Edgar Shaghoulian

Employment

University of California, Santa Cruz

Assistant Professor, Department of Physics and Santa Cruz Institute for Particle Physics, September 2022 - present.

University of Pennsylvania

Fellow at Center for Particle Cosmology, member of QuantISED Collaboration, member of Simons Collaboration on It from Qubit, September 2020 - September 2022.

Cornell University

Postdoctoral scholar, member of Simons Collaboration on the Nonperturbative Bootstrap, September 2017 - September 2020.

University of California, Santa Barbara

Postdoctoral scholar, September 2014 - September 2017.

Education

Stanford University

Ph.D. Physics, awarded June 2014. Thesis Advisor: Leonard Susskind

University of California, Berkeley

A.B. Physics, awarded May 2008
B.S. Mathematics, awarded May 2008

Research Interests

Quantum information in quantum gravity, quantum cosmology, black holes, conformal field theory, complex systems and glassy dynamics.

Awards

5th award in the Gravity Research Foundation 2021 Awards for Essays on Gravitation
Oskar Heil Fellowship in the Stanford School of Humanities and Sciences 2013-2014
NSF GRFP Honorable Mention 2008, 2009

Seminar and Conference Organization

Two-day Southern California Strings Seminar conference taking place at KITP, weekly high energy theory seminars at UC Santa Barbara, Cornell University, and University of Pennsylvania.

Editorial Work

Referee for Physical Review Letters (PRL), Physical Review D (PRD), Journal of High Energy Physics (JHEP), Physics Letters B (PLB), IOP Journal of Physics A (JPhysA), SciPost Physics, Fortschritte der Physik

Publications

[1] Edgar Shaghoulian, "A Tale of Two Horizons," Scientific American **327**, 42–47 (2022)

[2] Adam Levine and Edgar Shaghoulian, "Encoding beyond cosmological horizons in de Sitter JT gravity," (4 2022), arXiv:2204.08503 [hep-th]

[3] Edgar Shaghoulian and Leonard Susskind, "Entanglement in De Sitter space," JHEP **08**, 198 (2022), arXiv:2201.03603 [hep-th]

[4] Edgar Shaghoulian, "The central dogma and cosmological horizons," JHEP **01**, 132 (2022), arXiv:2110.13210 [hep-th]

[5] Vijay Balasubramanian, Ben Craps, Mikhail Khramtsov, and Edgar Shaghoulian, "Submerging islands through thermalization," JHEP **10**, 048 (2021), arXiv:2107.14746 [hep-th]

[6] Daniel Harlow and Edgar Shaghoulian, "Euclidean gravity and holography," IJMPD(6 2021)

[7] Daniel Harlow and Edgar Shaghoulian, "Global symmetry, Euclidean gravity, and the black hole information problem," JHEP **04**, 175 (2021), arXiv:2010.10539 [hep-th]

[8] Thomas Hartman, Yikun Jiang, and Edgar Shaghoulian, "Islands in cosmology," JHEP **11**, 111 (2020), arXiv:2008.01022 [hep-th]

[9] Ahmed Almheiri, Thomas Hartman, Juan Maldacena, Edgar Shaghoulian, and Amirhossein Tajdini, "The entropy of Hawking radiation," Rev. Mod. Phys. **93**, 035002 (2021), arXiv:2006.06872 [hep-th]

[10] Edgar Shaghoulian, "A symmetry principle for emergent spacetime," International Journal of Modern Physics D **0**, 2043014 (2020), arXiv:2005.08388 [hep-th]

[11] Thomas Hartman, Edgar Shaghoulian, and Andrew Strominger, "Islands in Asymptotically Flat 2D Gravity," JHEP **07**, 022 (2020), arXiv:2004.13857 [hep-th]

[12] David J. Gross, Jorrit Kruthoff, Andrew Rolph, and Edgar Shaghoulian, "Hamiltonian deformations in quantum mechanics, $T\bar{T}$, and the SYK model," Phys. Rev. D **102**, 046019 (2020), arXiv:1912.06132 [hep-th]

[13] Ahmed Almheiri, Thomas Hartman, Juan Maldacena, Edgar Shaghoulian, and Amirhossein Tajdini, "Replica Wormholes and the Entropy of Hawking Radiation," JHEP **05**, 013 (2020), arXiv:1911.12333 [hep-th]

