A. Barış Özgüler

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Google Scholar: https://scholar.google.com/citations?user=ihtC3f4AAAAJ&hl=en
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PROFILE

A theoretical physicist and an expert in quantum information science. My research focuses on quantum device simulations on large-scale computing resources and designing quantum algorithms that can be run on scalable hardware. I have extensive experience in all aspects of control stack between algorithms and physical implementation.

EDUCATION & WORK EXPERIENCE

Research Associate, Fermilab Quantum Institute (FQI) & Superconducting Quantum Materials and Systems (SQMS) National Quantum Center, Fermilab (July, 2020 – Present)

> **& Resident Associate**, Argonne National Laboratory: July, 2020 – Present

> Postdoctoral Research:

> * Designing hardware and noise models for superconducting radio frequency cavity-based qubits and integrating quantum algorithms relevant to condensed matter and high-energy physics to demonstrate the utility of the system.

> * Wrote proposals for and working on my project that will deliver an end-to-end 3D quantum device simulation software system that can run on high-performance computers (HPC).

> * ASIC Artificial Intelligence Codesign: The aim is to create a machine learning accelerator for quantum control that approximates the numeric optimization approaches and runs on custom hardware. The final accelerator will be integrated in a chip that will work in a harsh environment in the proximity of a quantum computer. Our group is collaborating with John Martinis (UCSB & Qolab).

>> *** Highlights from my postdoc work including the projects I am leading or contributing to:

>> https://chicagoquantum.org/events/cqe-workshop-scalable-quantum-control **(Lead organizer and Chair)**

>>> >> Review/Roadmap article based on the workshop is in preparation

>> arXiv: 2208.02645, Neural network accelerator for quantum control

>> arXiv: 2207.14006, Dynamics of qudit gates and effects of spectator modes on optimal control pulses

>> arXiv: 2204.08605, Quantum computing hardware for HEP algorithms and sensing

>> arXiv: 2201.07787, Numerical Gate Synthesis for Quantum Heuristics on Bosonic Quantum Processors

>> arXiv: 2108.13375, Benchmarking variational quantum eigensolvers for the square-octagon-lattice Kitaev model

>> arXiv: 2104.03300, Excitation dynamics in inductively coupled fluxonium circuits

>> arXiv: 2011.13143, Impacts of Noise and Structure on Quantum Information Encoded in a Quantum Memory

PhD in Physics, University of Wisconsin–Madison (2017-2020)

> M.A. in Physics (en route to PhD): 2015-2017 (GPA: 3.70/4.00)

> PhD Research:

>> Dissertation Title: *Theory and Simulations of Interacting Quantum Systems*

>>> Advisor: Prof. Maxim Vavilov

Grad student visitor at Los Alamos National Laboratory [Advisor: Dr. Jianxin Zhu] (Fall, 2019)

>*Project (related to my dissertation)*: Quantum transport through multi-terminal topological superconductor junctions

Undergraduate:

>**Education Abroad Program,** Physics & Math Departments, University of California, Los Angeles (2014-2015)

>**Physics Bachelor's Degree**, Koç University (GPA: 4.04/4.00), 2015

>> - My Department Rank: 1, My College of Sciences Rank: 1, My School Rank: Top 10 (of ~ 1000)

>**Mathematics Bachelor's Degree**, Koç University (GPA: 4.04/4.00), 2015

>> - My Department Rank: 1, My College of Sciences Rank: 1, My School Rank: Top 10 (of ~ 1000)

>*Rankings for my Bachelor's Degrees are based on the information obtained right before my graduation since I did not attend the commencement.*

>Took many grad courses from various subfields during my undergrad.

>Undergraduate Research:

>> - Summer Intern, CERN [Advisor: Dr. Chiara Bianchin] — 2013

>>> *Project*: Signal extraction in charmed Lambda baryon analysis via Monte Carlo simulation (ALICE Experiment)

>> - Summer Intern, Quantum Information and Nanoscale Metrology Group, University of Cambridge [Advisor: Prof. Mete Atatüre] — 2012

>>> *Project*: Designing and constructing an actively stabilized optical interferometer for wavelength multiplexing (to be used in spectrally close Zeeman transitions of silicon-vacancy color centers in diamond under magnetic field)

>> - Nano-Optics Research Laboratory, Koç University [Advisor: Prof. Alper Kiraz]   — 2010-2012

>>> *Project*: Designing wafer of a gas sensor and setting up mechanical and optical devices for ongoing experiments.

