Morgan W. Mitchell

CONTACT INFORMATION

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CITIZENSHIP

USA

EXPERTISE

Experimental quantum optics, atomic physics, quantum technology, foundations of physics.

EDUCATION

Ph.D. in Physics. **University of California at Berkeley** **June 1999**

Dynamics of photon-photon scattering in rubidium vapor. Advisor: R. Y. Chiao

M.A. in Physics, **University of California at Berkeley** **June 1993**

B.A. in Physics with High Honors. **Swarthmore College** **May 1990**

RESEARCH EXPERIENCE

ICFO - The Institute of Photonic Sciences, Castelldefels (Barcelona), Spain

ICREA Professor at ICFO - Quantum Optics **Oct 2011 to present**

Group Leader - Atomic Quantum Optics **July 2004 to Oct 2011**

Group of Aephraim Steinberg, University of Toronto

Research Associate **July 2002 – June 2004**

Group of Serge Haroche (Nobel 2012), Laboratoire Kastler-Brossel, ENS

Post-doctoral researcher **July 1999 – June 2000**

TEACHING EXPERIENCE

ICFO, Barcelona, Spain

Professor of Quantum Optics **July 2004 – present**

- Master and Ph.D. courses on theoretical and experimental quantum optics.
- Supervision of 16 Ph.D. theses, 6 Master theses, 14 summer undergraduates. Graduates to Oxford, Cambridge, Princeton, Stockholm, Berlin.

Reed College, Portland, Oregon

Visiting Assistant Professor **July 2000 – June 2002**

- Undergraduate teaching and curriculum development. Developed Bell test experiments for undergraduates.

MAIN RESEARCH AREAS

Atomic Quantum Sensing : Measurement sensitivity beyond the traditional quantum limits. Non-linear quantum measurements, spin squeezing, quantum metrology with nonlinear and atomic instruments.

Quantum randomness and local realism : Metrological approach to quantum randomness, including rigorous methods for quantum randomness quantification, use in loophole-free Bell tests, Bell test methodology.

Extreme entanglement generation : Entanglement generation in macroscopic atomic spin ensembles and bright non-classical photon beams. Applications to quantum simulation of quantum many-body systems.

Publication summary

As of December 2019, 107 refereed publications, including 5 Nature, 22 Physical Review Letters, 1 Physical Review X, 2 Nature Photonics, 1 Nature Communications, 1 Optica, 2 Applied Physics Letters, 1 Reviews of Modern Physics, 1 Reports in Progress in Physics, 9 New Journal of Physics, 11 Optics Express, 7 Optics Letters, 24 Physical Review A. "h-index" 37 (Scopus), 42 (Google). Citations in 2017: 798 (Scopus) 1376 (Google).

Selected high-visibility publications

[1] The BIG Bell Test Consortium. Challenging local realism with human choices. *Nature*, **557**, 212 (2018)

[2] G. Colangelo, F. M. Ciurana, L. C. Bianchet, R. J. Sewell, and **M. W. Mitchell**. Simultaneous tracking of spin angle and amplitude beyond classical limits. *Nature*, **543**, 525 (2017)

[3] M. Napolitano, M. Koschorreck, B. Dubost, N. Behbood, R. J. Sewell, and **M. W. Mitchell**. Interaction-based quantum metrology showing scaling beyond the Heisenberg limit. *Nature*, **471**, 486 (2011)

[4] **M. W. Mitchell**, J. S. Lundeen, and A. M. Steinberg. Super-resolving phase measurements with a multiphoton entangled state. *Nature*, **429**, 161 (2004)

[5] B. Hensen, et al. Loophole-free Bell inequality violation using electron spins separated by 1.3 kilometres. *Nature*, **526**, 682 (2015)

[6] M. Giustina, et al. Significant-loophole-free test of Bell's theorem with entangled photons. *Phys. Rev. Lett.*, **115**, 250401 (2015)

[7] L. K. Shalm, et al. Strong loophole-free test of local realism. *Phys. Rev. Lett.*, **115**, 250402 (2015)

