

## DAVID SCHURIG

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Department of Electrical and Computer Engineering  
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### EDUCATION

1991-2002  
Ph.D., Physics, University of California, San Diego, Thesis: Indefinite Focusing, Advisor: S. Schultz

1984-1989  
B.S., Engineering Physics, University of California, Berkeley

### PROFESSIONAL EXPERIENCE

2011 – present  
Associate Professor, Department of Electrical and Computer Engineering, University of Utah, Salt Lake City, UT

2007 – 2010  
Assistant Professor, Department of Electrical and Computer Engineering, North Carolina State University, Raleigh, NC

2004 – 2007  
Postdoctoral fellow, Department of Electrical and Computer Engineering, Duke University, Durham, North Carolina

2002 – 2004  
Postdoctoral fellow, University of California, San Diego, La Jolla, California

2000 – 2002  
Staff Physicist, Tristan Technologies, San Diego, California

1989 – 1991  
Research Associate, Lawrence Berkeley Lab, Berkeley, California

### TEACHING

Department of Electrical and Computer Engineering, University of Utah

Spring 2014, 2015, 2016, 2017, 2018, 2020, 2021, 2022, 2024  
ECE 5324/6324: Antenna Theory and Design  
General theory of conduction current antennas; linear antennas including dipoles and monopoles; antenna equivalent impedance; design antennas of one or more elements; matching techniques, transmission lines and conjugate matching; receiving antennas; antennas used for mobile communication systems and their radiation characteristics; antenna arrays and their design; wave propagation; loop antennas and Yagi-Uda arrays. Helical antennas, aperture antennas, broadband antennas; horn and parabolic radiators; communication links considerations. Textbook: *Antenna Theory and Design* - Warren L. Stutzman and Gary A. Thiele

Fall 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2019, 2021, 2022, 2023  
ECE 5350/6350: Applied Computational Electromagnetics with Commercial Solvers (formerly Metamaterials and Advanced Antenna Design)  
Use commercial electromagnetic solvers to explore topics relevant to antenna design and current research in metamaterials. Topics include: material parameter extraction, effective medium theory, resonant unit cell analysis, unit cell coupling, complex antenna shapes, real array effects, and co-located antenna interference.

Spring 2012, 2013

ECE 6310: Advanced Electromagnetic Fields

Review of Maxwell's macroscopic equations in integral and differential forms including boundary conditions, power and energy computations, and time-harmonic formulations. Macroscopic-electrical properties of matter. Oblique incidence planewave propagation and polarization in multi-layered media. Separation of variable solutions of the wave equation in rectangular, cylindrical and spherical coordinates. Textbook: *Advanced Engineering Electromagnetics* - Constantine A. Balanis

Department of Electrical and Computer Engineering, North Carolina State University

Fall 2008, 2009, 2010

ECE782 Special Topics: Metamaterials and Transformation Design (graduate)

Course covers topics relevant to current research in metamaterials and transformation design, including effective media, unit cell design, material parameter extraction, and material design with coordinate transformations. Assignments are computational projects using commercial Maxwell's equations solvers.

Spring 2010

ECE540 Photonics and Optical Communications (graduate)

Brief review of Maxwell's Equations, constitutive relations and boundary conditions. Reflection and refraction of plane waves; power and energy relations in isotropic media. Potential functions, Green's functions and their applications to radiation and scattering. Antenna fundamentals: linear antennas, uniform linear arrays and aperture antennas, microstrip antennas. Fundamentals of numerical methods for electromagnetic simulation and antenna design. Textbook: *Antenna Theory* - Constantine A. Balanis

Spring 2008, 2009

ECE523 Photonics and Optical Communications (graduate)

This course investigates photonic devices at the component level and examines the generation, propagation and detection of light in the context of optical communication systems. Topics include planar and cylindrical optical waveguides, LEDs, lasers, optical amplifiers, integrated optical and photodetectors, design tradeoffs for optical systems, passive optical networks, and wavelength division multiplexed systems. Textbook: *Fundamentals of Photonics*, B.E.A. Saleh and M.C. Teich

## SELECTED HONORS

2007

Essential Science Indicator's Hot Papers Special Topics

Hot papers are selected by virtue of being cited among the top one-tenth of one percent (0.1%) in a current bimonthly period. Papers are selected in each of 22 fields of science and must be published within the last two years. Special Topics highlights the most-cited of these new entries, one from each field.

2006

Scientific American's Top 50 Science Contributors

Annually, SCIENTIFIC AMERICAN 50 recognizes people, teams and organizations whose recent accomplishments, whether in research, business or policymaking, demonstrate leadership in shaping both established and emerging technologies.

2006

Science Magazine's Breakthrough of the Year, Runner up

Science highlights the breakthrough of the year and nine runners up across all fields of science.

2006

Discover Magazine's Top 6 Physics Stories

Discover annually highlights the top one hundred science stories of the year. Grouped by category, there were six physics stories in 2006.

2004

Intelligence Community Postdoctoral Fellowship

A two year postdoctoral fellowship covering both salary and some additional expenses awarded by the intelligence community through the Office of the Director of National Intelligence.