[14] David J. Gross, Jorrit Kruthoff, Andrew Rolph, and Edgar Shaghoulian, "$T\overline{T}$ in AdS_2 and Quantum Mechanics," Phys. Rev. D **101**, 026011 (2020), arXiv:1907.04873 [hep-th]

[15] Thomas Hartman, Jorrit Kruthoff, Edgar Shaghoulian, and Amirhossein Tajdini, "Holography at finite cutoff with a T^2 deformation," JHEP **03**, 004 (2019), arXiv:1807.11401 [hep-th]

[16] Tarek Anous, Raghu Mahajan, and Edgar Shaghoulian, "Parity and the modular bootstrap," SciPost Phys. **5**, 022 (2018), arXiv:1803.04938 [hep-th]

[17] Eric Mefford, Edgar Shaghoulian, and Milind Shyani, "Sparseness bounds on local operators in holographic CFT_d," JHEP **07**, 051 (2018), arXiv:1711.03122 [hep-th]

[18] Gary T. Horowitz and Edgar Shaghoulian, "Detachable circles and temperature-inversion dualities for CFT_d," JHEP **01**, 135 (2018), arXiv:1709.06084 [hep-th]

[19] Edgar Shaghoulian, "Modular Invariance of Conformal Field Theory on $S^1 \times S^3$ and Circle Fibrations," Phys. Rev. Lett. **119**, 131601 (2017), arXiv:1612.05257 [hep-th]

[20] Edgar Shaghoulian, "Emergent gravity from Eguchi-Kawai reduction," JHEP **03**, 011 (2017), arXiv:1611.04189 [hep-th]

[21] Alexandre Belin, Jan de Boer, Jorrit Kruthoff, Ben Michel, Edgar Shaghoulian, and Milind Shyani, "Universality of sparse $d > 2$ conformal field theory at large N," JHEP **03**, 067 (2017), arXiv:1610.06186 [hep-th]

[22] George Konstantinidis, Raghu Mahajan, and Edgar Shaghoulian, "Late-time Structure of the Bunch-Davies FRW Wavefunction," JHEP **10**, 103 (2016), arXiv:1608.06163 [hep-th]

[23] Edgar Shaghoulian and Huajia Wang, "Timelike BKL singularities and chaos in AdS/CFT," Class. Quant. Grav. **33**, 125020 (2016), arXiv:1601.02599 [hep-th]

[24] Edgar Shaghoulian, "Black hole microstates in AdS," Phys. Rev. D **94**, 104044 (2016), arXiv:1512.06855 [hep-th]

[25] Edgar Shaghoulian, "Modular forms and a generalized Cardy formula in higher dimensions," Phys. Rev. D **93**, 126005 (2016), arXiv:1508.02728 [hep-th]

[26] Edgar Shaghoulian, "A Cardy formula for holographic hyperscaling-violating theories," JHEP **11**, 081 (2015), arXiv:1504.02094 [hep-th]

[27] Dionysios Anninos, Raghu Mahajan, Djordje Radicevic, and Edgar Shaghoulian, "Chern-Simons-Ghost Theories and de Sitter Space," JHEP **01**, 074 (2015), arXiv:1405.1424 [hep-th]

[28] Edgar Shaghoulian, "FRW cosmologies and hyperscaling-violating geometries: higher curvature corrections, ultrametricity, Q-space/QFT duality, and a little string theory," JHEP **03**, 011 (2014), arXiv:1308.1095 [hep-th]

[29] Dionysios Anninos, Joshua Samani, and Edgar Shaghoulian, "Warped Entanglement Entropy," JHEP **02**, 118 (2014), arXiv:1309.2579 [hep-th]

[30] Dionysios Anninos, Frederik Denef, George Konstantinidis, and Edgar Shaghoulian, "Higher Spin de Sitter Holography from Functional Determinants," JHEP **02**, 007 (2014), arXiv:1305.6321 [hep-th]

[31] Michael P. Salem, Prashant Saraswat, and Edgar Shaghoulian, "Gravity waves from cosmic bubble collisions," JCAP **02**, 019 (2013), arXiv:1210.4165 [hep-th]

[32] Dionysios Anninos, Tarek Anous, Frederik Denef, George Konstantinidis, and Edgar Shaghoulian, "Supergoop Dynamics," JHEP **03**, 081 (2013), arXiv:1205.1060 [hep-th]