Ankara Fen Lisesi (Ankara **High School** of Science), 2010 (GPA: 95.68/100)

>- Top Science High School in Turkey

>- My Rank: 3 (of ~ 90 students)

>- **International Physics Olympiad (IPhO) Team Member** (5 people from each nation), 2009.

>> \>> Honorable Mention, IPhO 2009, Mexico. *[I was sick during the Olympiad, which negatively affected my score.]*

TED Ankara Koleji (TED Ankara College Foundation School) - **Middle School**, 2006

>- My Rank: 1 in the high school entrance exam of TED

PUBLICATIONS & PREPRINTS

- https://chicagoquantum.org/events/cqe-workshop-scalable-quantum-control **(Lead organizer and Chair)**

>\>> Review/Roadmap article based on the workshop is in preparation.

- D. Xu, **A. B. Özgüler** (Corresponding Author), G. D. Guglielmo, et al. Neural network accelerator for quantum control, [*D. Xu was our undergrad mentee*] [arXiv: 2208.02645] (**Accepted with score 5.5/6** by the Third International Workshop on Quantum Computing Software [https://events.cels.anl.gov/event/273], SC22 [https://sc22.supercomputing.org/])

> Our repo: https://github.com/fastmachinelearning/ml4quantum-release

- **A. B. Özgüler**, J. A. Job, Dynamics of qudit gates and effects of spectator modes on optimal control pulses [arXiv: 2207.14006] (Under review for Physical Review A)

> Our repo: https://github.com/Fermilab-Quantum-Science/3DSimulator

- **SQMS Collaboration**, Quantum computing hardware for HEP algorithms and sensing, arXiv: 2204.08605 (white paper submitted to Snowmass)

- **A. B. Özgüler**, D. Venturelli, Numerical Gate Synthesis for Quantum Heuristics on Bosonic Quantum Processors, arXiv:2201.07787 (Accepted to be published in https://www.frontiersin.org/research-topics/26678/programming-physical-quantum-systems-methods-applications-languages-and-compilers#overview)

- **SQMS Algorithms Group Collaboration**, Benchmarking variational quantum eigensolvers for the square-octagon-lattice Kitaev model, https://arxiv.org/abs/2108.13375 (Will be submitted to Phys. Rev. A)

- **A. B. Özgüler**, V. Manucharyan, M. G. Vavilov, Excitation dynamics in inductively coupled fluxonium circuits (2021) [arXiv:2104.03300. Will be submitted to Physical Review Applied]

- M. Otten, K. Kapoor, **A. B. Özgüler**, E.T. Holland, J.B. Kowalkowski, Y. Alexeev, A.L. Lyon, Impacts of Noise and Structure on Quantum Information Encoded in a Quantum Memory, Phys. Rev. A **104**, 012605.

- **A. B. Özgüler**, C. Xu, M. G. Vavilov, Response of a quantum disordered spin system to a local periodic drive, Phys. Rev. B **101**, 024204 (2020).

- **A. B. Özgüler**, R. Joynt, M. G. Vavilov, Steering Random Spin Systems to Speed up the Quantum Adiabatic Algorithm, Phys. Rev. A **98**, 062311 (2018).

- **A. B. Özgüler**. Signal Extraction Using Invariant Mass Analysis in $\Lambda_C{}^+$ Analysis in the pKπ Decay Channel in pp Collisions at $\sqrt{s}$= 7 TeV. No. CERN-STUDENTS-Note-2013-044. 2013.

WORK IN PROGRESS

Quantum time dynamics of qudit models:

Generalization to qudits: *Quantum time dynamics of 1D-Heisenberg models employing the Yang-Baxter equation for circuit compression* (https://arxiv.org/abs/2112.01690). Working with Bo Peng (PNNL), Andrey Khesin (MIT), Matt Otten (HRL), Yuri Alexeev (ANL).

Connections to ZX-calculus: Ongoing discussions with Steve Adachi Job (Lockheed Martin), Josh Job (Lockheed Martin) & Stuart Hadfield (NASA Ames)

Our repo & papers based on: https://github.com/Fermilab-Quantum-Science/3DSimulator (repo is private for now)

3D system simulator. Qudits are modeled via cQED Hamiltonian. Working on scalable solutions for generalized cases.

Collaborator: Joshua A. Job (Lockheed Martin)

Distinguishing between multi-terminal and two-terminal supercurrent [Preprint available upon request. Work in collaboration with the experimental group of Prof. Vladimir Manucharyan, Joint Quantum Institute & University of Maryland)]

Effects of gate voltage and magnetic field on multi-terminal Josephson junctions [Preprint available upon request], A. B. Özgüler, H. Lee, V. E. Manucharyan, M. G. Vavilov.