## CITATION METRICS

Google Scholar (includes patents)  
total citations: 32183 h-index: 39

## REVIEWED JOURNAL ARTICLES

1. R. G. Edwards, I. Krieger, M. P. Halling, S. D. Minter, T. D. Sparks, and D. Schurig, "Additive-Manufactured, Highly-Conductive Metasurfaces, With Application Enabling Secondary Properties, for Microwave Waveguide Components," *IEEE Access*, vol. 10, pp. 58921-58929, 2022.
2. R. G. Edwards, C. M. Norton, J. E. Campbell, and D. Schurig, "Effective conductivity of additive-manufactured metals for microwave feed components," *IEEE Access*, vol. 9, pp. 59979-59986, 2021.
3. N. Viswanathan, S. Venkatesh, and D. Schurig, "Optimization of a Sparse Aperture Configuration for Millimeter-wave Computational Imaging," *IEEE Transactions on Antennas and Propagation*, vol. 69, pp. 1107 - 1117, 2020.
4. H. Mehrpour Bernety and D. Schurig, "Omnidirectional retroreflective surface using geodesic polyhedra," *AIP Advances*, vol. 10, p. 025302, 2020.
5. H. M. Bernety, H. Zhang, D. Schurig, and C. M. Furse, "Field focusing for implanted medical devices," *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, vol. 4, pp. 273-278, 2020.
6. H. M. Bernety and D. Schurig, "Fast Beamforming for Dynamic, Randomly Configured Antenna Arrays and Metamaterials," *IEEE Antennas and Wireless Propagation Letters*, vol. 19, pp. 2087-2091, 2020.
7. S. Venkatesh and D. Schurig, "Transformation optics design of a planar near field magnifier for sub-diffraction imaging," *Optics express*, vol. 27, pp. 4694-4713, 2019.
8. H. M. Bernety, R. D. Puckett, D. Schurig, and C. Furse, "Comparison of passive 2-D and 3-D ring arrays for medical telemetry focusing," *IEEE Antennas and Wireless Propagation Letters*, vol. 18, pp. 1189-1193, 2019.
9. H. M. Bernety, S. Venkatesh, and D. Schurig, "Performance analysis of a helmet-based radar system for impact prediction," *IEEE Access*, vol. 6, pp. 75124-75131, 2018.
10. H. M. Bernety, S. Venkatesh, and D. Schurig, "Analytical phasing of arbitrarily oriented arrays using a fast, analytical far-field calculation method," *IEEE Transactions on Antennas and Propagation*, vol. 66, pp. 2911-2922, 2018.
11. R. Abbasi, M. Abe, M. A. B. Othman, T. Abu-Zayyad, M. Allen, R. Anderson, R. Azuma, E. Barcikowski, J. Belz, and D. Bergman, "First upper limits on the radar cross section of cosmic-ray induced extensive air showers," *Astroparticle Physics*, vol. 87, pp. 1-17, 2017.
12. S. Venkatesh, N. Viswanathan, and D. Schurig, "W-band sparse synthetic aperture for computational imaging," *Optics express*, vol. 24, pp. 8317-8331, 2016.
13. S. Venkatesh and D. Schurig, "Computationally fast EM field propagation through axi-symmetric media using cylindrical harmonic decomposition," *Optics express*, vol. 24, pp. 29246-29268, 2016.
14. E. S. G. Rodríguez, A. K. RamRakhyani, D. Schurig, and G. Lazzi, "Compact low-frequency metamaterial design for wireless power transfer efficiency enhancement," *IEEE Transactions on Microwave Theory and Techniques*, vol. 64, pp. 1644-1654, 2016.
15. G. Joshi, R. Miller, L. Ogden, M. Kavand, S. Jamali, K. Ambal, S. Venkatesh, D. Schurig, H. Malissa, and J. M. Lupton, "Separating hyperfine from spin-orbit interactions in organic semiconductors by multi-octave magnetic resonance using coplanar waveguide microresonators," *Applied Physics Letters*, vol. 109, p. 103303, 2016.