[8] C. Abellán, W. Amaya, D. Mitrani, V. Pruneri, and **M. W. Mitchell**. Generation of fresh and pure random numbers for loophole-free Bell tests. *Phys. Rev. Lett.*, **115**, 250403 (2015)

[9] R. J. Sewell, M. Koschorreck, M. Napolitano, B. Dubost, N. Behbood, and **M. W. Mitchell**. Magnetic sensitivity beyond the projection noise limit by spin squeezing. *Phys. Rev. Lett.*, **109**, 253605 (2012)

[10] M. Koschorreck, M. Napolitano, B. Dubost, and **M. W. Mitchell**. Sub-projection-noise sensitivity in broadband atomic magnetometry. *Phys. Rev. Lett.*, **104**, 093602 (2010)

Selected invited talks

Institut d'Optique 2010, ICOLS 2011, DAMOP 2011, NIST Boulder 2011, MPQ 2011, Stuttgart 2011, Niels Bohr Institute 2011 & 2012, ICAP 2012, QCMC 2012, Royal Society 2012, Innsbruck 2012, Cambridge 2012, Toronto 2012, Stanford 2012, Arizona 2012, Heidelberg 2012, Quantum Optics 2012, IQIS 2013, ECAMP 2013, Vienna 2013, NIST Gaithersburg 2013, IQOQI 2014, Quantum Optics 2014, Buenos Aires 2014, Geneva 2015, QuantumRandom 2015, Heraeus 2015 & 2016, YQI 2016, SQUINT 2016, RAQM 2016, La Sapienza 2016, Quantum Optics 2016, INRIM 2017, BQIT 2017, Photonics Ireland 2017, ICQT 2017, QCrypt 2017, Institut d'Optique 2017, IQEC 2018, Harvard & MIT 2018, Singapore 2018, Heidelberg 2018, Quantum Optics IX 2018, Quantum Sensing and Magnetometry 2019, Quantum Metrology and Physics Beyond the Standard Model 2019, Quantum 2019, CLEO 2019, CQM 2019, IFCS-EFTF 2019.

Research leadership

In 2016, I initiated the BIG Bell Test Collaboration to perform tests of local realism using human input. I recruited leading quantum optics groups from Europe (A. Acín, H. de Riedmatten, F. Sciarrino, S. Tanzilli, A. Wallraff, H. Weinfurter, A. Zeilinger), from Asia/Australia (J.-W. Pan, G. Pryde, A. White), and from the Americas (M. Larotonda, S.-W. Nam, G. Xavier). In 2016 the project generated $>$ 200 print and online media articles, attracted $>$ 100,000 citizen participants, performed 13 experiments on five continents, and closed for the first time the "freedom-of-choice" loophole (see [1] above).

Leader of randomness generation for loophole-free Bell tests: 1) groups of Ronald Hanson, Stephanie Wehner and Tim Taminiau, TU Delft, Netherlands [26]. 2) group of Anton Zeilinger, IQOQI Vienna, Austria [24]. 3) group of Sae Woo Nam, NIST Boulder, USA [23]. 4) device-independent protocols in the NIST Randomness Beacon programme.

Workpackage leader micro-fabricated optically pumped magnetometers for Quantum Technologies Flagship project MACQSIMAL.

Group leader, Cavity-Enhanced Quantum Optical Clocks, (QuantERA project), Ultra-stable optical oscillators from quantum coherent and entangled systems

Competitive funding

Quantum Technologies Flagship MACQSIMAL	560 k€
FET Launchpad UVALITH	150 k€
EMPIR USOQS	50 k€
QuantERA QClocks	150 k€
ERC Proof-of-Concept Grant, ERIDIAN	150 k€
ERC Proof-of-Concept Grant, MAMBO	150 k€
ERC Starting Grant, "Atomic Quantum Metrology"	1400 k€
EC Horizon 2020, "Quantum Simulation of Insulators and Conductors"	400 k€
Marie Curie Fellowships	1200 k€
Severo Ochoa Excellence programme	300 k€
Spanish national funding (Consolider Ingenio + others)	1300 k€
European Space Agency	100 k€
Private Foundations	800 k€

