# Unpil Baek (백운필)

*Curriculum Vitae*

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**in** unpilbaek

## Research Interests

– Quantum algorithms, electronic structure simulations, tensor network algorithms, machine learning

## Education

**2017-2023** — **Doctor of Philosophy – Physics**, *University of California, Berkeley*, GPA – 4/4.
  ○ *Committee:* K. Birgitta Whaley, co-chair; Joel Moore, co-chair; Irfan Siddiqi; Martin Head-Gordon
  ○ *Dissertation:* "Exploring electronic structure with near-term quantum computers"

**2017-2018** — **Master of Arts – Physics**, *University of California, Berkeley*, GPA – 4/4.

**2013-2017** — **Bachelor of Arts – Physics & Applied Mathematics**, *University of California, Berkeley*, GPA – 4/4.
  ○ Graduated *summa cum laude* in both, with Departmental Citation in Physics
  ○ *Senior Thesis:* "Einstein-Cartan Action under Gotay-Nester Algorithm," supervised by Prof. Robert Littlejohn

## Experience

**Sep 2018 - Aug 2023** — **Graduate Student Researcher**, *Whaley Group*, Berkeley, CA.
Advisor: Prof. K. Birgitta Whaley, Department of Chemistry
  ○ Developed and characterized performances of variational quantum-classical algorithms for electronic structure simulations on near-term, intermediate-scale quantum devices.
  ○ Applied the tensor network formalism to help design efficient quantum circuits for variational calculations in Hamiltonian simulations.

**May 2018 - May 2019** — **Graduate Student Researcher**, *Quantum Nanoelectronics Lab*, Berkeley, CA.
PI: Prof. Irfan Siddiqi, Department of Physics
  ○ Developed a new FPGA-based hardware for superconducting qubit control with Dr. Gang Huang (LBNL).
  ○ Designed and constructed 80/20 frames for several of the dilution refrigerators in the lab.

**June 2016 - May 2017** — **Undergraduate Student Researcher**, *Littlejohn Group*, Berkeley, CA.
PI: Prof. Robert Littlejohn, Department of Physics
  ○ Studied the multi-symplectic formalism, 3+1-split and Gotay-Nester algorithm and applied them to classical field theories such as Maxwell electromagnetism.
  ○ Implemented the Gotay-Nester algorithm on the gravitation under local Lorentz invariance.

**May 2015 - Dec 2015** — **Undergraduate Student Researcher**, *POLARBEAR experiment*, Berkeley, CA.
PI: Dr. Akito Kusaka, Lawrence Berkeley National Laboratory
  ○ Studied the Monte Carlo simulation of cosmic microwave background by tracking its angular maps and power spectral density plots for the Stokes parameters over time.
  ○ Wrote a Python script that implements the generalized transfer matrices and Jones matrices for stratified media, such as birefringent crystals, to calculate the reflection and transmission coefficients.

**Sept 2014 - May 2015** — **Undergraduate Student Researcher**, *ATLAS experiment*, Berkeley, CA.
PI: Prof. Marjorie Shapiro, Supervisor: Dr. Mark Cooke, Lawrence Berkeley National Laboratory
  ○ Worked on Monte Carlo studies of vector-like quark production for the ATLAS experiment.
  ○ Performed a branching ratio scan for the truth events associated with dilepton and trilepton events resulting from vector-like $TT$ and $BB$ decays.
  ○ Studied discrimination of large-$R$ jets by analyzing the substructure variables such as $i$-to-$j$ $k_T$-splitting scales ($\sqrt{d_{ij}}$) and ratios of two $N$-subjettiness variables ($\tau_{NM}$).

## Awards & Honors

**May 2018** — **Outstanding Graduate Student Instructor Award**.

**May 2017** — **UC Berkeley Departmental Citation in Physics**.

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| May 2017 | **Dorothea Klumpke Roberts Prize in Mathematics**. |
| Dec 2015, Dec 2014 | **Isidore Pomerantz Scholarship in Physics**. |
| Feb 2014 | **Edmund Frank Kraft Award for Freshmen**. |
| 2013-2017 | **UC Berkeley Undergraduate Dean's Honors List**. |

## Publications

[1] **Unpil Baek**, Diptarka Hait, James Shee, Oskar Leimkuhler, William J. Huggins, Torin F. Stetina, Martin Head-Gordon, and K. Birgitta Whaley. "Say NO to Optimization: A Nonorthogonal Quantum Eigensolver". In: *PRX Quantum* (2023).

[2] William J. Huggins, Joonho Lee, **Unpil Baek**, Bryan O'Gorman, and Birgitta K. Whaley. "A Non-Orthogonal Variational Quantum Eigensolver". In: *New Journal of Physics* (2020).

