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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: AA Overall GPA: AA	Sendai, Japan
	(*two courses taken in Tohoku Univ., other courses transfer from Tsinghua Univ.)	
	Master's thesis: "A hybrid system with a superconducting flux qubit and diamond NV centers"	
09/2012- present	**Tsinghua University** M.E. in Department of Microelectronics and Nanoelectronics	
	Major GPA: 92.3/100 Overall GPA: 90.6/100 Rank: 2/23	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: 91.6/100 Overall GPA: 88.2/100 Rank: 2/85	Wuhan, P.R. China
	Honor's Thesis: "Single photon detector based on nano-waveguide with optical enhancement"	

FELLOWSHIPS AND AWARDS

[1]	Advanced Individual of Cultural and sports activities	2009
[2]	Prize for the Best Organization	2009
[3]	National Scholarship of Encouragement	2010
[4]	Model Student of Academic Records	2010 - 2011
[5]	National Honor Fellowship	2011
[6]	Outstanding Graduates Award	2012
[7]	Tsinghua Univ. & Tohoku Univ. Joint Education Program Fellowship	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 measure 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
- Used COMSOL Multiphysics (a finite element analysis, solver and simulation software) to build optical models and design the device structure.
- Investigated the optical and transport properties of the nanowire gratings.
- Optimized the performance and found an optimal structure for the NbN superconducting nanowire single-photon detectors (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)
- Assisted 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 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/SiO_2 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 calculated the Hamiltonian function for the hybrid system with and without detuning between the qubit and NV center. Obtained the eigenvalue and eigenvector expression by different approaches such as using the Jaynes-Cummings model with rotating wave approximation, Heisenberg equations 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 cannot be considered as Harmonic oscillator in the strong driving power case.
- Measured the 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).
- Proved the existence of two photon process in the hybrid system by numerical modelling. Found the necessary parameters for the NV center coupled with the flux qubit which can observe the two photon process by experiment.

TEACHING EXPERIENCE

09/2011 - 01/2012 **Teaching Assistant**, Huazhong University of Science and Technology   Wuhan, P.R. China
Undergraduate Course: Physics Optics

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

06/2013 **ICQM Summer school on spintronics, quantum transport and Opto-valleytronics,**
Quantum Matter Science Innovation Center, Peking University   Beijing, 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 (2014-6)*.

[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 (2014): 1-6*.

[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 (2013-11)*.

[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 (2013-1)*

TECHNICAL SKILLS AND LANGUAGES

Experimental Skills: Optical Experiment, Microwave techniques, Cryogenic Measurement (dilution refrigerator, PPMS, ^{3}He 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