

## **Kevin D. Osborn, Ph.D.**

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## **Current Research Interests**

I am interested in low temperature physics, superconducting circuits, and quantum computing. Tunneling atom states (TS), which are described by a two-level model and adversely affect qubits, are studied in amorphous and crystalline dielectric films. Experiments include a solid-state maser made from defects, and projected dipole moment measurement of individual TS using cavity quantum electrodynamics. Superconducting titanium nitride is being investigated as a high-performance resonator circuit element, where quasiparticle defects are of interest. Superconducting circuits which use fluxons, with new degrees of freedom relative to Sine-Gordon solitons, are being investigated for reversible computing.

## **Professional Positions**

<b>Adjunct Associate Professor of Physics</b> , U. of Maryland at College Park	2013 – Present
<b>U.S. Gov. Scientist and Group Lead</b> , Lab. for Physical Sciences, College Park, MD	2007 – Present
<b>Research Associate and NRC Postdoctoral Fellow</b> , NIST, Boulder, CO	2001 – 2006
<b>Graduate Assistant</b> , Physics, U. of Illinois at Urbana-Champaign	1995 – 2001
<b>Graduate Assistant</b> , Physics, U. of Tennessee at Knoxville	1992 – 1995

## **Recent Scientific Activities**

**Research Advisor**, *Former Ph.D. thesis advisees*: M. S. Khalil, Ph.D., defended in October 2014, and B. Sarabi, defended in November 2014. *Former postdoctoral advisees*: H. Paik, S. Gladchenko, M. J. A. Stoutimore, A. Ramanayaka, Y. Rosen. Current G. Student and P.D. advisees: T. Kohler, W. Wustmann, P. Xu, S. Guchhait, and N. Forouzani.

**Reviewer**, Including physics and superconducting journals by APS, AIP and IEEE, 2007 – present

**Session Chair**: i) Superconducting and Quantum Metamaterials, ii) Decoherence and Defects in Superconducting Circuits, APS March Meeting, New Orleans, Louisiana, 2017. 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**

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

## **Memberships and Awards**

**Joint Quantum Institute, Associate Fellow**, 2013-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

## Patent Application

- “Reversible Computation with Flux Solitons”, Kevin D. Osborn, Full Patent Application to USPTO, submitted Nov., 12, 2015.

## Publications

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).
34. “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).
33. “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).
32. “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).
31. “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).
30. “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).
29. “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).
28. “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).
27. “Examining the role of hydrogen in the electrical performance of in situ fabricated metal-insulator-metal trilayers using an atomic layer deposited Al<sub>2</sub>O<sub>3</sub> dielectric,” Alexander C. Kozen, Marshall A. Schroeder, Kevin D. Osborn, C. J. Lobb, Gary W. Rubloff, Appl. Phys. Lett., **102**, 173501 (2013).
26. “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).
25. “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).
24. “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).
23. “An analysis method for asymmetric resonator transmission applied to

- superconducting devices," M. S. Khalil, M. J. A. Stutimore, F. C. Wellstood, K. D. Osborn, *Journal of Applied Physics* **111**, 054510 (2012).
22. "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).
  21. "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).
  20. "Decoupling a Cooper-pair box to enhance the lifetime to 0.2 ms," Z. Kim, B. Suri, V. Zaretsky, S. Novikov, K. D. Osborn, A. Mizel, F. C. Wellstood, B. S. Palmer , *Phys. Rev. Lett.* **106**, 120501 (2011).
  19. "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).
  18. "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).
  17. "Reducing quantum-regime dielectric loss of silicon nitride for superconducting quantum circuits," Hanhee Paik and Kevin D. Osborn, *Applied Physics Letters*, **96**, 072505 (2010).
  16. "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).
  15. "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).
  14. "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).
  13. "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).
  12. "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).
  11. "Single-photon pump," K.D. Osborn, M.W. Keller, *Applied Physics Letters*, **89**, 083518 (2006).
  10. "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).
  9. "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).
  8. "Low-leakage superconducting tunnel junctions with a single-crystal Al<sub>2</sub>O<sub>3</sub> 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).
  7. "HEMT Amplified SET Measurements of Individual InGaAs Quantum Dots," K. D. Osborn, Mark W. Keller, R. P. Mirin, *AIP Conference Proceedings*, *Physics of Semiconductors: 27<sup>th</sup> International Conference on the Physics of Semiconductors*, **772**, 819 (2005).