16. S. Kunwar, R. Abbasi, C. Allen, J. Belz, D. Besson, M. Byrne, B. Farhang-Boroujeny, W. Gillman, W. Hanlon, and J. Hanson, "Design, construction and operation of a low-power, autonomous radio-frequency data-acquisition station for the TARA experiment," *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, vol. 797, pp. 110-120, 2015.
17. A. Rajagopalan, A. K. Ramrakhyani, D. Schurig, and G. Lazzi, "Improving power transfer efficiency of a short-range telemetry system using compact metamaterials," *IEEE Transactions on Microwave Theory and Techniques*, vol. 62, pp. 947-955, an. 6742630, 2014.
18. R. Abbasi, M. A. B. Othman, C. Allen, L. Beard, J. Belz, D. Besson, M. Byrne, B. Farhang-Boroujeny, A. Gardner, and W. Gillman, "Telescope Array Radar (TARA) Observatory for Ultra-High Energy Cosmic Rays," *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, vol. 767, pp. 322-338, 2014. (D. Schurig and S. Venkatesh being added as authors.)
19. S. Venkatesh, D. Shrekenhamer, W. Xu, S. Sonkusale, W. Padilla, and D. Schurig, "Interferometric direction finding with a metamaterial detector," *Applied Physics Letters*, vol. 103, an. 254103, 2013.
20. D. Shrekenhamer, W. Xu, S. Venkatesh, D. Schurig, S. Sonkusale, and W. J. Padilla, "Experimental realization of a metamaterial detector focal plane array," *Physical Review Letters*, vol. 109, an. 177401, 2012.
21. D. Schurig, G. V. Eleftheriades, D. R. Smith, and S. A. Tretyakov, "Guest editorial: Special cluster on metamaterials," *IEEE Antennas and Wireless Propagation Letters*, vol. 10, pp. 1476-1479, an. 6135452, 2011.
22. D. Schurig, "An aberration-free lens with zero F-number," *New Journal of Physics*, vol. 10, an. 115034, 2008.
23. M. Rahm, D. Schurig, D. A. Roberts, S. A. Cummer, D. R. Smith, and J. B. Pendry, "Design of electromagnetic cloaks and concentrators using form-invariant coordinate transformations of Maxwell's equations," *Photonics and Nanostructures - Fundamentals and Applications*, vol. 6, pp. 87-95, 2008.
24. M. Rahm, S. A. Cummer, D. Schurig, J. B. Pendry, and D. R. Smith, "Optical design of reflectionless complex media by finite embedded coordinate transformations," *Physical Review Letters*, vol. 100, an. 063903, 2008.
25. S. A. Cummer, M. Rahm, and D. Schurig, "Material parameters and vector scaling in transformation acoustics," *New Journal of Physics*, vol. 10, an. 115025, 2008.
26. S. A. Cummer, B. I. Popa, D. Schurig, D. R. Smith, J. Pendry, M. Rahm, and A. Starr, "Scattering theory derivation of a 3D acoustic cloaking shell," *Physical Review Letters*, vol. 100, an. 024301, 2008.
27. D. Schurig, J. B. Pendry, and D. R. Smith, "Transformation-designed optical elements," *Optics Express*, vol. 15, pp. 14772-14782, 2007.
28. R. B. Gregor, C. G. Parazzoli, J. A. Nielsen, M. A. Thompson, M. H. Tanielian, D. C. Vier, S. Schultz, D. R. Smith, and D. Schurig, "Microwave focusing and beam collimation using negative index of refraction lenses," *IET Microwaves, Antennas and Propagation*, vol. 1, pp. 108-115, 2007.
29. **S. A. Cummer and D. Schurig, "One path to acoustic cloaking," *New Journal of Physics*, vol. 9, an. 45, 2007. Cited 1300 times.**
30. D. R. Smith, D. Schurig, and J. J. Mock, "Characterization of a planar artificial magnetic metamaterial surface," *Physical Review E - Statistical, Nonlinear, and Soft Matter Physics*, vol. 74, an. 036604, 2006.
31. D. R. Smith, J. Gollub, J. J. Mock, W. J. Padilla, and D. Schurig, "Calculation and measurement of bianisotropy in a split ring resonator metamaterial," *Journal of Applied Physics*, vol. 100, an. 024507, 2006.
32. **D. Schurig, J. B. Pendry, and D. R. Smith, "Calculation of material properties and ray tracing in transformation media," *Optics Express*, vol. 14, 2006. Cited 967 times.**

33. **D. Schurig, J. J. Mock, and D. R. Smith, "Electric-field-coupled resonators for negative permittivity metamaterials," *Applied Physics Letters*, vol. 88, pp. 1-3, an. 041109, 2006. Cited 946 times.**
34. **D. Schurig, J. J. Mock, B. J. Justice, S. A. Cummer, J. B. Pendry, A. F. Starr, and D. R. Smith, "Metamaterial electromagnetic cloak at microwave frequencies," *Science*, vol. 314, pp. 977-980, 2006. Cited 8874 times.**
35. D. Schurig, "Off-normal incidence simulations of metamaterials using FDTD," *International Journal of Numerical Modelling: Electronic Networks, Devices and Fields*, vol. 19, pp. 215-228, 2006.
36. **J. B. Pendry, D. Schurig, and D. R. Smith, "Controlling electromagnetic fields," *Science*, vol. 312, pp. 1780-1782, 2006. Cited 10118 times.**
37. B. J. Justice, J. J. Mock, L. Guo, A. Degiron, D. Schurig, and D. R. Smith, "Spatial mapping of the internal and external electromagnetic fields of negative index metamaterials," *Optics Express*, vol. 14, pp. 8694-8705, 2006.
38. T. Driscoll, D. N. Basov, A. F. Starr, P. M. Rye, S. Nemat-Nasser, D. Schurig, and D. R. Smith, "Free-space microwave focusing by a negative-index gradient lens," *Applied Physics Letters*, vol. 88, an. 081101, 2006.
39. **S. A. Cummer, B. I. Popa, D. Schurig, D. R. Smith, and J. Pendry, "Full-wave simulations of electromagnetic cloaking structures," *Physical Review E - Statistical, Nonlinear, and Soft Matter Physics*, vol. 74, an. 036621, 2006. Cited 1034 times.**
40. D. R. Smith, J. J. Mock, A. F. Starr, and D. Schurig, "Gradient index metamaterials," *Physical Review E - Statistical, Nonlinear, and Soft Matter Physics*, vol. 71, an. 036609, 2005.
41. D. Schurig and D. R. Smith, "Sub-diffraction imaging with compensating bilayers," *New Journal of Physics*, vol. 7, an. 162, 2005.
42. D. R. Smith, D. Schurig, J. J. Mock, P. Kolinko, and P. Rye, "Partial focusing of radiation by a slab of indefinite media," *Applied Physics Letters*, vol. 84, pp. 2244-2246, 2004.
43. D. R. Smith, P. Kolinko, and D. Schurig, "Negative refraction in indefinite media," *Journal of the Optical Society of America B: Optical Physics*, vol. 21, pp. 1032-1043, 2004.
44. D. Schurig and D. R. Smith, "Negative index lens aberrations," *Physical Review E - Statistical, Nonlinear, and Soft Matter Physics*, vol. 70, pp. 065601/1-065601/4, an. 065601, 2004.
45. M. I. Faley, K. Pratt, R. Reineman, D. Schurig, S. Gott, C. G. Atwood, R. E. Sarwinski, D. N. Paulson, T. N. Starr, and R. L. Fagaly, "High temperature superconductor dc SQUID micro-susceptometer for room temperature objects," *Superconductor Science and Technology*, vol. 17, pp. S324-S327, 2004.
46. D. R. Smith, D. Schurig, M. Rosenbluth, S. Schultz, S. A. Ramakrishna, and J. B. Pendry, "Limitations on subdiffraction imaging with a negative refractive index slab," *Applied Physics Letters*, vol. 82, pp. 1506-1508, 2003.
47. **D. R. Smith and D. Schurig, "Electromagnetic wave propagation in media with indefinite permittivity and permeability tensors," *Physical Review Letters*, vol. 90, pp. 077405/1-077405/4, 2003. Cited 1357 times.**
48. D. Schurig and D. R. Smith, "Spatial filtering using media with indefinite permittivity and permeability tensors," *Applied Physics Letters*, vol. 82, pp. 2215-2217, 2003.
49. D. Schurig and D. Smith, "Universal description of spherical aberration free lenses composed of positive or negative index media," *arXiv preprint physics/0307088*, 2003.
50. D. R. Smith, D. Schurig, and J. B. Pendry, "Negative refraction of modulated electromagnetic waves," *Applied Physics Letters*, vol. 81, pp. 2713-2715, 2002.

