# Cihan Okay

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## Biographical Data

**Name:** Cihan Okay
**Citizenship:** Turkish, Canadian
**Date/Place of birth:** November 9, 1985 / Istanbul, Turkey

## Current Position

2020- Assistant Professor, Department of Mathematics
Bilkent University, Ankara, Turkey

## Past Positions

2017-2020 Postdoctoral fellow, Stewart Blusson Quantum Matter Institute
The University of British Columbia, Vancouver, Canada
Group leader: Robert Raussendorf

2014-2017 Postdoctoral fellow, Department of Mathematics
Western University, London, Canada
Advisor: John F. Jardine

## Education

2009-2014 Ph.D. Mathematics
The University of British Columbia, Vancouver, Canada
Dissertation: Homotopy colimits of classifying spaces of finite abelian groups
Advisor: Alejandro Adem

2007-2009 M.Sc. Mathematics
Bilkent University, Ankara, Turkey
Thesis: The monomial Burnside functor
Advisor: Laurence Barker

2003-2007 B.S. Physics
Bilkent University, Ankara, Turkey
Senior Project: Non-rotating black holes
Advisor: Metin Gürses

## Awards & Grants

2022-2025 European Union Horizon Program €212K to support the project
Foundations of quantum computational advantage (HORIZON-CL4-2021-DIGITAL-EMERGING-01-23)

2020-2023 Air Force Office of Scientific Research $420K to support the project
Topology of quantum resources: Homotopical methods in resource theories for quantum information and quantum computing (award number FA9550-21-1-0002)

## Publications

1. *Commutative d-Torsion K-Theory and Its Applications*, Journal of Mathematical Physics 62, 102201 (2021)
2. *On the extremal points of the $\Lambda$-polytopes and classical simulation of quantum computation with magic states* with Michael Zurel, Robert Raussendorf, Quantum Information and Computation Vol.21 No.13&14, 1533-7146 (2021)
3. *Classifying space for quantum contextuality* with Daniel Sheinbaum, Annales Henri Poincaré 22, 529-562 (2021)
4. *A hidden variable model for universal quantum computation with magic states on qubits* with Michael Zurel, Robert Raussendorf, Physical Review Letters 125, 260404 (2020)
5. *Quasi-exact quantum computation* with Dong-Sheng Wang, Guanyu Zhu, Raymond Laflamme, Phys. Rev. Research 2, 033116 (2020)
6. *Phase space simulation method for quantum computation with magic states on qubits* with Robert Raussendorf, Juani Bermejo-Vega, Emily Tyhurst, Michael Zurel, Phys. Rev. A 101, 012350 (2020)
7. *Homotopical approach to quantum contextuality* with Robert Raussendorf, Quantum 4, 217 (2020)
8. *On the mod-$\ell$ homology of the classifying space for commutativity* with Ben Williams, Algebraic & Geometric Topology 20-2 883-923 (2020)
9. *A computationally universal phase of quantum matter* with Robert Raussendorf, Dong-Sheng Wang, David T. Stephen, Hendrik Poulsen Nautrup, Phys. Rev. Lett. 122, 090501 (2019)
10. *The cohomological and the resource-theoretic perspective on quantum contextuality: common ground through the contextual fraction* with Emily Tyhurst, Robert Raussendorf, Quantum Information and Computation 18, 1272-1294 (2018)
11. *Dimension functions for spherical fibrations* with Ergun Yalcin, Algebraic & Geometric Topology 18.7 3907-3941 (2018)
12. *Spherical posets from commuting elements,* Journal of Group Theory, ISSN 1433-5883 (2018)
13. *Topological proofs of contextuality in quantum mechanics* with Sam Roberts, Stephen D. Bartlett, Robert Raussendorf, Quantum Information and Computation 17, 1135-1166 (2017)
14. *Equivalence between contextuality and negativity of the Wigner function for qudits* with Nicolas Delfosse, Juan Bermejo-Vega, Dan E. Browne, Robert Raussendorf, New J. Phys. 19 123024 (2017)
15. *Contextuality as a resource for models of quantum computation on qubits* with Juan Bermejo-Vega, Nicolas Delfosse, Dan E. Browne, Robert Raussendorf, Phys. Rev. Lett. 119, 120505 (2017)
16. *Contextuality and Wigner function negativity in qubit quantum computation* with Robert Raussendorf, Dan E. Browne, Nicolas Delfosse, Juan Bermejo-Vega, Phys. Rev. A 95, 052334 (2017)
17. *Colimits of abelian groups,* Journal of Algebra Volume 443, Pages 1-12 (2015)
18. *Homotopy colimits of classifying spaces of abelian subgroups of a finite group,* Algebraic & Geometric Topology 14 2223-2257 (2014)

