensional atomic crystals," ***Nat. Photonics*** 9, 30–34 (2014)

13. **Zheng Sun**, LinHong Yang, XueChu Shen, ZhangHai Chen, "Anisotropic Raman spectroscopy of a single β-Ga_2O_3 nanobelt," ***Science Bulletin***, 57(6) (2012) **(Cover Story)**

14. Qijun Ren, Jian Lu, H H Tan, Shan Wu, Liaoxin Sun, Weihang Zhou, Wei Xie, **Zheng Sun**, Yongyuan Zhu, C Jagadish, S C Shen, Zhanghai Chen, "Spin-Resolved Purcell Effect in a Quantum Dot Microcavity System,"***Nano Lett.***, 12 (7), 3455-3459 (2012)

15. Lin-Hong Yang, Hong-Xing Dong, **Zheng Sun**, Liao-Xin Sun, Xue-Chu Shen, Zhang-Hai Chen: Temperature-Induced Phase Transition of In_2O_3 from a Rhombohedral Structure to a Body-Centered Cubic Structure. ***Chinese Physics Letters***, 28(8) (2011)

16. **Zheng Sun**, Yuan-Ping Xu, Sheng Li, Thomas F George, "Forbidden Singlet Exciton Transitions Induced by Localization in Polymer Light-Emitting Diodes in a Strong Electric Field," ***Journal of Physical Chemistry B***, 115(5) 869-73 (2011)

Conference Proceedings

1. American Physical Society **(APS)** March Meeting, **Denver, CO**, Mar 2- 6, 2020
"Optical Switching Based on a Single Layer of WSe_2,"
Zheng Sun, Ke Xu, Beaumariage Jonathan, Jerry Liang, Susan Fullerton-Shirey, David Snoke

2. American Physical Society **(APS)** March Meeting, **Denver, CO**, Mar 2- 6, 2020
"Calibration of long-lifetime polariton structures,"
Jonathan Beaumariage, **Zheng Sun**, Mark Steger, David Myers, Shouvik Mukherjee, David Snoke, Loren Pfeiffer, Kenneth West

3. American Physical Society **(APS)** March Meeting, **Denver, CO**, Mar 2- 6, 2020
"Dynamics of an Exciton-Polariton Condensate in a Tilted Ring Microcavity,"
Shouvik Mukherjee, Valerii Kozin, Anton Nalitov, Ivan Shelykh, **Zheng Sun**, David Myers, Burcu Ozden, Jonathan Beaumariage, Loren Pfeiffer, Kenneth West, Andrew Daley, David Snoke

4. Fudan- Guanghua International Forum for Young Scholars (**Invited**), **Shanghai, China**, Dec 25-27, 2019
"Light-matter Interaction in Semiconductors,"
Zheng Sun

5. Universal Bose- Einstein Condensation (**UBEC**), **Pittsburgh, PA**, Apr 1- 5, 2019
"Natural Oscillations of a Polariton Condensation in a Ring,"
Shouvik Mukherjee, David Myers, Rosaria Lena, Burcu Ozden, Jonathan Beaumariage, **Zheng Sun**, Mark Steger, Loren Pfeiffer; Kenneth West, Andrew Daley, David Snoke

6. American Physical Society **(APS)** March Meeting, **Boston, MA**, Mar 4- 8, 2019
"Room temperature dynamical control and electroluminescence from microcavity polaritons in monolayer transitional metal dichalcogenides,"
Biswanath Chakraborty, Jie Gu, **Zheng Sun**, Mandeep Khatoniar, Rezlind Bushati, Alexandra Bohemke, Rian Koots, Vinod M Menon

7. American Physical Society **(APS)** March Meeting, **Boston, MA**, Mar 4- 8, 2019
"Exciton-Polariton Condensate in a Ring Microcavity,"
Shouvik Mukherjee, David Myers, Rosaria Lena, Burcu Ozden, Jonathan Beaumariage, **Zheng Sun**, Mark Steger, Loren Pfeiffer; Kenneth West, Andrew Daley, David Snoke

8. IEEE Photonics Conference (**IPC**), **Reston, VA**, Sep 30- Oct 4, 2018
"Electrical Tuning of Exciton-Polaritons in Monolayer WS_2,"
Biswanath Chakraborty, Jie Gu, **Zheng Sun**, Mandeep Khatoniar, Rezlind Bushati, Alexandra Bohemke, Rian Koots, Vinod M Menon