[33] Sean A. Hartnoll and Edgar Shaghoulian, "Spectral weight in holographic scaling geometries," JHEP **07**, 078 (2012), arXiv:1203.4236 [hep-th]

[34] Edgar Shaghoulian, "Holographic Entanglement Entropy and Fermi Surfaces," JHEP **05**, 065 (2012), arXiv:1112.2702 [hep-th]

[35] Richard Massey, Chris Stoughton, Alexie Leauthaud, Jason Rhodes, Anton Koekemoer, Richard Ellis, and Edgar Shaghoulian, "Pixel-Based Correction for Charge Transfer Inefficiency in the Hubble Space Telescope Advanced Camera for Surveys," Mon. Not. Roy. Astron. Soc. **401**, 371–384 (2010), arXiv:0909.0507 [astro-ph.CO]

Invited Talks

Black holes, cosmology, and quantum entanglement, Vanderbilt Department Colloquium, March 2023.

Black holes, cosmology, and quantum entanglement, Harvard Black Hole Initiative Colloquium, October 2022.

The central dogma and entanglement in de Sitter space, Online Workshop on BPS State Counting, Holography, and Quantum Information, September 2022.

Disorder and averaging in quantum gravity, Crete Physics Sessions Initiative, June 2022.

Black holes, cosmology, and quantum entanglement, Boston University seminar, May 2022.

The central dogma and entanglement in de Sitter space, International Center for Theoretical Sciences virtual seminar, May 2022.

The central dogma and entanglement in de Sitter space, NYU HEP seminar, May 2022.

The central dogma and entanglement in de Sitter space, University of British Columbia virtual seminar, April 2022.

The central dogma and entanglement in de Sitter space, University of Maryland seminar, April 2022.

The central dogma and entanglement in de Sitter space, Southwest Strings Meeting at UT Austin, April 2022.

The central dogma and entanglement in de Sitter space, Utrecht virtual seminar, April 2022.

The central dogma and entanglement in de Sitter space, University of Chicago seminar, April 2022.

The central dogma and entanglement in de Sitter space, Tokyo IPMU virtual seminar, April 2022.

Black holes, cosmology, and quantum entanglement, University of Houston Department Colloquium, March 2022.

Black holes, cosmology, and quantum entanglement, UC Santa Cruz Department Colloquium, March 2022.

The central dogma and cosmological horizons, Purdue virtual seminar, March 2022.

The central dogma and cosmological horizons, Tehran IPM virtual seminar, March 2022.

Applications of the Gravitational Path Integral to Black Holes and Cosmology, Princeton Gravity Initiative seminar, February 2022.

The central dogma and cosmological horizons, UC Davis virtual seminar, February 2022.

The central dogma and cosmological horizons, Aspen conference "Low Dimensional Models of Quantum Gravity," February 2022.

Higher form symmetries and confinement in gauge/gravity duality, KITP Program "Confinement, Flux Tubes, and Large N," January 2022.

The central dogma and cosmological horizons, AnLy seminar series, January 2022.

The central dogma and cosmological horizons, IfQ-ExU workshop, December 2021.

A symmetry principle for emergent spacetime, University College London virtual seminar, May 2021.

Replica wormholes and the black hole information paradox, MIT virtual seminar, March 2021.

Hamiltonian deformations in quantum mechanics, IFS virtual seminar, March 2021.

Replica wormholes and the black hole information paradox, University of Mississippi virtual seminar, December 2020.

Replica wormholes, the black hole information paradox, and cosmology, UW Madison high energy/cosmology virtual seminar, December 2020.

Replica wormholes, the black hole information paradox, and cosmology, University of Illinois at Urbana-Champaign virtual seminar, December 2020.

Islands beyond AdS, "Island Hopping 2020: from Wormholes to Averages," CERN, November 2020.

Looking for islands, Trinity College Dublin theoretical physics virtual colloquium, October 2020.

Looking for islands, Quantum Aspects of Spacetime and Matter virtual seminar, October 2020.

Looking for islands, "Frontiers of Holographic Duality," Moscow, October 2020.

Looking for islands, Vienna Joint Physics virtual seminar, October 2020.

Looking for islands, Durham Center for Particle Theory virtual seminar, October 2020.

Looking for islands, University of Pennsylvania virtual seminar, September 2020.

