

EDUCATION



POSTDOCTORAL RESEARCH - TRAPPED ION QUANTUM COMPUTING 2020
Massachusetts Institute of Technology

Scalable trapped-ion chips with **integrated photonics** for optical control
Integrated photonics + CMOS compatible surface electrode ion trap chips



DOCTOR OF PHILOSOPHY - EXPERIMENTAL QUANTUM PHYSICS 2015
Purdue University

“Experiments with synthetic spin-orbit coupling with Bose Einstein condensates”



BACHELOR OF SCIENCE - PHYSICS , MINOR ASTROPHYSICS 2008
Michigan Technological University

“Electrical characterization of individual layers of multiwall carbon nanotubes”

ACADEMIC RESEARCH

MIT LINCOLN LABORATORY, JOHN CHIAVERINI, JEREMY SAGE & ISAAC CHUANG,
Postdoctoral Research Associate (Active Secret Security Clearance) 2018-2020



- **Quantum Computing** - Integration of photonics within ion trap chips for *scalable* optical addressing of trapped ion qubits at **multiple wavelengths**
- **Trapped ion qubits** - High fidelity 2 qubit MS gates, surface trap chips, cryo/UHV
- **Integrated Photonics Process Development** at the MIT Lincoln Micro-Electronics Lab fab cleanroom: waveguides, grating couplers -SiN and Al₂O₃ for **UV** → Infrared λ
- **Photonics** design (**Lumerical**) *and* testing: Waveguides and input couplers loss etc, grating couplers - precise diffraction angle measurement for targeting ions with 3 μ m beams
- **Published in Nature** - <https://www.nature.com/articles/s41586-020-2811-x>



PURDUE QUANTUM CENTER, Y. CHEN, Research Assistant 2010-2015

- **Quantum Simulation** of synthetic spin-orbit coupling and magnetic fields with BECs
- Designed all optical ⁸⁷Rb Bose Einstein condensate laser cooling apparatus



PURDUE QUANTUM CENTER, GABOR CSATHY , Research Assistant 2009

- Non-Abelian $\frac{5}{2}$ fractional **quantum Hall** state measurements (RF, Van der Pauw etc.)
- 5mK base temp ‘wet’ Helium dilution fridge operation

INDUSTRY RESEARCH

INTEL CORP. PTD, Process R&D Yield and Integration Engineer 2015 - 2018



- **7nm** node front-end FinFET process technology R&D for flagship Core i9, Xeon CPUs
- Metal gate, gate oxide, fin trim-isolation, polySi, EPI source/drain process layers
- **Patent WO/2019/066775** - developed, patented and implemented new metal gate process for patterned high/low voltage threshold control for all future Intel processes
- **Spin qubit quantum computing** process technology R&D on 300mm wafers
- **Awarded 6 prestigious Intel Logic/Portland Technology Development Awards**
Identified multiple root causes of defects reducing yield and performance, developed new inline metrology to quantify SEM images, designed experiments using: dry/wet etch chemistries, thin films and etch interactions etc. and implemented new processes
- Yield analysis with SQL database mining and JMP/SAS data tables and JSL

INDUSTRY EXPERIENCE

INTEL CORP. PTD, *Image analysis software development*

2016



- Created paradigm shifting MATLAB based image analysis tools for defect quantification - (Intel Logic Technology Development Division Award 2016)
- Managed senior software development team of group leaders to expand software - Delivered scalable, real-time image analysis suite - quickly adopted across all nodes - (Technology Manufacturing Group Excellence Award 2018) - *groups highest award*
- Trained 4 groups of senior Ph.D. engineers (60 total) on software and methodology
- Image analysis now measures **all of the highest pareto defects** in development creating defect density data which informs *all high impact process changes*.