51. S. A. Ramakrishna, J. B. Pendry, D. Schurig, D. R. Smith, and S. Schultz, "The asymmetric lossy near-perfect lens," *Journal of Modern Optics*, vol. 49, pp. 1747-1762, 2002.
52. S. Jin, T. H. Tiefel, M. McCormack, H. M. O'Bryan, L. H. Chen, R. Ramesh, and D. Schurig, "Thickness dependence of magnetoresistance in La-Ca-Mn-O epitaxial films," *Applied Physics Letters*, vol. 67, p. 557, 1995.
53. L. H. Chen, S. Jin, T. H. Tiefel, R. Ramesh, and D. Schurig, "Large magnetoresistance in La-Ca-Mn-O films," *Proceedings of the 1995 33rd Annual IEEE International Magnetics Conference (INTERMAG'95). Part 1 (of 3)*, vol. 31, pp. 3912-3914, 1995.
54. D. A. Schurig, G. L. Klunder, M. A. Shannon, R. E. Russo, and R. J. Silva, "Signal analysis of transients in pulsed photoacoustic spectroscopy," *Review of Scientific Instruments*, vol. 64, pp. 363-373, 1993.

## BOOK CHAPTER

D. Schurig and D. R. Smith, "Negative Index Lenses," in *Negative-Refraction Metamaterials: Fundamental Principles and Applications*, G. V. Eleftheriades and K. G. Balmain, Eds., John Wiley and Sons, 2005, pp. 213-248.

## CONFERENCE PAPERS

1. *(Invited)* D. Schurig, N. Viswanathan, "Antenna design and wireless link analysis on the POWDER platform," presented at Utah RF and Wireless Day, 2022.
2. J. Breen, J. Duerig, E. Eide, M. Hibler, D. Johnson, S. Kasera, D. Maas, A. Orange, N. Patwari, and R. Ricci, "Mobile and wireless research on the POWDER platform," in *Proceedings of the 19th Annual International Conference on Mobile Systems, Applications, and Services*, 2021, pp. 509-510.
3. N. Viswanathan and D. Schurig, "Exploiting intervoxel covariance as prior information in millimeter-wave computational imaging systems," in *Computational Imaging V*, 2020, p. 113960L.
4. *(Invited)* J. Breen, A. Buffmire, J. Duerig, K. Dutt, E. Eide, M. Hibler, D. Johnson, S. K. Kasera, E. Lewis, and D. Maas, et. al., "POWDER: Platform for Open Wireless Data-driven Experimental Research," in *Proceedings of the 14th International Workshop on Wireless Network Testbeds, Experimental evaluation & Characterization*, 2020, pp. 17-24.
5. H. M. Bernety and D. Schurig, "How to Phase Antenna Arrays and Metasurfaces of Arbitrarily Oriented and Polarized Elements?," presented at 2019 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, 2019.
6. N. Viswanathan, S. Venkatesh, and D. Schurig, "Exploiting Inter Voxel Correlation in Compressed Computational Imaging," presented at *Computational Optical Sensing and Imaging*, 2018.
7. H. M. Bernety, S. Venkatesh, and D. Schurig, "Constructive Analytical Phasing (CAP) for Arbitrarily Oriented Arrays of Linearly Polarized Elements," presented at 2018 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, 2018.
8. H. M. Bernety, D. Schurig, and C. Furse, "Field focusing with novel implantable lens designs using 3D printing," presented at 2018 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, 2018.
9. H. M. Bernety, S. Venkatesh, and D. Schurig, "Analytical far-field calculation of arbitrarily oriented antenna arrays," presented at 2017 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, 2017.
10. H. M. Bernety and D. Schurig, "Analysis of a helmet-based FMCW radar for impact prediction," presented at 2017 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, 2017.