Looking for islands, IIT Kanpur virtual seminar, July 2020.

Islands in asymptotically flat 2d gravity, AEI Potsdam virtual seminar, July 2020.

Replica wormholes and the information paradox, IPM Tehran virtual seminar, May 2020.

Replica wormholes and the information paradox, Brown University virtual seminar, April 2020.

Replica wormholes and the information paradox, Perimeter Institute virtual seminar, April 2020.

Replica wormholes and the information paradox, KITS Beijing virtual seminar, April 2020.

Quantum mechanics in the ultraviolet, King's College London seminar, March 2020.

Replica wormholes and the information paradox, Queen Mary seminar, March 2020.

1d T-Tbar and Hamiltonian deformations in quantum mechanics, KITP conference, January 2020.

Replica wormholes and the black hole information paradox, Caltech seminar, January 2020.

Replica wormholes and black hole information, KITP discussion, January 2020.

Replica wormholes and the black hole information paradox, IPMU virtual seminar, January 2020.

Quantum mechanics in the ultraviolet, Princeton seminar, November 2019.

Quantum mechanics in the ultraviolet, University of Minnesota seminar, October 2019.

Quantum gravity in a finite box, Harvard seminar, September 2019.

Quantum gravity in a finite box, Boston University seminar, September 2019.

Quantum gravity in a finite box, Brandeis seminar, September 2019.

Quantum mechanics in the ultraviolet, "$T\bar{T}$ and Other Solvable Deformations of Quantum Field Theories," Simons Center for Geometry and Physics, April 2019.

$T\overline{T}$ and quantum mechanics, "Advances in Quantum Field Theory," CERN, April 2019.

Quantum mechanics in the ultraviolet, Johns Hopkins seminar, February 2019.

Quantum mechanics in the ultraviolet, Stanford seminar, February 2019.

Discussion on $T\bar{T}$, "Qubits on the Horizon: Aruba 2019," Aruba, January 2019.

Discussion on $T\bar{T}$, "Chaos and Order: from Strongly Correlated Systems to Black Holes," KITP, November 2018.

Quantum gravity in a finite box, Massachusetts Institute of Technology CTP seminar, October 2018.

Holography at finite cutoff with a T^2 deformation, McGill CHEP seminar, October 2018.

Higher form symmetries and the emergence of gravity, University of Milano-Bicocca seminar, July 2018.

Higher form symmetries and the emergence of gravity, Columbia seminar, April 2018.

Higher form symmetries and the emergence of gravity, UC Berkeley seminar, March 2018.

Parity in two-dimensional conformal field theory, UC Santa Barbara seminar, January 2018.

Gauge/Gravity duality and the Eguchi-Kawai mechanism, Simons Center for Geometry and Physics seminar, October 2017.

Modular constraints in higher dimensions, Cornell seminar, October 2017.

Modular constraints in higher dimensions, "Information in Quantum Field Theory," Aspen workshop, June 2017.

Gauge/Gravity duality and the Eguchi-Kawai mechanism, ICTP seminar, Trieste, May 2017.

Gauge/Gravity duality and the Eguchi-Kawai mechanism, "New Developments in AdS_3/CFT_2 Holography," Galileo Galilei Institute, April 2017.

Gauge/Gravity duality and the Eguchi-Kawai mechanism, Stanford colloquium, February 2017.

Gauge/Gravity duality and the Eguchi-Kawai mechanism, Harvard seminar, February 2017.

Gauge/Gravity duality and the Eguchi-Kawai mechanism, Caltech seminar, December 2016.

Gauge/Gravity duality and the Eguchi-Kawai mechanism, UCSB seminar, November 2016.

Gauge/Gravity duality and the Eguchi-Kawai mechanism, Southern California Strings Seminar, October 2016.

Large-N quantum gauge theory and universality, Amsterdam string theory seminar, October 2016.

Modular invariance and black hole entropy, "Quantum Aspects of Black Holes and its Recent Progress," ICTP workshop in Yerevan, August 2016.

Large-c methods in 2D CFT, Fourth Summer School on High Energy Physics and Quantum Field Theory, Yerevan, August 2016.

Timelike BKL singularities and chaos in AdS/CFT, "Singularities in general relativity and their quantum fate," Warsaw, June 2016.

Modular forms, new Cardy formulas, and black hole entropy, "Strings in Greater Tokyo," April 2016.