## Presentations

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| Mar 2022 | **Unpil Baek**, Diptarka Hait, James Shee, Oskar Leimkuhler, William J. Huggins, Martin Head-Gordon, K. Birgitta Whaley. "Say NO to Optimization: A Non-Orthogonal Quantum Eigensolver". In: *APS 2022 March Meeting*. Mar. 15. 2022. URL: `https://meetings.aps.org/Meeting/MAR22/Session/K36.1` |
| Mar 2021 | **Unpil Baek**, William J. Huggins, K. Birgitta Whaley. "Error-resilient Tensor Network-based Ansatz for a Noisy Quantum Computer". In: *APS 2021 March Meeting*. Mar. 18. 2021. URL: `https://meetings.aps.org/Meeting/MAR21/Session/S34.15/Session/V26.15` |
| Mar 2019 | **Unpil Baek**, Yilun Xu, Gang Huang, Lawrence Doolittle, Irfan Siddiqi. "An FPGA-based quantum feedback system for real-time qubit control". In: *APS 2019 March Meeting*. Boston, MA, USA. Mar. 7. 2019. URL: `http://meetings.aps.org/Meeting/MAR19/Session/V26.15` |
| | Gang Huang, Yilun Xu, Lawrence Doolittle, **Unpil Baek**, Irfan Siddiqi. "Scalable FPGA-based qubit control hardware". In: *APS 2019 March Meeting*. Boston, MA, USA. Mar. 7. 2019. URL: `http://meetings.aps.org/Meeting/MAR19/Session/V26.14` |
| | Ravi Naik, Bradley Mitchell, **Unpil Baek**, Dar Dahlen, John Mark Kreikebaum, Vinay Ramasesh, Michael Blok, Irfan Siddiqi. "Limitations and improvements of two qubit gates in superconducting circuit QED". In: *APS 2019 March Meeting*. Boston, MA, USA. Mar. 6. 2019. URL: `http://meetings.aps.org/Meeting/MAR19/Session/L29.6` |
| | Bradley Mitchell, Ravi Naik, **Unpil Baek**, Dar Dahlen, John Mark Kreikebaum, Kevin P O'Brien, Vinay Ramasesh, Machiel Blok, Wim Lavrijsen, Costin Iancu, Irfan Siddiqi. "Experimental Methods for Improving Heuristic Quantum Algorithms on NISQ Devices". In: *APS 2019 March Meeting*. Boston, MA, USA. Mar. 4. 2019. URL: `http://meetings.aps.org/Meeting/MAR19/Session/C42.12` |

## Teaching

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| Spring 2020 | **Head Graduate Student Instructor**, *Physics C191. Quantum Information Science and Technology*, UC Berkeley.<br>Led weekly discussion sections and prepared lecture summaries, weekly homework and exams. |
| Spring 2018 | **Graduate Student Instructor**, *Physics 5A. Introductory Mechanics and Relativity*, UC Berkeley.<br>Led three discussion sections and graded weekly homework and exams. |
| Fall 2017 | **Graduate Student Instructor**, *Physics 7A. Physics for Scientists and Engineers*, UC Berkeley.<br>Led two discussion sections and two lab sections, held weekly office hours, and graded weekly labs, quizzes, and exams. |
| Aug 2013 | **Seminar Instructor**, Daejeon Man-nyeon Middle School, South Korea.<br>○ Motivated the middle school students to study abroad and pursue careers on physics.<br>○ Introduced topics such as light polarization to explain how 3D television works. |

## Computing Skills

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| Coding | Python, C++, MATLAB, Julia, Mathematica |
| Utilities | Git, GitHub, JupyterLab, Vim, HTML & CSS, LaTeX, Markdown |

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| Systems  | macOS, Windows, Linux    |

## Languages

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| Fluent         | Korean (native), English     |
| Conversational | Japanese, Mandarin Chinese   |

## Selected Courses

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| 2017-present | **Berkeley (graduate):** Quantum Many-Body Seminar (L. Lin), Quantum Computing (U. Vazirani), Mathematical Introduction to Electronic Structure Theory (L. Lin), Bayesian Data Analysis and Machine Learning for Physical Science (U. Seljak), String Theory (Y. Nomura), Quantum Theory of Solids (D. Lee). |
| 2013-2017 | **Berkeley (undergraduate): [graduate]** Quantum Field Theory (Y. Nomura, H. Murayama), Topological quantum field theory and conformal field theory (N. Reshetikhin), Geometry and Topology for Physicists (R. Littlejohn), Mathematical Methods for the Physical Sciences (J. Wilkening), Equilibrium Statistical Physics (A. Vishwanath), Quantum Mechanics (R. Littlejohn), General Relativity (S. Rajendran), Classical Electromagnetism (M. White). **[undergraduate]** Advanced Experimentation Laboratory (H. Häffner), Instrumentation Laboratory (J. Fajans). |

## Hobbies

- Jazz piano
- Reading
- Learning languages
- Traveling

## References

**K. Birgitta Whaley**,
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**Irfan Siddiqi**,
*Professor*,
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**Robert G. Littlejohn**,
*Professor Emeritus*,
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