Kevin D. Osborn, Ph.D.

www.physics.umd.edu/~kosborn

Current Research Interests

I am interested in phenomena observed in superconducting circuits for quantum computing and digital computing including: qubit coherence, quantum decohereing effects in materials, quantum-state manipulation in circuits, and ballistic flux quanta. Related to the former two, my group studies quantum two-level systems (TLS) in materials that are qubit defects, by performing characterization with custom superconducting circuits. Recent works includes the quantitative measurement of individual physical TLS moments (p_z) using cavity quantum electrodynamics (C-QED) and the random-defect maser made from TLSs. On another project, we have shown through simulation that ballistic flux quanta will be useful for efficient digital computing. As a result, the subfield of superconducting digital may experience advantages in timing. Furthermore, the gates will enable efficient digital computing relative to all irreversible gates, including today's industrial-manufactured CMOS gates, but more immediately the impact is on superconducting digital logic. The gates, originally proposed by myself and another, are now under experimental study. They use long Josephson junctions with other circuit elements for nonlinear properties. The bit is a flux quanta and the state is defined as its polarity. These flux quanta are also topological solitons. The efficiency comes from reversible dynamics dependent on the initial states.

Professional Positions

Adjunct Associate Professor of Physics, U. of Maryland at College Park 2013 – Present
U.S. Gov. Scientist and Group Lead, Lab. for Physical Sciences, College Park, MD 2007 – Present
NRC Postdoctoral Fellow and Research Associate, NIST, Boulder, CO 2001 – 2006
Graduate Assistant, Physics, U. of Illinois at Urbana-Champaign 1995 – 2001

Recent Scientific Activities

Research Advisor, *Former Ph.D. thesis advisees*: T. Kohler, defended in 2021, M. S. Khalil, defended in 2013, and B. Sarabi, defended in 2014. *Former postdoctoral advisees:* H. Paik, S. Gladchenko, M. J. A. Stoutimore, A. Ramanayaka, Y. Rosen, P. Xu, S. Guchhait, E. Bhatia, L. Yu, and N. Foroozani. Current Grad. Student and Research advisees: C.C. Hung, R. Clarke, and W. Wustmann.

Reviewer, Physics and superconducting journals by APS, AIP and IEEE, 2007 – present

Session Chair: Applied Superconductivity Conference cochair, 2020: Novel Computing: Reversible and Neuromorphic Computing. APS March Meeting, New Orleans, Louisiana, 2017: i) Superconducting and Quantum Metamaterials, ii) Decoherence and Defects in Superconducting Circuits. Superconducting Qubits: Materials and Characterization, APS March Meeting, San Antonio, TX, 2015. Superconducting Qubits: Resonators and Loss Mechanisms, APS March Meeting, Boston, MA, 2012.

LPS Seminar Series Co-Chair, with C. J. Lobb, Laboratory for Physical Sciences, Fall 2012- Spring 2013

Program Organizer and Chair, Superconducting Electronics Approaching Landauer's Limit and Reversibility (SEALeR) Workshop, Annapolis, MD, Feb 2012

Vice Chair, chaired with I. Siddiqi, Decoherence in Superconducting Qubit (DISQ) Workshop, Berkeley, CA, Dec. 2007

Education

Doctor of Philosophy, Physics, University of Illinois at Urbana-Champaign August 2001
Thesis: "Superfluid Density Measurements of High-Temperature Superconducting Films", *advised by* Professor Dale J. Van Harlingen

Master of Science, Physics, University of Tennessee at Knoxville August 1995
Master's Thesis research performed at the ALS, Lawrence Berkeley National Laboratory, Berkeley, CA and Louisiana State U., Baton Rouge, LA

Bachelor of Science, Physics, University of Mary Washington May 1992
Undergrad research in electronic nuclear detectors, Fredericksburg, VA

Memberships and Awards

Joint Quantum Institute, Associate Fellow, 2014-present
Center for Nanophysics and Advanced Materials, Affiliate, 2007-present
National Research Council (NRC) Postdoctoral Fellowship, 2004 – 2006
American Physical Society Member, 1996 – present
Sigma Pi Sigma, Physics Honor Society, 1995
Phi Beta Kappa, Scientific Honor Society, 1991

Patents

- "Asynchronous Reversible Computing" Kevin D. Osborn and W. Wustmann, Patent Application submitted January 2022.
- "Logic gates with flux solitons," Kevin D. Osborn and W. Wustmann, Patent 10778229B1, Issued 9/15/2020.
- "Reversible Computation with Flux Solitons", Kevin D. Osborn, Patent 9812836, Issued 11/7/2017.