PATENTS



PATENT WO2019066775, <https://patents.justia.com/inventor/robert-niffenegger>

INTEGRATED CIRCUIT STRUCTURES HAVING DIFFERENTIATED WORKFUNCTION LAYERS
Intel Corporation, Portland Technology Development (PTD), 2017

Pang, Ying and **Niffenegger, Robert** and Lavric, Dan S. and Gstrein, Florian and Agarwal, Ashish and Sadhukhan, Padmanava and Heussner, Robert W. and Joel M. Gregie
⇒ Process of Record (POR) for **all** future Intel Xeon,i9,i7 CPUs

PUBLICATIONS

nature

"INTEGRATED MULTI-WAVELENGTH CONTROL OF AN ION QUBIT",

Niffenegger, Robert J., Stuart J, Sorace-Agaskar C, Kharas D, Bramhavar S, Bruzewicz C, Loh W, McConnel R, Reens D, West GN, Chiaverini J, Sage JM.
Nature 586, 538–542 (2020). <https://doi.org/10.1038/s41586-020-2811-x>

**nature
communications**

"SPIN CURRENT GENERATION AND RELAXATION IN A QUENCHED SPIN-ORBIT-COUPLED BOSE-EINSTEIN CONDENSATE",

(2019) **Nature communications**. Jan 22;10(1):375.
Li CH, Qu C, **Niffenegger Robert J**, Wang SJ, He M, Blasing DB, Olson AJ, Greene CH, Lyanda-Geller Y, Zhou Q, Zhang C, Chen Y.
<https://www.nature.com/articles/s41467-018-08119-4>

**SPIE.
PHOTONICS
WEST**

"A VISIBLE-LIGHT INTEGRATED PHOTONIC PLATFORM FOR ATOMIC SYSTEMS",

Bramhavar S, Sorace-Agaskar C, Kharas D, Loh W, Maxson R, West GN,
Niffenegger Robert J, Juodawlkis PW, Chiaverini J, Sage JM.
(2019) Integrated Optics: Devices, Materials, and Technologies XXIII Mar 4 (Vol. 10921, p. 109211D). International Society for Optics and Photonics.

PHYSICAL
REVIEW A

"STUECKELBERG INTERFEROMETRY USING PERIODICALLY DRIVEN SPIN-ORBIT-COUPLED BOSE-EINSTEIN CONDENSATES",

Olson AJ, Blasing DB, Qu C, Li CH, **Niffenegger Robert J**, Zhang C, Chen YP. (2017).
Physical Review A, 95(4), p.043623. <https://link.aps.org/doi/10.1103/PhysRevA.95.043623>

PHYSICAL
REVIEW A

"TUNABLE LANDAU-ZENER TRANSITIONS IN A SPIN-ORBIT-COUPLED BOSE-EINSTEIN CONDENSATE",

Olson AJ, Wang SJ, **Niffenegger Robert J**, Li CH, Greene CH, Chen YP. (2014) *Physical Review A*, 90(1)013616 <https://link.aps.org/doi/10.1103/PhysRevA.90.013616> (133 citations)

PHYSICAL
REVIEW A

"OPTIMIZING THE EFFICIENCY OF EVAPORATIVE COOLING IN OPTICAL DIPOLE TRAPS",

Olson AJ, **Niffenegger, Robert J** and Chen Y, (2013)
Physical Review A, 87(5)053613 <https://link.aps.org/doi/10.1103/PhysRevA.87.053613>

ACADEMIC RESEARCH



PURDUE UNIVERSITY, J. MELOSH, *Research Assistant* 2009

- Computational Physics - Non-Newtonian mass flow effects on crater formation



NASA AMES RESEARCH CENTER, *Intern* 2007 & 2008

- 2008 - Bayesian electrical and safety diagnostics development
- 2007 - Binary star simulation and exoplanet detection - **Kepler mission**



NASA GODDARD SPACEFLIGHT CENTER, *Intern* 2005 & 2006

- 2006 - Simulation of thermodynamics of Saturn's moons - **Cassini mission**
- 2005 - Prototyped lunar low frequency radio telescope - Ulysses Mission

TEACHING EXPERIENCE



PURDUE UNIVERSITY, *Physics Lecturer and class administrator* 2013

- Created syllabus, lesson plans, created homework and wrote exams independently
- Electromagnetism and Modern Physics for Engineers (300 students)
- Lectured 3 classes per week, graded exams etc.