PROPOSALS

Big Idea Generator Proposal, April 2022

Funding info: http://big.uchicago.edu/

Project Title: Improving simulation capabilities of quantum systems using HPC resources and techniques

PI: Prof. Fred Chong (UChicago)
Co-PI: Dr. Yuri Alexeev (ANL), Dr. **A. Barış Özgüler** (FNAL)

I converted my LDRD proposal (right below) into a proposal for a seed opportunity. I am the de-facto PI. The PI has to be from UChicago or affiliated for this funding opportunity, that's why I am listed as a co-PI above.

Fermilab LDRD Proposal, November 2021

Project Title: Improving simulation capabilities of quantum systems using HPC resources and techniques

PI: Dr. **A. Barış Özgüler** (FNAL)
Co-PI: Dr. Yuri Alexeev (ANL), Prof. Jens Koch (Northwestern University)

This proposal is at top 10 (~ 50 projects) and selected to be funded. There is currently a "moratorium" on LDRD projects at Fermilab, so we haven't received the official approval.

PRESENTATIONS

Invited talk, Neural network accelerator for quantum control (Workshop paper: https://arxiv.org/abs/2208.02645), Third International Workshop on Quantum Computing Software [https://events.cels.anl.gov/event/273], SC22 [https://sc22.supercomputing.org/]), November, 2022.

Invited talk, Pulse-level control and dynamics of qudit gates, "Advanced Simulations of Quantum Computations" Workshop, IEEE International Conference on Quantum Computing and Engineering (QCE) 2022, September, 2022. (https://qce.quantum.ieee.org/2022/workshops-program)

Contributed talk, Pulse-level control for qudit algorithms, QSC/SQMS Quantum Algorithms Workshop, NM (May, 2022) https://cquic.unm.edu/events/2022/05/qaw.html

Contributed talk, Numerical Gate Synthesis for Quantum Heuristics on Multi-Mode Bosonic Systems, APS March Meeting, 2022

SQMS Talk, Algorithms for Bosonic Quantum Processors: Gate Synthesis and Pathway to Scalability, 1/21/22

Contributed talk, Quantum Approximate Optimization Algorithm (QAOA) for a Bosonic Systems, Fermilab (August, 2021)

Talk, Excitation dynamics in inductively coupled fluxonium circuits, FQI, Fermilab, 4/27/2021.

Contributed talk, Quantum Approximate Optimization Algorithm with Qudits on Superconducting Radio Frequency Cavity-Transmon System, April 19-20 2021 CQE Members and Partners Workshop

Poster, Quantum Approximate Optimization Algorithm with Qudits on Superconducting Radio Frequency Cavity-Transmon System, Sixth International Conference for Young Quantum Information Scientists (YQIS 6), 4/14/21.

Talk, Quantum Control, QAOA, 2D Rigetti, SQMS FNAL Talk, 4/9/2021.

Talk, SRF Quantum Computing Discussion with HEP/QIS, Fermilab, 4/5/2021.

Talk, Excitation dynamics: From 1D chains to Kitaev honeycomb model, SQMS HEP/CM Simulations Subthrust Talk, 3/23/2021.

Contributed talk, Excitation dynamics in an inductively coupled fluxonium chain, APS March Meeting 2021 (Virtual).

FQI Talk, QAOA on 3D Device, 2/16/2021.

Poster, Response of a quantum disordered spin system to a local periodic drive, New perspectives on quantum many-body chaos, The Royal Society, February 8-11, 2021.

Poster, Excitation dynamics in galvanically coupled fluxonium circuits, 24th Annual Conference on Quantum Information Processing, February 1-5, 2021.

SQMS Talk, QAOA on 3D Device, 1/29/2021.

Talk at Jens Koch Group, Qudit Algorithms on Optimally Controlled Cavity-Qubit Systems, Northwestern University (Virtual), November, 2020.

Contributed talk, Effect of magnetic field on multi-terminal Josephson junctions, APS March Meeting 2020 (Meeting cancelled due to COVID).

Invited talk, Theory and Simulations of Interacting Quantum Systems, Postdoc candidate seminars, 2020.

Poster, Speedup of the Quantum Adiabatic Algorithm using Quantum Steering and Catalysis. Collaborative work with C. Cao, J. Xue, M. G. Vavilov, T. Xiang, N. Shannon, R. Joynt. Presented by Robert Joynt at QIP 2020, January 6-10, 2020, Shenzen, China.