## Preprints

1. *Simplicial quantum contextuality* with Aziz Kharoof, Selman Ipek, arXiv:2204.06648 (2022)
2. *Hidden variable model for quantum computation with magic states on any number of qudits of any dimension* with Michael Zurel, Robert Raussendorf, Arne Heimendahl, arXiv:2110.12318 (2021)
3. *The role of cohomology in quantum computation with magic states* with Robert Raussendorf, Michael Zurel, Polina Feldmann arXiv:2110.11631 (2021)
4. *Commutative simplicial bundles* with Pal Zsamboki, arXiv:2001.04052 (2021)

## Patents

1. *Method of simulating a quantum computation, system for simulating a quantum computation, method for issuing a computational key, system for issuing a computational key*, Inventors: Robert Raussendorf, Michael Owen Zurel, Cihan Okay
   International Application Number: CA2021050445, Filed: April 1, 2021

## Conference & Workshop Talks

1. “Simplicial homotopy in quantum foundations", Invitation to New Trends in Algebra, Geometry and Homotopy Theory (in honor of Alejandro Adem’s 60th birthday), Invited talk, Mérida (2022)
2. “Simplicial distributions and quantum contextuality", Applied Category Theory, Contributed talk, Glasgow (2022)
3. “Topology, probability and quantum", Izmir Mathematics Days IV, Invited talk, Izmir (2022)
4. “Simplicial quantum contextuality", Algebraic Structures in Quantum Computation (ASQC5), Invited talk, Vancouver (2022)
5. “Simplicial quantum contextuality", Quantum Information and Probability: from Foundations to Engineering, Contributed Talk, Vaxjo (2022)
6. “A hidden variable model for universal quantum computation with magic states on qubits", International Congress on Mathematical Physics, Contributed Talk, Geneva (2021)
7. “A hidden variable model for universal quantum computation with magic states on qubits", 26th International Conference on Applications of Computer Algebra, Special Session on Polytopes - Algebra - Computation (2021)
8. “A hidden variable model for universal quantum computation with magic states on qubits", Canadian Mathematical Society Summer Meeting Special Session on Quantum Mathematics (2021)
9. “A generalized cohomology theory for quantum contextuality ", 18th International Conference on Quantum Physics and Logic, Prerecorded Contributed Talk (2021)
10. “A generalized cohomology theory for quantum contextuality ", The 4th workshop Quantum Contextuality in Quantum Mechanics and Beyond, Prague (2021)
11. “A hidden variable model for universal quantum computation with magic states on qubits", Quantum Optics & Information Meeting - KOBIT (2021)
12. “Homotopical approach to quantum contextuality", Mathematics Days IV, Istanbul Center for Mathematical Sciences (2020)
13. “Stable homotopy and quantum contextuality", Algebraic Structures in Quantum Computation (ASQC4) Workshop, UBC (2020)
14. “Classifying space for quantum contextuality", Contextuality as a Resource in Quantum Information, University of Oxford (2019)
15. “Homotopical approach to contextuality", 15th International Conference on Quantum Physics and Logic (2019)
16. “Topology of contextuality", Canadian Mathematical Society Summer Meeting Special Session on Mathematical Techniques for Analysing Quantum Structures and Materials, University of Regina (2019)
17. “On the mod-$\ell$ homotopy type of the classifying space for commutativity", Canadian Mathematical Society Summer Meeting Special Session on Topology, University of Regina (2019)
18. “Homotopical approach to contextuality", The 3th workshop Quantum Contextuality in Quantum Mechanics and Beyond, Prague (2019)

19. “Cohomological framework for contextuality", Discrete phase space methods for quantum fault-tolerance, Physics Center Bad Honnef (2018)

20. “Covariance of Wigner function", Algebraic Structures in Quantum Computation, University of British Columbia (2018)

21. “A classifying space for commutativity", Antalya Algebra days, Nesin Mathematics Village (2018)

22. “Applications of classifying spaces in quantum computation", Applied Algebraic Topology, Hokkaido University (2017)

23. “Topological proofs of contextuality in quantum mechanics", Algebraic Structures in Quantum Computation, University of British Columbia (2017)

24. “Filtrations of classifying spaces", AMS Special Session on Representation Spaces and Toric Topology, City University of New York (2017)

25. “Cohomology and contextuality", Algebraic Structures in Quantum Computation, University of British Columbia (2016)

**Seminar & Colloquium Talks**

1. “Simplicial techniques in quantum foundations", Topology seminar, University of British Columbia (2022)

2. “Homotopy classification of operator solutions of linear systems", Topology seminar, University of Rochester (2021)

3. “Homotopy classification of operator solutions of linear systems", Topology seminar, Hebei Normal University (2021)

4. “Topology of quantum computational resources", Pure Maths Colloquium, The University of Sheffield (2021)

