



Institute of Microelectronics,
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Department of Physics
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Han Cai

OBJECTIVE

To pursue a PhD in quantum information with an emphasis on experiments

EDUCATION

09/2013-present	NTT Basic Research Laboratories	Hybrid Nanostructure Physics Research Group	
	Sub group: Superconducting Circuits for Quantum Information Technologies		Kanagawa, Japan
09/2013-present	Tohoku University	M.E. in Department of Physics	
	Major GPA: A	Overall GPA: A	Sendai, Japan
09/2012- present	Tsinghua University	M.E. candidate in Department of Microelectronics and Nanoelectronics	
	Major GPA: 91/100	Overall GPA: 88/100	Beijing, P.R. China
09/2008-07/2012	Huazhong University of Science and Technology	B.E. in School of Optical and Electronic Information	
	Major GPA: 91/100	Overall GPA: 87/100	Wuhan, P.R. China

Award

[1]	Advanced Individual of Cultural and sports activities	2009
[2]	Prize for The Best Organization	2009
[3]	National Encouragement scholarship	2010
[4]	Model Student of Academic Records	2010&2011
[5]	National Scholarship	2011
[6]	Outstanding Graduates	2012
[7]	Joint Education Program scholarship	2013-2015

RESEARCH EXPERIENCE

Wuhan National Laboratory for Optoelectronics, in Huazhong University of Science and Technology

09/2008– 06/2012 **Electronic Design Course Project:** Portable Heart Rate Meter

- Using SCM (single chip microcomputer) and algorithms in C language to measured the heart rate of subjects and alarmed if the heart rate measured was abnormal.

Laser Course Project: Simulation of the Laser mode in Optical Resonators

- Programmed through Matlab to simulate laser modes in the plane-parallel resonator, spherical resonator, and concave-convex cavity.

Optical Course Project: Designing of a Telescope

- Designed relevant parameters of the optical telescope, analyzed aberration of the system and evaluated optical quality of the telescope.

Undergraduate thesis Project: Single photon detector based on nano-waveguide with optical enhancement

- Using COMSOL to building the optical model and design the device structure.
- Investigating the optical and transport properties of the nanowire gratings.
- Optimizing the performance and found a optimal structure for the NbN nanowire SNSPD with high efficiency.

Tsinghua National Laboratory for Information Science and Technology & Superconducting Quantum Computation Group, Institute of Microelectronics in Tsinghua University

09/2012 – 09/2013 **Project:** Construction of superconducting single-photon detection system

(Subproject of “Genuine Quantum Network” Project under the National 973 Program Guiding Projects on Major Scientific Problems)

- Participated in presenting a novel photon-number-resolving detector using spatial multiplexing based on superconducting serial nanowires configuration which successfully addresses the problem of leakage current, thus allowing both high quantum efficiency and large number of resolvable photons.
- Participated in developing an analytical model for optical cavity integrated superconducting nanowire single-photon detectors (SNSPD) and reached a general conclusion on cavity design verified through finite element simulation and self-designed experiment.
- Participated in proposing air cavity and Si/SiO₂ DBR structure to realize 100% photon absorptance with NbN nanowires of only 25% filling factor, while the former best one needs at least 50% filling factor.
- Participated in fabrication of Nb/Al-AlO_x/Nb and Al/AlO_x/Al Josephson Junctions, Nb coplanar waveguide resonators, SQUID amplifiers, and the construction of superconducting qubit measurement setup based on dilution refrigerator.

Quantum Sensing and Measurement Group, Department of Physics in Tohoku University& Hybrid Nanostructure Physics Research Group in NTT Basic Research Laboratories

09/2013 – present **Project:** Superconducting qubit and electron spin hybrid quantum system

- Independently finish the calculation of hybrid system Hamiltonian function with and without detuning between the qubit and NV center and obtain the eigenvalue and eigenvector expression by different approaches such as using the Jay-Cummings model with rotating approximation, Heisenberg function with steady state approximation and time-independent perturbation theory.
- Independently developed a numerical model and an analytical model for analyzing the hybrid system, succeeded to use the new model reproducing the spectrum with power broadening in the experiment result, and reached a general conclusion on hybrid system that the flux qubit can't be considered as Harmonic oscillator in the strong driving power case.
- Independently do the measurement of superconducting flux qubit coupling with NV center in the diamond based on Triton refrigerator (Include Gap-tunable flux qubit; Rabi oscillation; I_{half} measurement; T1 measurement; Ramsey measurement and Spectroscopy measurement).
- Independently presented the existence of two photon process in the hybrid system by the numerical model and found the necessary parameters for the NV center which coupled with the flux qubit and then might observe the two photon process by experiment.

ACADEMIC ACTIVITIES

07/ 2012	Summer School on Low-temperature Physics and Experimental Technology, State Key Laboratory of Low-Dimensional Quantum Physics, Tsinghua University	Beijing, P.R. China
11/ 2012	Workshop on Quantum Network Using Superconducting Quantum Circuits, University of Science and Technology of China	Anhui, P.R. China
11/ 2012	3rd International Workshop on Frontier Applications of Superconducting Devices, Shanghai Center for superconductivity, Chinese Academy of Sciences	Shanghai, P.R. China
07/2013	The 12th National Conference on Superconductivity, University of Electronic Science and Technology of China	Chengdu, P.R. China
08/ 2013	Utrecht Summer School in the course Theoretical Physics, Department of Physics, Utrecht University	Utrecht, The Netherlands

PUBLICATIONS

- [1] **Han Cai**, Zheng Xu, Heyu Yin, Risheng Cheng, Tiefu Li, Jianshe Liu and Wei Chen, “High-speed superconducting nanowire single photon detectors with Strong photon absorption structures”, *Chinese Journal of Low Temperature Physics*.
- [2] Heyu Yin, **Han Cai**, Risheng Cheng, Zheng Xu, Zhennan Jiang, Jianshe Liu, Tiefu Li and Wei Chen, "Polarization independent superconducting nanowire detector with high-detection efficiency", *Rare Metals*.
- [3] Yin Heyu, Cheng Risheng, Xu Zheng, **Cai Han**, Liu Jianshe, Li Tiefu, and Chen Wei, “Physical Model and Research Progress of the SNSPD”, *Micronanoelectronic Technology*.
- [4] Risheng Cheng, Heyu Yin, Jianshe Liu, Tiefu Li, **Han Cai**, Zheng Xu and Wei Chen, “Photon-number- resolving detector based on superconducting serial nanowires”, *IEEE Transactions on Applied Superconductivity*.
- [5] Risheng Cheng, Heyu Yin, Jianshe Liu, Tiefu Li, **Han Cai**, Zheng Xu and Wei Chen, “Improvement of superconducting nanowire detectors absorptance by air cavity structure”, *Optics Express*.

TECHINICAL SKILLS AND LANGUAGES

Experimental Skills: Optical Experiment, Microwave techniques, Cryogenic Measurement (dilution refrigerator, PPMS, ³He refrigerator, liquid helium dewar), Nanofabrication (magnetron sputtering, e-beam evaporation, RIE, PECVD, e-beam lithography, photolithography), SEM, XRD, AFM

Programming Languages: LabVIEW, C/C++

Scientific Software: MATLAB, COMSOL Multiphysics, L-Edit, Protel, Pspice, Mathematica

Languages: Chinese, English