11. K. N. Poudel, D. Schurig, and N. Patwari, "Spatial imaging using a communication system's channel state information," presented at 2016 USNC-URSI Radio Science Meeting, 2016.
12. S. Pandey, B. Gupta, B. Cui, D. Schurig, and A. Nahata, "Terahertz waveguide with a negative effective index of refraction measured using time domain techniques," presented at 2016 41st International Conference on Infrared, Millimeter, and Terahertz waves (IRMMW-THz), 2016.
13. N. Viswanathan, S. Venkatesh, and D. Schurig, "Receiver/Transmitter configuration optimization for compressed computational millimeter-wave imaging," presented at IEEE International Symposium on Antennas and Propagation, and North American Radio Science Meeting, Vancouver, BC, Canada, 2015.
14. S. Venkatesh, N. Viswanathan, and D. Schurig, "W-Band Sparse Synthetic Aperture for Computational Imaging," presented at OSA Imaging and Applied Optics, Arlington, VA, 2015.
15. D. Schurig, N. J. Korevaar, and S. Venkatesh, "Parallel transport design for gradient index lenses," presented at META 2015: 6th International Conference on Metamaterials Photonic Crystals and Plasmonics, New York, NY, 2015.
16. D. Schurig, "Homogenization of metamaterials and effective medium models," presented at Metamaterials'2015: The 9th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics, Oxford, UK, 2015.
17. E. S. G. Rodriguez, D. Schurig, and G. Lazzi, "Using Signal Estimation for Near-Field Plate Optimization," presented at IEEE International Symposium on Antennas and Propagation, and North American Radio Science Meeting, Vancouver, BC, Canada, 2015.
18. A. Orange and D. Schurig, "The design of spherical aberration free multi-layer lenses for the K- and W-bands," presented at SPIE Optical Engineering and Applications, San Diego, CA, 2015.
19. *(Invited)* D. Schurig, "Quantitative Metamaterial Property Extraction," presented at International Conference on Computational & Experimental Engineering and Sciences, Seattle, WA, 2013.
20. *(Invited)* D. Schurig, "Transformation optics for imaging," presented at OSA Frontiers in Optics, Orlando, FL, 2013.
21. A. Rajagopalan, A. K. Ramrakhyani, D. Schurig, and G. Lazzi, "Improving power transfer efficiency in bio-telemetry systems using negative permeability metamaterials," presented at 15th International Conference on Electromagnetics in Advanced Applications, Turin, Italy, 2013.
22. W. Xu, D. Shrekenhamer, S. Venkatesh, D. Schurig, S. Sonkusale, and W. Padilla, "Metamaterial inspired microwave focal plane array," presented at Metamaterials '2011 The Fifth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics, Barcelona, Spain, 2011.
23. *(Invited)* D. Schurig, "An aberration-free lens with zero F-number," presented at OSA Topical Meeting: Imaging Systems, Tucson, AZ, 2010.
24. *(Invited)* D. Schurig and D. R. Smith, "Transformation Design for Imaging and Communications," presented at META 2008 International Workshop on Metamaterials, Nanjing, China, 2008.
25. *(Invited)* D. Schurig, J. Pendry, D. R. Smith, S. Cummer, J. J. Mock, B. J. Justice, and A. Starr, "Ideal Invisibility?," presented at Idea City, Toronto, Canada, 2007.
26. C. G. Parazzoli, R. B. Greegor, M. H. Tanielian, D. R. Smith, S. Cummer, D. Schurig, and R. Ziolkowski, "Applications of metamaterials in the GHz frequency domain," presented at IEEE Antennas and Propagation Society International Symposium, Honolulu, HI, 2007.
27. *(Invited)* D. Schurig, J. J. Mock, D. R. Smith, J. Pendry, and T. F. Starr, "Electric Metamaterials," presented at Progress In Electromagnetics Research Symposium, Boston, MA, 2006.

28. (*Invited*) D. Schurig, "Transformation optics and metamaterials, a path to interesting devices," presented at Sixth Red Raider Minisymposium on Mathematical Modeling of Novel Materials and Devices, Texas Tech University, Lubbock, 2006.
29. (*Opening talk*) D. Schurig, "Transformation optics and metamaterials, a path to interesting devices," presented at Young Scientist Meeting on Metamaterials, Universidad de Sevilla, 2006.
30. T. Driscoll, D. N. Basov, P. M. Rye, S. Nemat-Nasser, D. Schurig, and D. R. Smith, "Free space microwave focusing by a negative-index gradient lens," presented at SPIE Complex Photonic Media, San Diego, CA, 2006.
31. (*Invited*) D. R. Smith and D. Schurig, "New optics using negative refraction," presented at OSA Topical Meeting on Information Photonics, Charlotte, NC, 2005.
32. D. Schurig and D. R. Smith, "Negative Index Aberrations," presented at PECS-VI International Symposium on Photonic & Electromagnetic Crystal Structures, Crete, Greece, 2005.
33. (*Invited*) D. Schurig and D. R. Smith, "Negative Index Lenses," presented at SPIE International Congress on Optics and Optoelectronics, Warsaw University of Technology, Poland, 2005.
34. D. Schurig and D. R. Smith, "Negative index lens aberrations," presented at APS March Meeting, Los Angeles, CA, 2005.
35. M. C. Martin, H. Zhao, A. Liddle, E. H. Anderson, W. J. Padilla, D. Schurig, and D. R. Smith, "Fabrication and optical measurements of nanoscale meta-materials: Terahertz and beyond," presented at 30th International Conference on Infrared and Millimeter Waves and 13th International Conference on Terahertz Electronics, Williamsburg, VA, 2005.
36. Z. Hao, M. C. Martin, A. Liddle, E. H. Anderson, W. Padilla, D. Schurig, and D. R. Smith, "Fabrication and Optical Measurements of Nanoscale Meta-Materials: Terahertz and Beyond," presented at APS March Meeting, Los Angeles, CA, 2005.
37. J. Gollub, D. R. Smith, D. C. Vier, T. Perram, J. J. Mock, and D. Schurig, "Experimental characterization of magnetic surface plasmons " presented at APS March Meeting, Los Angeles, CA, 2005.
38. (*Invited*) D. Schurig and D. R. Smith, ""Focusing" Evanescent Waves with Indefinite Media," presented at Progress In Electromagnetics Research Symposium, Honolulu, HI, 2003.
39. (*Invited*) D. Schurig and D. R. Smith, "Spatial Filtering Using Media with Indefinite Permittivity and Permeability Tensors," presented at Progress In Electromagnetics Research Symposium, Honolulu, HI, 2003.
40. S. Schultz, D. Vier, D. Schurig, S. Oseroff, and R. Ramesh, "FMR, magnetization, and magneto-resistant measurements of La<sub>2/3</sub>Ca<sub>1/3</sub>MnO<sub>3</sub> laser ablated films," presented at APS March Meeting, St. Louis, Missouri, 1996.