5. “Topology of quantum computational resources", Math Department Colloquium, Simon Fraser University (2021)

6. “On the vertices of the $\Lambda$-polytopes", Quantum Technology & Computing group, IBM Research - Zurich (2021)

7. “Commutative simplicial bundles and their classifying spaces", Algebraic Geometry and Differential Topology seminar, Alfréd Rényi Institute of Mathematics (2020)

8. “Applications of Homotopy Theory in Quantum Computation", Mathematics Seminars, Koc University (2020)

9. “Applications of Homotopy Theory in Quantum Computation", Mathematics Seminars, Bogazici University (2020)

10. “On the mod-$\ell$ homotopy type of the classifying space for commutativity", Topology seminar, Bilkent University (2019)

11. “On the mod-$\ell$ homotopy type of the classifying space for commutativity", Algebra seminar, Alfréd Rényi Institute of Mathematics (2019)

12. “Dimension functions for spherical fibrations", Topology seminar, Bilkent University (2018)

13. “Spherical posets from commuting elements", Topology seminar, University of British Columbia (2018)

14. “Applications of classifying spaces in quantum computation", Topology seminar, Bilkent University (2017)

15. “Spherical posets from commuting elements", Geometry and Topology seminar, University of Western Ontario (2016)

16. “Spherical posets from commuting elements", Topology seminar, Bilkent University (2016)
17. “Filtrations of classifying spaces", Topology seminar, University of Rochester (2016)
18. “Cohomology of metacyclic groups", Algebra seminar, University of Western Ontario (2016)
19. “Introduction to the Coq proof assistant", Homotopy theory seminar, University of Western Ontario (2016)
20. “Towards a refinement of the Bloch-Kato conjecture", Geometry and Topology seminar, University of Western Ontario (2015)
21. “Filtrations of classifying spaces", Equivariant homotopy and infinity categories, Bogazici University (2015)
22. “Towards a refinement of the Bloch-Kato conjecture", Topology seminar, Bilkent University (2015)
23. “Hopf invariant one problem", Homotopy theory seminar, University of Western Ontario (2015)
24. “Homotopy groups of the circle (Homotopy type theory)", Homotopy theory seminar, University of Western Ontario (2014)
25. “Filtrations of classifying spaces", Geometry and Topology seminar, University of Western Ontario (2014)
26. “Nilpotent groups and colimits", Algebra seminar, University of Western Ontario (2014)
27. “Homotopy Colimits of Classifying Spaces of Abelian Groups", Geometry and Topology seminar, University of Western Ontario (2014)
28. “Homotopy colimits of classifying spaces of abelian groups", Topology seminar, University of British Columbia (2013)
29. “Homotopy colimits of classifying spaces of finite groups and $K$–theory", Topology seminar, Bilkent University (2012)
30. “Homotopy colimits of classifying spaces of finite groups and $K$–theory", Topology seminar, University of British Columbia (2012)

## Poster Presentations

1. Poster “Clifford covariance of Wigner functions, positive representation of Pauli measurement, and cohomology", 25nd Annual Conference on Quantum Information Processing, Pasadena (2022)
2. Poster “Hidden variable model for universal quantum computation with magic states on qubits", 24nd Annual Conference on Quantum Information Processing, Munich (2021)
3. Poster “Homotopical approach to quantum contextuality", Southwest Quantum Information and Technology (SQuInT) Workshop, Eugene (2020)
4. Poster “Cohomological and resource-theoretic perspective on quantum contextuality" and “A computationally universal phase of quantum matter", 22nd Annual Conference on Quantum Information Processing (2019)
5. Poster “Cohomological and resource-theoretic perspective on quantum contextuality", 15th International Conference on Quantum Physics and Logic (2018)

## Seminar & Workshop Organization

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|---|---|
| Fall 2021<br>Spring 2022 | Department’s Topology Seminar (weekly), Bilkent |
| Sept 7-9<br>2021 | Workshop on Spaces of Homomorphisms and Classifying Spaces (co-organized with Omar Antolín Camarena, Simon Gritschacher, Bernardo Villarreal), Online |

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| July 14, 2021 | Parallel session: Mathematical Structures in Quantum Foundations, Encontro Nacional SPM (co-organized with Rui S. Barbosa), Online |
| 2020-2022 | MathGrad Seminar (biweekly), Bilkent (co-organized with Selman Ipek) |
| Fall 2020<br>Spring 2021 | Department's Topology Seminar (weekly), Bilkent |
| Fall 2020<br>Spring 2021 | Graduate seminar (weekly), Bilkent |
| June 22-24 2020 | Fourth Workshop on Algebraic Structures in Quantum Computation, co-organized by Robert Raussendorf, UBC |
| 2019-2020 | Quantum Information Meetings (weekly) of Robert Raussendorf's Group, UBC |
| Fall 2019 | Reading seminar (weekly) on Classification of symmetry-protected topological phases, UBC |
| Fall 2019 | Reading seminar (weekly) on Introduction to Stable homotopy theory, UBC |
| Fall 2018-<br>Winter 2019 | Reading seminar (weekly) on Topological quantum computation, UBC |