Publications

47. "Dual-Resonator Kinetic-Inductance Detector for Distinction between Signal and 1/f Frequency Noise" N. Foroozani, B. Sarabi, S. H. Mosely, T. Stevenson, E.J. Wollack, O. Noroozian, K. D. Osborn, https://arxiv.org/abs/2202.11310 (2022).
46. "Evidence for weakly and strongly interacting two-level systems in amorphous silicon" Liuqi Yu, Shlomi Matityahu, Yaniv J. Rosen, Chih-Chiao Hung, Andrii Maksymov, Alexander L. Burin, Moshe Schecter, Kevin D. Osborn, arXiv:2110.10747 (2021).
45. "Asynchronous Reversible Computing Unveiled Using Ballistic Shift Registers" Kevin D. Osborn and Waltraut Wustmann, arXiv:2201.12999 (2021).
44. "Probing hundreds of individual quantum defects in polycrystalline and amorphous alumina" Chih-Chiao Hung, Liuqi Yu, Neda Foroozani, Stefan Fritz, Dagmar Gerthsen, Kevin D. Osborn, arXiv:2107.04131 , Physical Review Applied, **17**, 034025 (2022).
43. "Reversible Fluxon Logic With Optimized CNOT Gate Components" Kevin D. Osborn and Waltraut Wustmann, IEEE Transactions on Applied Superconductivity, 31, 1300213 (2021).
42. "Reversible Fluxon Logic: Topological particles allow ballistic gates along 1D paths" W. Wustmann, K. D. Osborn, Phys. Rev. B 101, 014516 (2020), DOI: 10.1103/PhysRevB.101.014516.
41. "Reversible Fluxon Logic for Future Computing" K. D. Osborn, W. Wustmann, *2019 IEEE International Superconductive Electronics Conference (ISEC)*, Riverside, CA, USA, 2019, pp. 1-5, doi: 10.1109/ISEC46533.2019.8990955
40. "Using Surface Engineering to Modulate Superconducting Coplanar Microwave Resonator Performance" E. H. Lock, P. Xu, T. Kohler, L. Camacho, J. Prestigiacomo, Y. J. Rosen., and K. D. Osborn, IEEE Trans. Appl. Supercond., 29, 1700108 (2019). DOI: 10.1109/TASC.2019.2891883
39. "Experimental designs of ballistic reversible logic gates using fluxons," L. Yu, W. Wustmann and K. D. Osborn, 2019 IEEE International Superconductive Electronics Conference (ISEC), 2019, pp. 1-3, doi: 10.1109/ISEC46533.2019.8990914.
38. "Development of transmon qubits solely from optical lithography on 300mm wafers" N. Foroozani, C. Hobbs, C. C. Hung, S. Olson, D. Ashworth, E. Holland, M. Malloy, P. Kearney, B. O'Brien, B. Bunday, D. DiPaola, W. Advocate, T. Murray, P.

Hansen, S. Novak, S. Bennett, M. Rodgers, B. Baker-O'Neal, B. Sapp, E. Barth, J. Hedrick, R. Goldblatt, S. S. Papa Rao, K. D. Osborn, QS&T, **4**, 025012 (2019). DOI: 10.1088/2058-9565/ab0ca8