Modular forms, new Cardy formulas, and black hole entropy, IPMU seminar, Tokyo, April 2016.

Holography for quantum cosmology, 32nd Annual Pacific Coast Gravity Meeting, April 2016.

Modular forms, new Cardy formulas, and black hole entropy, Massachusetts Institute of Technology CTP seminar, March 2016.

Modular invariance and black hole entropy, UCLA TEP Seminar, November 2015.

Modular invariance and black hole entropy, UCSB Seminar, October 2015.

Modular invariance and black hole entropy, McGill CHEP Seminar, October 2015.

Recent advances in dS/CFT, "Cosmological Frontiers in Fundamental Physics," Solvay Institutes, July 2015.

Modular invariance and black hole entropy, "Quantum Gravity Foundations: UV to IR," KITP, June 2015.

Non-unitary CFT duals to de Sitter quantum gravity, "Lattice for Beyond the Standard Model Physics," Lawrence Livermore National Laboratory, April 2015.

A generalized Cardy formula for black hole microstates, UC Davis HEFTI seminar, April 2015.

A generalized Cardy formula for black hole microstates, Texas A&M seminar, March 2015.

dS_4 and dS_3, Caltech seminar, January 2015.

Recent advances in dS/CFT, USC seminar, November 2014.

Recent advances in dS/CFT, KITP seminar, October 2014.

Recent advances in dS/CFT, IPMU seminar, Tokyo, April 2014.

Warped entanglement entropy, IPMU seminar, Tokyo, April 2014.

Covariant holographic entanglement entropy beyond AdS/CFT, Stanford ITP seminar, April 2014.

FRW cosmology, NYU High Energy Physics Seminar, November 2013.

Warped entanglement entropy, "Quantum Aspects of Black Holes and its Recent Progress," Yerevan State University, September 2013.

Beyond minisuperspace in higher spin de Sitter cosmology, Strings 2013 Gong Show, June 2013.

New CMB signatures of the string landscape, UCLA TEP Seminar, June 2013.

New CMB signatures of the string landscape, Stanford ITP Seminar, February 2013.

Multicentered black holes as glassy systems, "Out of Equilibrium Statistical Physics and String Theory," University of Michigan, October 2012.

Hyperscaling violation from holography, "Generalized Geometry, String Theory, and Deformations," Harvard University, August 2012.

Multicentered black holes as glassy systems, "Cosmology and Complexity," Greece, June 2012.

Teaching Experience

Stanford University

Teaching Assistant – Undergraduate/Graduate Physics Courses **September 2008 - May 2014**

Served as the primary teaching assistant for fifteen physics courses, spanning lower division, upper division, and graduate classes. Duties included holding a lecture session and office hours, writing and grading homework, writing and grading exams, and helping develop the curricula.

The Princeton Review

Instructor – MCAT Physics **January 2007 - March 2011**

Responsible for running the physics portion of the MCAT preparation course, which required lecturing on all physics topics expected to appear on the exam and holding office hours.

American University of Armenia

Instructor – Computer programming **June 2008 - August 2008**

Spent a summer in Armenia teaching introductory computer programming and software.

San Quentin Prison University Project

Tutor – Introductory mathematics and special topics **January 2008 - May 2008**

Tutored inmates in mathematics as part of a volunteer program that allowed them to earn an A.A. degree while incarcerated. The program operated as an extension of Patten University.

Activities

SLAC Users Organization Washington D.C. lobbying trip

Stanford ITP representative **Spring 2011/2012**

Traveled twice to Washington, D.C. to meet with members of both houses of Congress and DOE, NSF, and NIST to explain our work in high energy physics and request sustained federal funding.

Stanford Physics Graduate Studies Committee

Student Representative **September 2008 - June 2010**

Student member of the committee in charge of investigating all aspects of graduate study (e.g. thesis requirements, qualification exams, funding structure) and proposing/making changes as necessary.

References

Dionysios Anninos danninos@gmail.com
Vijay Balasubramanian vijay@physics.upenn.edu
David J. Gross gross@kitp.ucsb.edu
Daniel Harlow harlow@mit.edu
Thomas Hartman hartman@cornell.edu
Juan Maldacena malda@ias.edu
Leonard Susskind sonnysusskind@gmail.com

Languages

English and Armenian, elementary Spanish