9. 9th International Conference On Spontaneous Coherence in Excitonics Systems (**(ICSCE9)**), **Montréal, Canada**, Jul 16-20, 2018
"Stress induced bandgap renormalization in atomic crystals,"
Zheng Sun, Jonathan.beaumariage, Hema C P Movva, Sayema Chowdhury, Anupam Roy, Sanjay K Banerjee, David W Snoke

10. East China Normal University (**ECNU**) International Forum for Young Scientists (Scholars) (**Invited**), **Shanghai, China**, Apr 26-28, 2018
"Control of light-matter interaction in 2D semiconductors,"
Zheng Sun

11. Conference on Lasers and Electro-Optics and Quantum Electronics and Laser Science **(CLEO/QELS)**, **San Jose, CA**, May 13-18, 2018
"Tuning Exciton-polaritons in Monolayer WS_2 Using Electrical Field Gating,"
B Chakraborty, Jie Gu, M. Khatoniar, **Z. Sun**, V. M. Menon

12. Conference on Lasers and Electro-Optics and Quantum Electronics and Laser Science **(CLEO/QELS)**, **San Jose, CA**, May 14-19, 2017
"Valley polarized exciton polaritons from two-dimensional semiconductor in microcavity,"
Z. Sun, J. Gu, A. Ghazryan, Z. Shotan, C. R. Considine , M.Dollar, P. Ghaemi, V. M. Menon

13. Emerging Researchers National **(ERN)** in STEM, **Washington DC**, March 2-4, 2017
"Exciton polaritons in two-dimensional atomic crystal in Micro-cavity,"
Z. Sun, J. Gu, Z. Shotan, R. Considin, M. Dollar and V. M. Menon

14. American Physical Society **(APS)** March Meeting, **New Orleans, LA**, March 13-17, 2017
"Room temperature valley polaritons,".
Z. Sun, J. Gu, Z. Shotan, R. Considin, M. Dollar and V. M. Menon

15. Material Research Science and Engineering Centers **(MRSEC)**, **New York, NY**, Nov 17, 2016
"Interaction of two-dimensional atomic crystal and optical devices,"
Z. Sun and V. M. Menon

16. Conference on Lasers and Electro-Optics and Quantum Electronics and Laser Science **(CLEO/QELS)**, **San Jose, CA**, June 6-9, 2016
"Broadband control of light-matter interaction in 2D semiconductors using photonic hypercrystals,"
Z. Sun, T. Galfsky, C. R. Considine, Y-H- Lee, E. Narimanov and V. M. Menon **(Equal contribution)**

17. Conference on Lasers and Electro-Optics and Quantum Electronics and Laser Science **(CLEO/QELS)**, **San Jose, CA**, June 6-9, 2016
"Preferential emission into epsilon-near-zero metamaterial," Tal Galfsky,
Z. Sun, Zubin Jacob, Vinod M. Menon

18. Conference on Lasers and Electro-Optics and Quantum Electronics and Laser Science **(CLEO/QELS)**, **San Jose, CA**, June 10-14, 2015
"Pseudospin selective microcavity polariton emission from two-dimensional atomic crystals,"
Z. Sun, X. Liu, H-T Huang, Y-H. Lee, S. Kena-Cohen, and V. M. Menon

19. Materials Research Society **(MRS)**, **Boston, MA**, Dec 4, 2014
"Formation of Microcavity Polaritons in Monolayer MoS_2,"
X. Liu, **Z. Sun**, T. Galfsky, F. Xia, E-C Lin, Y-H Lee, S. Kéna-Cohen and V. M. Menon

Professional Services

Served as Reviewer for the following journals and peer review metrics refer to **My Publons**:

• Nature (1) • Physical Review Letter (5) • Nature Photonics (3) • Physical Review X (1)• Nano Letters (1) • Physical Review B (4) • Physical Review Materials (2) • Optica (1) • Scientific Report (1) • Optics Letters (1)• Optical Express (4) • Physica Scripta (1)• Solid State Communications (1) • Semiconductor Science and Technology (1) • Materials Research Express(4)

Media Coverage

•"Photonic hypercrystals drastically enhance light emission in 2D materials", **Phys. org**, Aug 2016

•"Study unveils new half-light half-matter quantum particles", **National Science Foundation**, **Phys. org**, **Nanotechnology Now**, **Science Daily**, and more, Dec 2014.