37. "Using Surface Engineering to Modulate Superconducting Coplanar Microwave Resonator Performance" E. H. Lock, P. Xu, T. Kohler, L. Camacho, J. Prestigiacomo, Y. J. Rosen., and K. D. Osborn, IEEE Trans. Appl. Supercond., **29**, 1700108 (2019). DOI: 10.1109/TASC.2019.2891883
36. "Ballistic Reversible Gates Matched to Bit Storage: Plans for an Efficient CNOT Gate Using Fluxons" K. D. Osborn, W. Wustmann, In: Reversible Computation. RC 2018. Lecture Notes in Computer Science, vol 11106., p. 189, Springer, Cham (2018).
35. "Projected Dipole Moments of Individual Two-Level Defects Extracted Using Circuit Quantum Electrodynamics" B. Sarabi, A. N. Ramanayaka, A. L. Burin, F. C. Wellstood, and K. D. Osborn, Phys. Rev. Lett., **116**,167002 (2016).
35. "Random-Defect Laser: Manipulating Lossy Two-Level Systems to Produce a Circuit with Coherent Gain" Yaniv J. Rosen, Moe S. Khalil, Alexander L. Burin, and Kevin D. Osborn, Phys. Rev. Lett., **116**, 163601 (2016).
34. "Cavity quantum electrodynamics using a near-resonance two-level system: Emergence of the Glauber state" B. Sarabi, A. N. Ramanayaka, A. L. Burin, F. C. Wellstood, and K. D. Osborn, Appl. Phys. Lett. **106**, 172601 (2015). Featured Article (Cover).
33. "Superconducting TiN Films Sputtered Over a Large Range of Substrate DC Bias" H. M. Iftekhar Jaim, J. A. Aguilar, B. Sarabi, Y. J. Rosen, A. N. Ramanayaka, E. H. Lock, C. J. K. Richardson, and K. D. Osborn, IEEE Trans. Appl. Supercond. **25**, 1100505 (2015).
32. "Landau-Zener population control and dipole measurement of a two-level-system bath," M. S. Khalil, S. Gladchenko, M. J. A. Stoutimore, F. C. Wellstood, A. L. Burin, and K. D. Osborn, Phys. Rev. B. **90**,100201(R) (2014).
31. "Quantum Coherent manipulation of two-level systems in superconducting circuits," A. L. Burin, A. O. Maksymov, and K. D. Osborn, Supercond. Sci. Technol. **27**, 084001 (2014).
30. "Evidence for hydrogen two-level systems in atomic layer deposition oxides," M. S. Khalil, M. J. A. Stoutimore, S. Gladchenko, A. M. Holder, C. B. Musgrave, A. C. Kozen, G. Rubloff, Y. Q. Liu, R. G. Gordon, J. H. Yum, S. K. Banerjee, C. J. Lobb, K. D. Osborn, Appl. Phys. Lett. **103**, 162601 (2013).
29. "Bulk and Surface Tunneling Hydrogen Defects in Alumina," Aaron M. Holder, Kevin D. Osborn, C. J. Lobb, Charles B. Musgrave, Phys. Rev. Lett. **111**, 065901 (2013).
28. "Examining the role of hydrogen in the electrical performance of in situ fabricated metal-insulator-metal trilayers using an atomic layer deposited Al2O3 dielectric," Alexander C. Kozen, Marshall A. Schroeder, Kevin D. Osborn, C. J. Lobb, Gary W. Rubloff, Appl. Phys. Lett., **102**, 173501 (2013).
27. "Universal dielectric loss in amorphous solids from simultaneous bias and microwave field," Alexander L. Burin, Moe S. Khalil, Kevin D. Osborn, Phys. Rev. Lett., **110**, 157002 (2013).
26. "A Josephson junction defect spectrometer for measuring two-level systems", M. J. A. Stoutimore, M. S. Khalil, C. J. Lobb, K. D. Osborn, Appl. Phys. Lett., **101**, 062602 (2012).
25. "Squeezed noise due to two-level system defects in superconducting resonator circuits," So Takei, Victor M. Galitski, Kevin D. Osborn, Phys. Rev. B **85**, 104507 (2012).
24. "An analysis method for asymmetric resonator transmission applied to superconducting devices," M. S. Khalil, M. J. A. Stoutimore, F. C. Wellstood, K. D. Osborn, Journal of Applied Physics **111**, 054510 (2012).