Invited talk, Effect of Magnetic Field on Multi-terminal Josephson Junctions, Theoretical Division Seminar, Los Alamos National Lab, NM, USA, November 2019

Talk, Multi-terminal Josephson Junctions, Talk in the group meeting of Dr. Jianxin Zhu, Los Alamos National Lab, NM, USA, 10/25/2019

Poster, Andreev Bound States in Multi-terminal Josephson Junctions, 2nd Minnesota Condensed Matter Summer School, June 10-15, 2019, Minneapolis, MN.

Poster, Phase Transitions and Edge States in Fluxonium Qubit Systems, CNLS 39th Annual Conference - Strongly Correlated Quantum Materials, 29 April-3 May, 2019, Santa Fe, NM.

Invited talk, Faster Quantum Adiabatic Algorithm, Physics Department Seminars at:
    Bilkent University, Turkey, January 2019
    Mimar Sinan Fine Arts University, Turkey, January 2019
    Koç University, Turkey, January 2019

Contributed talk, Phase Transitions and Edge States in Fluxonium Qubit Systems, APS March Meeting 2019, Boston, MA

Contributed talk, Steering Random Spin Systems to Speed up the Quantum Adiabatic Algorithm, Adiabatic Quantum Computing Conference, June, 2018, NASA Ames Research Center, CA

Contributed talk, Simulating Disordered Spin Systems for Quantum Computing using HTCondor, HTCondor Week 2018, May, 2018, UW-Madison, WI

Contributed talk, Fast quantum annealing protocol for Ising Hamiltonian with strong random field, APS March Meeting 2018, Los Angeles, CA

Physics Prelim Seminar, Fast Quantum Annealing, UW-Madison, WI, December, 2017.

Some other notable events attended that are not mentioned in other sections:

Workshop, Fast Machine Learning for Science (https://indico.cern.ch/event/1156222/), October 3-6, 2022.

>> We present our work "Neural network accelerator for quantum control" (https://arxiv.org/abs/2208.02645)

IEEE Quantum Week 2020 & 2021

Illinois Quantum Computing Summer School (by Chicago Quantum Exchange), June 2019

Open Science Grid (OSG) User School 2018, UW-Madison, July, 2018

Software Carpentry Workshop, UW-Madison, January, 2018

TEACHING & MENTORING & DIVERSITY

Mentor of NSF MSGI Grad Student (Andrey Khesin, MIT). Our project is "Developing machine learning models for quantum optimal control using HPC simulations of quantum systems".

>> Andrey is a math grad student at MIT. His PhD advisor is Peter Shor.

>> Andrey gave a talk at https://cquic.unm.edu/events/2022/05/qaw.html. I invited him.

>> We are working on: Quantum time dynamics of qudit models

Co-mentor of CS Professor Stephen Providence (Coppin State University) [Fermilab Visiting Faculty Program]

Mentor of Joseph Oluwole (https://chicagoquantum.org/oqi-undergraduate-fellowship)

Mentor of SULI Student, Alisha Roberts (Undergrad student at New Mexico Institute of Mining and Technology). Project on quantum optimal control for neutrino oscillations. Summer 2022.

Co-mentor of the undergrad student, David Xu (Columbia University) for ASIC Artificial Intelligence Quantum Control project on Embedded Scalable Platforms (Columbia University grad course). Spring 2022.

>> Check out our paper: D. Xu, **A. B. Özgüler**, G. D. Guglielmo, et al. Neural network accelerator for quantum control, [arXiv: 2208.02645]

Teaching Assistant, Physics 103-104 [Intro Physics Courses] (UW-Madison, 2015-2017)

Volunteer French Tutor, Greater University Tutoring Service (UW-Madison, 2018-2019)

Volunteer Turkish Tutor, Greater University Tutoring Service (UW-Madison, 2016)

Volunteer Physics & Math Tutor, Koç University Office of Learning and Teaching (2012-2013)

Teaching Assistant, Math.107 — Linear Algebra (Koç University, 2012)

LEADERSHIP

I am the lead organizer and the chair: Workshop on Scalable Quantum Control, Chicago Quantum Exchange (CQE) (August 15th, 2022)

> This workshop brought together researchers with expert knowledge of different layers of the control stack in order to stimulate collaborations and accelerate the scaling-up of quantum.

> I was **"the committee"**. I did significant work, brought together (legendary) experts. It was a great workshop. The workshop presentations are available here: https://github.com/relugzosiraba/cqe-workshop-scalable-quantum-control.

> Workshop website: https://chicagoquantum.org/events/cqe-workshop-scalable-quantum-control

> *An important output of the workshop*: The Review/Roadmap article is in preparation.