## Teaching Experience

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| Fall 2022 | Math 421/521: Introduction to Quantum Computation, Bilkent |
| Spring 2022 | Math 102-11: Calculus II, Bilkent |
| Fall 2021 | Math 101-14: Calculus I, Bilkent |
| Spring 2021 | Math 421/521: Introduction to Quantum Computation, Bilkent |
| Fall 2020 | Math 101-8: Calculus I, Bilkent |
| Winter 2017 | Mathematics 1225B: Methods of Calculus, UWO |
| Fall 2016 | Math 9144A: Homological algebra, UWO |
| Winter 2016 | Mathematics 1225B: Methods of Calculus, UWO |
| Summer 2015 | Calculus 1000A: Calculus I, UWO |
| Winter 2015 | Mathematics 1225B: Methods of Calculus, UWO |
| Fall 2014 | Calculus 1000A: Calculus I, UWO |
| Summer 2013 | Math 105-922: Integral Calculus with Applications to Commerce and Social Sciences, UBC |
| Summer 2012 | Math 105-922: Integral Calculus with Applications to Commerce and Social Sciences, UBC |

## Students Supervised

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| Spring 2022 | Melin Okandan, Undergraduate senior project, *Unital quantum channels*, Bilkent |
| Fall 2021 | Melin Okandan, Undergraduate senior project, *Basic properties of quantum channels*, Bilkent |
| Summer 2021 | Ecem Ilgun, Undergraduate summer project, *Introduction to quantum contextuality*, Bilkent |
| Fall 2020 | Oussama Amir, Undergraduate senior project, *Algebraic aspects of symmetric informationally complete measurements*, Bilkent |
| February 2020 | Daniel Sheinbaum, Ph.D, *Applications and Connections between Twisted Equivariant K-theory, Quantum Mechanics and Condensed Matter*, co-supervised by Alejandro Adem, UBC |

## Postdocs Supervised

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| Sept 2022- | Igor Sikora, Ph.D. Mathematics (2022), University of Warwick |
| Oct 2021- | Selman Ipek, Ph.D. Physics (2021), University at Albany, SUNY |
| Oct 2021- | Aziz Muhammad Kharoof, Ph.D. Pure Mathematics (2019), University of Haifa |
| Oct 2021- | Ho Yiu Chung, Ph.D. Pure Mathematics (2020), University of Southampton |

## List of Collaborators

Robert Raussendorf (University of British Columbia), Stephen D. Bartlett (The University of Sydney), Raymond Laflamme (University of Waterloo), Dan E. Browne (University College London), Ben Williams (University of British Columbia) Ergun Yalcin (Bilkent University) Pal Zsamboki (Alfred Renyi Institute of Mathematics), Nicolas Delfosse (Microsoft Quantum), Daniel Sheinbaum (Instituto de Matematicas, UNAM), Juani Bermejo-Vega (Free University of Berlin), Emily Tyhurst (University of Toronto) Sam Roberts (PsiQuantum), Michael Zurel (University of British Columbia) Dong-Sheng Wang (University of Waterloo), David T. Stephen (Max Planck Institute for Quantum Optics), Hendrik Poulsen Nautrup (Universitat Innsbruck), Guanyu Zhu (IBM T.J. Watson Research Center), Polina Feldmann (University of British Columbia), Arne Heimendahl (University of Cologne), Markus Frembs (Griffith University)

## Service to the Profession

1. Evaluation of workshop proposal(s) submitted to Banff International Research Station (BIRS)
2. Reviewer for the Research in the Mathematical Sciences (RMSB) journal
3. Reviewer for the Transformation groups journal

## Fellowships & Scholarships

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| 2020-2021 | Pacific Institute for the Mathematical Sciences (PIMS) Collaborative Research Groups Postdoctoral Fellowship (declined) |
| 2009-2013 | UBC Four Year Doctoral Fellowship & International Partial Tuition Scholarship |
| 2007-2009 | Graduate Scholarship for M.Sc., The Scientific and Technological Research Council of Turkey |
| 2003-2007 | Full scholarship at Bilkent University |

## Other Information

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| Computer | Python, GAP, Coq, Java |
| Language | Native Turkish, Fluent English |
| Volunteer Work | Vancouver International Film Festival, Vancouver Guitar Society |
| Outreach | Advisor of QTurkey student branch of Bilkent |

For further information please contact me directly.

Last update: August 13, 2022