6. "Single-electron transistor spectroscopy of InGaAs self-assembled quantum dots," K.D. Osborn, M.W. Keller, R.P. Mirin, *Physica E*, **21**, 501 (2004).
5. "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).
4. "Critical dynamics of superconducting  $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$  films," K.D. Osborn, D.J. Van Harlingen, Vivek Aji, Nigel Goldenfeld, S.Oh, J.N. Eckstein, *Physical Review B* **68**, 144516 (2003).
3. "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).
2. "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).
1. "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).

## Recent Presentations

- "Free-Dynamical Reversible Josephson Junction Logic Gates," Applied Superconductivity Conference, Denver, CO, Sept. 7, 2016.
- "The Random-Defect Laser: Manipulating lossy two-level systems to create a circuit with coherent gain," Quantum Metamaterials and Technology Workshop, Spetses, Greece, June 23, 2016.
- "1/f permittivity noise probed uniformly in a film with two level systems: The power law of field saturation and the relationship to loss," APS March Meeting, Mar. 18, 2016.
- "Flux Solitons Studied for Energy-Conserving Reversible Computing," APS March Meeting San Antonio, TX, March 6, 2015.
- "Low-Dissipation Flux Solitons as Practical Reversible Objects," Applied Superconductivity Conference, Charlotte, NC, August 13, 2014.
- "Millikelvin defects in resonators: Defect interactions and dipole moment extraction in thin films," NASA-Goddard, Greenbelt, MD, July 15, 2014.
- "Quantum computing circuit two-level system defects and their phenomena," Rutgers University, New Brunswick, NJ, November 14, 2013.
- "Resonator Studies for Quantum Computing," Quantum Computing and Quantum Algorithm Program Review, San Diego, CA, August 13, 2013.
- "Two Level Systems in Superconducting Devices," Tulane University, February 13, 2013.
- "Two Level Systems: Nonequilibrium Dynamics and ab initio screening," IARPA/ARO Coherent Superconducting Qubit Program Review, San Francisco, CA, Jan. 23, 2013.
- "Non-Equilibrium Dynamics in the Two Level Systems of Amorphous Dielectrics," NIST, Gaithersburg, MD, October 23, 2012.
- "Resonator Studies for Quantum Computing: Nonequilibrium Response of TLSs in Dielectrics," NSA/ARO Quantum Computing and Quantum Algorithm Program Review, Denver, CO, August 14, 2012.
- "SQUIDs, Superconducting Electronics, Landauer's Limit and Reversibility," SEALeR Workshop, Annapolis, Maryland, March 15, 2012.
- "Universal and NonUniversal Properties of Silicon Nitride Films," IARPA/ARO Coherent Superconducting Qubit Program Review, San Francisco, CA, Jan. 19, 2012.
- "Resonant Amorphous Defect States in Coherent Superconducting Devices," Tulane University, Chemistry Department, October 3, 2011.

- “Resonator Studies for Qubit Coherence and Readout: The Josephson Junction Defect Spectrometer,” NSA/ARO Quantum Computing and Quantum Algorithm Program Review, Denver, CO, August 9, 2011.
- “Low-Temperature Defects in Quantum-Regime Superconducting Devices ,” JQI Seminar, University of Maryland Physics Department, College Park, MD, May 09, 2011.
- “Low Loss Amorphous Silicon Nitride,” Northrop Grumman, Linthicum, MD, February 8, 2011.