## **SEMINARS, WORKSHOPS, PANELS**

1. R. G. Edwards, "Additive-Manufactured, Highly-Conductive Metasurfaces for Microwave Waveguide Components," Presenting at 2024 IEEE International Microwave Filter Workshop, 2024.
2. D. Schurig, "Metasurface Design for Near Field Radiative Heat Transfer," presented at Electrical and Computer Engineering Graduate Seminar, University of Utah, 2020.
3. (*Invited*) D. Schurig, R. Edwards, A. Orange, "A New Architecture for Massive MIMO Base Stations," presented at L3-Harris lunch seminar, Salt Lake City, Utah, 2019.
4. D. Schurig, "Antenna Design I," presented at POWDER Mobile Wireless Week, Salt Lake City, Utah, 2019.
5. D. Schurig, "Antenna Hands On," presented at POWDER Mobile Wireless Week, Salt Lake City, Utah, 2019.



6. *(Invited)* D. Schurig, "What I talk about when I talk about metamaterials: invisibility, space warps, lenses..." presented at MPQ Laboratory retreat, Sologne, France, 2019.
7. *(Invited)* J. Breen, A. Buffmire, J. Duerig, K. Dutt, E. Eide, M. Hibler, D. Johnson, S. K. Kasera, E. Lewis, and D. Maas, "Panel: Experimentation Meets Platforms: A Survey of macro trends in mobile communication research and its impact on future testbed development," presented at InfoComm2019, Paris, France, 2019.
8. *(Invited)* D. Schurig, "Antenna Research: Reconfigurable and User-Supplied Designs," presented at POWDER Workshop at IEEE International Conference on Communications, Kansas City, MO, 2018.
9. *(Invited)* D. Schurig, "From Metamaterials to Massive MIMO: Patterned Media in Electromagnetics, or There and Back Again.," presented at CETHIL Lab Seminar, INSA Lyon, 2018.
10. *(Invited)* D. Schurig, S. Venkatesh, A. Orange, N. Viswanathan, and S. Srinivas, "Transformation Design in Electromagnetics," presented at Electrical and Computer Engineering Graduate Seminar, University of Utah, 2013.
11. *(Invited)* D. Schurig, "Transformation Design and Simulation: EM Resizer," presented at ANSYS Metamaterials Seminar, UC Irvine, 2013.
12. *(Invited)* D. Schurig, S. Venkatesh, A. Orange, N. Viswanathan, M. Pate, and S. Srinivas, "Transformation Design and Metamaterials: Part 1138," presented at Electrical and Computer Engineering Graduate Seminar, University of Utah, 2012.
13. *(Invited)* D. Schurig, "Materials in the Meta-age," presented at Intelligence Community Postdoctoral Research Fellowship Colloquium, McLean, VA, 2011.
14. *(Invited)* D. Schurig, "Designing Lenses, Antennas and Invisibility Cloaks with Space Warps," presented at Electrical and Computer Engineering Graduate Seminar, University of Utah, 2010.
15. *(Invited)* D. Schurig, "Practical Limitations of Hyper-Lenses," presented at International Workshop on Electromagnetic Metamaterials III: Toward Real World Applications, Los Alamos National Laboratory, 2009.
16. *(Invited)* D. Schurig, "The transformation design method and metamaterials: tools to realize invisibility cloaks and other interesting devices.," presented at OSA Section Meeting, Rochester, NY, 2008.
17. *(Invited)* D. Schurig, "Transformation design and metamaterials: tools for conceiving and realizing unique devices.," presented at Department of Electrical and Computer Engineering Seminar, Boston University, 2008.
18. *(Invited)* D. Schurig, "Transformation design and metamaterials: tools for conceiving and realizing unique devices.," presented at Physics Department Colloquium, Boston College, 2008.
19. *(Invited)* D. Schurig, "Transformation Design and Metamaterials," presented at Advanced Technologies for Audio Collection and Transmission (ATACT) Workshop, Tyson's Corner, VA, 2008.
20. *(Invited)* D. Schurig, "The transformation design method and metamaterials: tools to realize invisibility and other interesting effects," presented at Physics Department Seminar, University of California, Berkeley, 2007.
21. *(Invited)* D. Schurig, "The transformation design method and metamaterials: tools to realize invisibility and other interesting effects," presented at Nanocenter Colloquium, University of South Carolina, Columbia, 2007.
22. *(Invited)* D. Schurig, "The transformation design method and metamaterials: tools to realize invisibility and other interesting effects," presented at Physics Department Colloquium, Washington State University, Pullman, 2007.
23. *(Invited)* D. Schurig, "The transformation design method and metamaterials: tools to realize invisibility and other interesting effects," presented at Electrical and Computer Engineering Department Seminar, University of North Carolina, Charlotte, 2007.