23. “Jaynes-Cummings treatment of superconducting resonators with dielectric loss due to two-level systems”, M. Bhattacharya, K. D. Osborn, and Ari Mizel, Phys. Rev. B **84**, 104517 (2011).
22. “Loss Dependence on Geometry and Applied Power in Superconducting Coplanar Resonators", M. S. Khalil, F. C. Wellstood, K. D. Osborn, IEEE Transactions on Applied Superconductivity, **21**, 879 (2011).
21. “Decoupling a Cooper-pair box to enhance the lifetime to 0.2 ms,“ Z. Kim, B. Suri, V. Zaretskey, S. Novikov, K. D. Osborn, A. Mizel, F. C. Wellstood, B. S. Palmer , Phys. Rev. Lett. **106**, 120501 (2011).
20. “Anomalous Switching Curves in a dc SQUID Phase Qubit,” H. Kwon, A.J. Przybysz, B.K. Cooper, H. Paik, K.D. Osborn, B.S. Palmer, R. Budoyo, J.R. Anderson, C.J. Lobb, F.C. Wellstood, IEEE Transactions on Applied Superconductivity, **21**, 860 (2011).
19. “Superposition of Inductive and Capacitive Coupling in Superconducting LC Resonators," Gladchenko, S.; Khalil, M.; Lobb, C. J.; Wellstood, F. C.; Osborn, K. D.; IEEE Transactions on Applied Superconductivity, **21**, 875 (2011).
18. “Reducing quantum-regime dielectric loss of silicon nitride for superconducting quantum circuits,” Hanhee Paik and Kevin D. Osborn, Applied Physics Letters, **96**, 072505 (2010).
17. “Coherent interactions between phase qubits, cavities, and TLS defects,” R.W. Simmonds, M.S. Allman, F. Altomare, K. Cicak, K.D. Osborn, J.A. Park, M. Sillanpaa, A. Sirois, J.A. Strong, J.D. Whittaker, Quantum Information Processing, **8**, 117 (2009).
16. “Vacuum-Gap Capacitors for Low-Loss Superconducting Resonant Circuits,” K. Cicak, M.S. Allman, J.A. Strong, K.D. Osborn, R.W. Simmonds, IEEE Transactions on Applied Superconductivity, **19**, 948 (2009).
15. “Frequency-Tunable Josephson Junction Resonator for Quantum Computing,” K.D. Osborn, J.A. Strong, A.J. Sirois, R.W. Simmonds, IEEE Transactions on Applied Superconductivity, **17**, 166 (2007).
14. “Elimination of two level fluctuators in superconducting quantum bits by an epitaxial tunnel barrier,” Seongshik Oh, K. Cicak, J.S. Kline, M.A. Sillanpaa, K.D. Osborn, J.D. Whittaker, R.W. Simmonds, D.P. Pappas, Physical Review B, **74**, 100502, (2006).
13. “Epitaxial growth of rhenium with sputtering,” S. Oh, D.A. Hite, K. Cicak, K.D. Osborn, R.W. Simmonds, R. McDermott, K.B. Cooper, M. Steffen, J.M. Martinis, D.P. Pappas, Thin Solid Films, **496**, 389 (2006).
12. “Single-photon pump,” K.D. Osborn, M.W. Keller, Applied Physics Letters, **89**, 083518 (2006).
11. “Simultaneous state measurement of coupled Josephson phase qubits,” R. McDermott, R.W. Simmonds, M. Steffen, K.B. Cooper, K. Cicak, K.D. Osborn, Seongshik Oh, D.P. Pappas, J.M. Martinis, Science, **307**, 1299 (2005).
10. “Decoherence in Josephson qubits from dielectric loss,” J.M. Martinis, K.B. Cooper, R. McDermott, M. Steffen, M. Ansmann, K.D. Osborn, K. Cicak, Seongshik Oh, D.P. Pappas, R.W. Simmonds, C.C. Yu., Physical Review Letters, **95**, 210503 (2005).
9. “Low-leakage superconducting tunnel junctions with a single-crystal Al_2O_3 barrier,” S. Oh, K. Cicak, R. McDermott, K.B. Cooper, K.D. Osborn, R.W. Simmonds, M. Steffen, J.M. Martinis, D.P. Pappas, Superconductor Science & Technology, **18**, 1396 (2005).
8. “HEMT Amplified SET Measurements of Individual InGaAs Quantum Dots,” K. D. Osborn, Mark W. Keller, R. P. Mirin, AIP Conference Proceedings, Physics of Semiconductors: 27th International Conference on the Physics of Semiconductors, **772**, 819 (2005).
7. “Single-electron transistor spectroscopy of InGaAs self-assembled quantum dots,” K.D. Osborn, M.W. Keller, R.P. Mirin, Physica E, **21**, 501 (2004).

6. “Superconducting qubits and the physics of Josephson Junctions,” John M. Martinis, K. Osborn, Proceedings of Les Houches Summer School on Quantum Entanglement and Information Processing (2004).
5. “Critical dynamics of superconducting $Bi_2Sr_2CaCu_2O_{8+d}$ films,” K.D. Osborn, D.J. Van Harlingen, Vivek Aji, Nigel Goldenfeld, S.Oh, J.N. Eckstein, Physical Review B **68**, 144516 (2003).
4. “Study of buried interfaces by soft x-ray fluorescence spectroscopy excited by synchrotron radiation,” D.L.Ederer, J.A. Carlisle, J. Jimenez, J.J. Jia, K. Osborn, T.A. Callcott, R.C.C. Perera, J.H. Underwood, L.J. Terminello, A. Asfaw, F.J. Himpsel, JVST A **14**, 859 (1996).
3. “Variable Groovespaced grating monochromator for soft x-ray emission spectroscopy at CAMD/LSU,” A. Asfaw, D. L. Ederer, L. Zhou, L. Lin, K. Osborn, T. A. Callcott, K. E. Miyano, E. Morikawa, Rev. Sci. Instrum. **66**, 1627 (1995).
2. “Two New Optical Designs for Soft-X-Ray Spectrometers Using Variable-Line-Space Gratings,” K.D. Osborn, T.A. Callcott, Review of Scientific Instruments **66**, 3131 (1995).