PURDUE UNIVERSITY, *Electrical Engineering Teaching Assistant* 2014

- Quantum Optics and Coherent Electronics for Electrical Engineer PhDs



PURDUE UNIVERSITY, *Physics Lecturer* 2013 & 2012

- Electromagnetism and Modern Physics for Engineers (300 students)
- Lectured 3 classes per week, graded exams etc.



PURDUE UNIVERSITY, *Physics Lecturer - Classical Mechanics* 2011

- Lectured 3 classes per week, graded exams etc.
- 300 students



PURDUE UNIVERSITY, *Physics Lab Teaching Assistant* 2010

- Modern Physics for undergraduate physics honor students
- Electromagnetism for Engineers



PURDUE UNIVERSITY, *Mathematics Recitation Teaching Assistant* 2009

- Calculus II for Engineers



PURDUE UNIVERSITY, *Physics Teaching Assistant* 2008

- Physics lab teaching assistant - Electromagnetism for Engineers
- Physics lab teaching assistant - Mechanics



Michigan Tech

MICHIGAN TECH. UNIVERSITY, *Modern Physics Teaching Assistant* 2008

- Modern Physics lab TA for Physics Major Honor students

SPECIALIZED PROFESSIONAL CONFERENCES

- North American Conference on Trapped Ions (2019) - University of Maryland, USA
- International Workshop on Silicon Quantum Electronics (2017) - Portland, OR, USA
- Very Large Scale Integration Conference (2017) - Kyoto, Kyoto Prefecture, Japan

- Adiabatic Quantum Computing Conference (2016) - Google Los Angeles - Venice, CA, USA
- Symposium on Novel Topological Quantum Matter (2013) - UT Dallas - Dallas, Texas, USA

CONFERENCE TALKS

- "Integrated multi-wavelength photonic addressing of trapped ion qubits"
Niffenegger Robert J, Stuart J, Bruzewicz C, McConnell R, West G, Simon G, Kharas D, Sorace-Agaskar C, Bramhavar S, Sage J, Chiaverini J. Bulletin of the American Physical Society. 2019 Mar 4.
- "Transport behaviors of BEC in synthetic spin-orbit and gauge fields",
Niffenegger, Robert, Li, C. and Olson, A. and Chen, Y. American Physical Society Division of Atomic, Molecular and Optical Physics Meeting 2014, Madison, WI
- "Spin Transport in Spin Orbit Coupled Bose Einstein Condensates",
Niffenegger, Robert, Olson, A., Li, C. and Chen, Y. American Physical Society March Meeting 2014, Denver, CO
- "Experimental studies of transport and dynamics of BEC in synthetic gauge fields and spin-orbit coupling",
Niffenegger, Robert, Olson, A., Li, C., Blasing, D. and Chen, Y. American Physical Society Division of Atomic, Molecular and Optical Physics Meeting 2013, Quebec City, Canada
- "Experiments on BECs with Synthetic Gauge Fields and Spin Orbit Coupling",
Niffenegger, Robert and Olson, A. and Chen, Y. American Physical Society March Meeting 2013, Baltimore, MA

Computer Skills

- Matlab - image analysis and computational simulation
- JMP/SAS and SQL - large data set analysis, commonalities, SQL data mining
- Python - Machine learning, CNN etc.
- Labview, Fortran, IDL, Visual Basic, C++, C
- ARTIQ - Quantum control based on Python

University Organizations



PURDUE UNIVERSITY, *President* - *Physics Graduate Student Association* 2013

- Worked with faculty to help PhD students graduate faster
- Reorganized student physics 'help center' and teaching assistant roles



PURDUE UNIVERSITY, *Senator* - *Purdue Graduate Student Government* 2012

- Represented Physics graduate students



Michigan Tech

MICHIGAN TECH. UNIVERSITY, *President* - *Undergraduate Student Government* 2008

- Passed new constitution flattening student organization structure
- Updated student fee allocations to improve student facilities - ski hill/rec center