24. *(Invited)* D. Schurig, "The transformation design method and metamaterials: tools to realize invisibility and other interesting effects," presented at Electrical and Computer Engineering Department Seminar, Virginia Polytechnic Institute and State University, 2007.
25. *(Invited)* D. Schurig, "The transformation design method and metamaterials: tools to realize invisibility and other interesting effects," presented at Physics Department Colloquium, University of California, Davis, 2007.
26. *(Invited)* D. Schurig, "The transformation design method and metamaterials: tools to realize invisibility cloaks and other interesting devices," presented at Viterbi School of Engineering Seminar, University of Southern California, 2007.
27. *(Invited)* D. Schurig, "The transformation design method and metamaterials: tools to realize invisibility and other interesting effects," presented at Laboratory of Atomic and Solid State Physics Seminar, Cornell University, 2007.
28. *(Invited)* D. Schurig, "The transformation design method and metamaterials: tools to realize invisibility cloaks and other interesting devices," presented at Mixed Signal, RF and Microwave Seminar, California Institute of Technology, 2007.
29. *(Invited)* D. Schurig, "Transformation Design and Metamaterials," presented at International Workshop on Electromagnetic Metamaterials II: Gradient Lenses to Invisibility Cloaks, Los Alamos National Laboratory, 2007.
30. *(Invited)* D. Schurig, "The Transformation Design Method and Metamaterials: Tools to Realize Invisibility and Other Interesting Effects," presented at Fermi National Accelerator Laboratory, Batavia, IL, 2007.
31. *(Invited)* D. Schurig, "A New Electric Metamaterial and Two Applications Areas," presented at International Workshop on Electromagnetic Metamaterials I: Phenomenology and Applications, Los Alamos National Laboratory, 2006.
32. D. R. Smith and D. Schurig, "New Optics Using Negative Refraction," presented at Information Photonics, 2005.
33. Z. Hao, A. Liddle, W. J. Padilla, and D. Schurig, "Fabrication and Optical Measurements of Nanoscale Meta-Materials: Terahertz and Beyond," presented at APS March Meeting, 2005.
34. *(Invited)* D. Schurig, "When Refraction is Negative," presented at Physics Department Colloquium, California State University, Los Angeles, 2004.
35. *(Invited)* D. Schurig, "Spatial filtering using media with indefinite permittivity and permeability tensors" presented at DARPA Negative Index Metamaterials Workshop, Arlington, VA, 2003.
36. *(Invited)* D. Schurig, "When Refraction is Negative," presented at Physics Department Seminar, California State University, Long Beach, 2003.
37. S. Schultz, D. Vier, D. Schurig, S. Oseroff, and R. Ramesh, "FMR, magnetization, and magneto-resistant measurements of  $\text{La}_{2/3}\text{Ca}_{1/3}\text{MnO}_3$  laser ablated films," presented at APS March Meeting, 1996.

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Google Scholar patent citations: 830

1. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, E. K. Jung, J. T. Kare, N. P. Myhrvold, D. Schurig, C. T. Tegreene, T. A. Weaver, and C. Whitmer, "Systems and methods for selective sensing and selective thermal heating using nanostructures," US Patent 10,785,832, 2020.
2. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, E. K. Jung, J. T. Kare, N. P. Myhrvold, J. B. Pendry, D. Schurig, C. T. Tegreene, and T. A. Weaver, "Nanostructure sensors and sensing systems," US Patent 10,520,373, 2019.

3. J. A. Bowers, W. D. Duncan, R. A. Hyde, J. T. Kare, N. Kundtz, R. Liu, B. M. McWilliams, J. B. Pendry, D. A. Roberts, and D. Schurig, "Method and system for pumping of an optical resonator," US Patent 10,199,793, 2019.
4. **J. Pendry, D. Smith, and D. Schurig, "Electromagnetic cloaking method," US Patent 9,677,856, 2017. Cited 81 times.**
5. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, M. Y. Ishikawa, E. K. Jung, J. T. Kare, N. P. Myhrvold, J. B. Pendry, D. Schurig, and C. T. Tegreene, "Casimir effect memory cell," US Patent 9,691,500, 2017.
6. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, E. K. Jung, J. T. Kare, N. P. Myhrvold, D. Schurig, C. T. Tegreene, T. A. Weaver, and C. Whitmer, "Systems and methods of sensing and/or heating using nanostructures," US Patent App. 14/530,219, 2016.
7. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, E. K. Jung, J. T. Kare, N. P. Myhrvold, J. B. Pendry, D. Schurig, C. T. Tegreene, and C. Whitmer, "Customized user options for optical device," US Patent 8,934,166, 2015.
8. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, E. K. Jung, J. T. Kare, N. P. Myhrvold, J. B. Pendry, D. Schurig, C. T. Tegreene, and C. Whitmer, "Adjustable optics for ongoing viewing correction," US Patent 9,046,683, 2015.
9. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, E. K. Jung, J. T. Kare, N. P. Myhrvold, J. B. Pendry, D. Schurig, C. T. Tegreene, and C. Whitmer, "Optical device with interchangeable corrective elements," US Patent 9,033,497, 2015.
10. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, E. K. Jung, J. T. Kare, N. P. Myhrvold, J. B. Pendry, D. Schurig, C. T. Tegreene, and C. Whitmer, "Optical device with active user-based aberration correction," US Patent 9,004,683, 2015.
11. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, E. K. Jung, J. T. Kare, N. P. Myhrvold, J. B. Pendry, D. Schurig, C. T. Tegreene, and C. Whitmer, "Corrective alignment optics for optical device," US Patent 9,052,502, 2015.
12. J. A. Bowers, R. A. Hyde, J. T. Kare, N. Kundtz, B. M. McWilliams, J. B. Pendry, D. Schurig, D. R. Smith, A. F. Starr, and C. T. Tegreene, "Metamaterial surfaces," US Patent 9,099,786, 2015.
13. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Evanescent electromagnetic wave conversion lenses III," US Patent 9,083,082, 2015.
14. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Evanescent electromagnetic wave conversion lenses I," US Patent 9,081,202, 2015.
15. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Evanescent electromagnetic wave conversion lenses II," US Patent 9,081,123, 2015.
16. R. Marco, D. R. Smith, and D. A. Schurig, "Finite-embedded coordinate designed transformation-optical devices," US Patent 8,837,031, 2014.
17. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, M. Y. Ishikawa, E. K. Jung, J. T. Kare, N. P. Myhrvold, T. J. Nugent, J. B. Pendry, and D. Schurig, "Optical and metamaterial devices based on reactive composite materials," US Patent 8,871,121, 2014.
18. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Evanescent electromagnetic wave conversion apparatus I," US Patent 8,634,141, 2014.
19. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Evanescent electromagnetic wave conversion apparatus II," US Patent 8,634,142, 2014.

20. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Evanescent electromagnetic wave conversion apparatus III," US Patent 8,634,140, 2014.
21. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Evanescent electromagnetic wave conversion methods III," US Patent 8,630,044, 2014.
22. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Focusing and sensing apparatus, methods, and systems," US Patent 8,705,183, 2014.
23. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Evanescent electromagnetic wave conversion methods II," US Patent 8,634,143, 2014.
24. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Evanescent electromagnetic wave conversion methods I," US Patent 8,634,144, 2014.
25. K. G. Caldeira, P. L. Hagelstein, R. A. Hyde, E. K. Jung, J. T. Kare, N. P. Myhrvold, J. B. Pendry, D. Schurig, C. T. Tegreene, and C. Whitmer, "Fabrication technique for replaceable optical corrective elements," US Patent App. 13/385,688, 2013.
26. R. A. Hyde, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, and T. A. Weaver, "Rolled resonant element," US Patent 8,299,874, 2012.
27. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Emitting and negatively-refractive focusing apparatus, methods, and systems," US Patent 7,869,131, 2011.
28. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Emitting and focusing apparatus, methods, and systems," US Patent 7,872,812, 2011.
29. J. A. Bowers, R. A. Hyde, E. K. Jung, J. B. Pendry, D. Schurig, D. R. Smith, C. T. Tegreene, T. A. Weaver, C. Whitmer, and L. L. Wood, "Negatively-refractive focusing and sensing apparatus, methods, and systems," US Patent 7,777,962, 2010.
- 30. D. R. Smith, D. Schurig, A. F. Starr, J. J. Mock, and The Regents of the University of California, "Metamaterials," US Patent 7,538,946, 2009. Cited 307 times.**
- 31. D. R. Smith and D. Schurig, "Indefinite materials," US Patent 7,522,124, 2009. Cited 161 times.**
32. J. B. Pendry, D. Schurig, and D. R. Smith, "Electromagnetic compression apparatus, methods, and systems," US Patent 7,629,941, 2009.
33. R. E. Sarwinski, R. C. Reineman, S. J. D. Gott, D. A. Schurig, and D. N. Paulson, "Self-adjusting assembly and method for close tolerance spacing," US Patent App. 10/228,694, 2004.

## GRANTS

(award k\$/Schurig share k\$)

2018 - 2023

PAWR Platform POWDER-RENEW: A Platform for Open Wireless Data-driven Experimental Research with Massive MIMO Capabilities  
National Science Foundation  
(15476/~1000)

2016 - 2021

SCH: INT: Reducing Traumatic Brain Injury Risk with Impact Compensation  
National Science Foundation  
(1811/252)

2016 - 2017

Multi-Functional RF System  
University of Utah Research Foundation  
PI: Schurig  
(35/35)

2013 - 2015

DHS MetaImager Project: Program Acceleration  
Duke University, Prime: Department of Homeland Security  
PI: Schurig  
(400/400)

2010 - 2012

Intelligence Community Young Investigator Award  
Office of the Director of National Intelligence  
PI: Schurig  
(200/200)

2009 - 2010

Meta-materials Gradient Index Lenses for GHz Imaging  
Central Intelligence Agency  
PI: Schurig  
PI: Willie Padilla, Boston College  
(500/250)

2009 - 2010

Quasi-conformal Transformation Optics for Novel Electromagnetic Control Using...  
Sensor Metrix, Prime: Central Intelligence Agency  
PI: Schurig  
PI: David Smith, co-PI: Nan Jokerst, Duke University  
PI: Anthony Starr, SensorMetrix, San Diego, CA  
(482/125)

2009 - 2014

MURI: Transformation Optical Metamaterials  
Duke University, Prime: Army Research Office  
PI (Coordinator): David Smith, co-PI: Steve Cummer, co-PI Nan Jokerst, Duke University  
PI: Vladimir Shalaev, co-PI: Evgenia Narimonov, co-PI: Alexandra Boltasseva, Purdue University  
PI: Xiang Zhang, UC Berkeley  
PI: Schurig  
Consultant: John Pendry, Imperial College, London  
(2,166/243)

2008 - 2011

Exploring the Limits of Energy Scavenging - from Microwave to Nanoscale  
National Science Foundation  
PI: Robert Trew  
co-PI: Ki Wook Kim  
co-PI: Schurig  
(328/40)