> On 8/16/2022; we hosted two of our speakers, John Martinis (Google quantum supremacy experiment lead) and Zlatko Minev (IBM), at the SQMS Center to discuss collaborations.

Host of Prof. John Martinis (Google quantum supremacy experiment lead), Fermilab visit, August 16, 2022. He gave a talk entitled "Correlated errors in qubits from cosmic rays" at the SQMS Center.

Organizing and hosting many recurring events at SQMS & FQI, Fermilab.

Organizing Committee Member for the Workshop, Classical Simulations of Quantum Devices, Fermilab, 2021.

APS March Meeting 2021 Session Chair, R31: Long Distance Quantum Communication

Panelist, Towards a Quantum Internet (Seminar by Panagiotis Spentzouris), Fermilab, December, 2020.

Turkish Educational Foundation (Türk Eğitim Vakfı) Outstanding Success Scholarship (2010-2015)

> >> Awarded to successful high school graduates or undergrads with leadership characteristics to support their undergrad work. Awarded to ~ 50 people in the nation each year. I was awarded right after I graduated high school.

COMPUTING EXPERIENCE

Python, Julia, Mathematica, MATLAB.

Experience with (and using): C/C++

Technologies and Tools: Linux, PETSc, Docker.

Prior Experience: Java, ROOT, Qiskit, Cirq.

FELLOWSHIPS & SCHOLARSHIPS

James Nelson Humphrey Award, Department of Physics, UW-Madison (May, 2019)

> >> Awarded for my success during the grad research

The Scientific and Technological Research Council of Turkey (TÜBİTAK) Undergraduate Fellowship (2010-2015)

>> Support for undergrad due to my international Olympiad success at high school

Turkish Educational Foundation (Türk Eğitim Vakfı) Outstanding Success Scholarship (2010-2015)

>> Awarded to successful high school graduates or undergrads with leadership characteristics to support their undergrad work. Awarded to ~ 50 people in the nation each year. I was awarded right after I graduated high school.

Koç University Suna-İnan Kıraç Fellowship (2010-2015)

>> Given to selected students of high university entrance exam score. I was the student with the highest university entrance exam score (with additional points due to my international olympiad success) entering Koç University.

Koç University Global Exchange Scholarship *[for UCLA education abroad program]* (2014)

>> Merit-based scholarship covering all expenses of the education abroad program

CERN Engin Arık Fellowship (2013)

>> Awarded for summer internship at CERN

HONORS & AWARDS

Awarded travel grant by Los Alamos National Laboratory for the grad research in the group of Dr. Jianxin Zhu, October 2019

Awarded travel grant by Illinois Quantum Computing Summer School, June 2019

Awarded travel grant by CNLS 39th Annual Conference - Strongly Correlated Quantum Materials, March 2019

UW–Madison Student Research Grants Competition Conference Award (Travel Grant) for APS March Meeting 2019 talk, March 2019

Honorarium for the invited talk *Faster Quantum Adiabatic Algorithm*, Koç University, Turkey, January 2019

Awarded travel grant by Universities Space Research Association (USRA) for Adiabatic Quantum Computing Conference 2018 talk (NASA Ames Research Center, CA)

UW–Madison Student Research Grants Competition Conference Award (Travel Grant) for APS March Meeting 2018 talk, March 2018

Excellent Teaching Assistant evaluations, Physics 104, Spring 2017

GRE Physics Full Score, 2014

Selected by TÜBİTAK as one of five attendees from Turkey for the 62nd Lindau Nobel Laureate Meetings, 2012

Travel support by Quantum Information and Nanoscale Metrology Group for summer research, University of Cambridge, 2012

Student with the highest university entrance exam score (higher than max possible, with additional points due to my international olympiad success) entering Koç University, 2010

Honored by the Turkish President due to my international olympiad success, 2010.

Prize money by The Scientific and Technological Research Council of Turkey (TÜBİTAK) due to the international olympiad success, 2009.

International Physics Olympiad (IPhO) Team Member (5 people from each nation), 2009.
>> Honorable Mention, IPhO 2009, Mexico. *[I was sick during the Olympiad, which negatively affected my score.]*

Rank 1: Augmented Mechanics course by Prof. Nihat Berker (Emeritus, MIT), Feza Gürsey Institute, İstanbul, 2008

Rank 1 as a team: Ankara Mathematics Competition Among High Schools, 2008

REFEREEING: PRX Quantum, Physical Review A, Physical Review Research, IEEE Transactions on Quantum Engineering, ACM Transactions on Quantum Computing.

PROFESSIONAL MEMBERSHIP: American Physical Society