Professional Service

US NSF Quantum Leap Challenge Institutes Expert Evaluator 2020

ERC Advanced Grant Evaluation Panel 2019–20

Local organizing committee, ICAP Barcelona 2014–18

CLEO/QELS Programme committees "Q. Science, Engineering and Technology" 2010–11 "Fundamental Science 1: Q. Optics of Atoms, Molecules and Solids" 2012–14

Organizer, OSA symposium on Quantum Simulators, 2013

Organizer, Conference "Engineering, Manipulation and Characterization of Quantum States of Matter and Light," Barcelona 2010.

Editorial Advisory Board *Quantum Measurements and Quantum Metrology* (Journal).

Referee for Nature, Science, Nature Physics, Nature Photonics, Nature Communications, PNAS, Physical Review Letters, Optics Express, Optics Letters, New Journal of Physics, Physical Review A, Journal of Physics B, American Journal of Physics.

Expert Referee for ERC Starting, Consolidator and Advanced Grants, Spanish ANEP, French ONR, Austrian FWF, Australian ARC, Canadian NSERC, US NSF.

Ph.D. thesis committees for Niels Bohr Institute, Institut d'Optique, LENS, ICFO, Autonomous University of Barcelona, Autonomous University of Madrid, Aarhus University, École Normale Supérieure.

Patents

"Ultrafast quantum random number generation process and system therefore," Swiss 01283/12 & US 13/566,500
"Process for quantum random number generation in a multimode laser cavity," US 14/923,495
"Monolithic Frequency Converter," European EP16382440, US 15/711,453

Companies founded

QuSide Technologies S.L. Quantum randomness generation and optical quantum technologies. Incorporated 2017.

Popular articles

[1] R. J. Sewell and **M. W. Mitchell**. Collaboration and precision in quantum measurement. *Physics Today*, **64**, 72 (2011)

[2] M. Napolitano, M. Koschorreck, B. Dubost, N. Behbood, R. Sewell, and M. Mitchell.

Quantum optics and the "Heisenberg limit" of measurement. *Opt. Photon. News*, **22**, 40 (2011)

[3] R. J. Sewell and **M. W. Mitchell**. コラボで上がる測定精度. *Parity (Japanese Physics Magazine)*, **27**, 50 (2012)

[4] C. Abellán, W. Amaya, and **M. W. Mitchell**. Un test de Bell sin escapatorias. *Investigación y Ciencia (Spanish edition of Scientific American)*, **472**, 10 (2016)

Press coverage

Redes (Spanish television) 2005, La Vanguardia 20 February 2012 & 4 March, 2012, El Pais 25 March, 2011, Physics World 24 March, 2011, QueQuiCom (Catalan television) 2014 Horizon Magazine 2014, Scientific American 2014, Le Scienze 2014 Science News 2015 Muy Interesante 2015, Phys.org 2015, FQXi 2015, Physics World 2015, Le Monde 2015, New Scientist 2015, Nature 2015, Science 2015, Forbes 2015, New York Times 2015 Neue Zuricher Zeitung 2016 El Pais 2016 La Repubblica 2016 PBS Newshour 2016 Il Sole 24 Ore 2016 El Mundo 2016 Sverige Radio 2016 Tele Basel 2016 Nature News 2017 El Periodico 2017 La Vanguardia 2017 APS Physics Central 2017 Chemistry World 2017 Scientific American 2017 CORDIS 2017 El Pais 2018 Wired 2018 MIT Technology Review 2018 The New Yorker 2018

Awards and recognition

Best publication at Kavli Institute of Nanoscience Delft	2016
Paul Ehrenfest Best Paper Award for Quantum Foundations	2016
Nature (journal) "Editor's Choice" (first position)	2015
Science (journal) "Breakthrough of the year" top ten	2015
Optics and Photonics News "Optics in 2015"	2015
Vanguardia de la Ciencia (top research result in any field in Spain, first runner-up)	2012
European Research Council Starting Grant	2011
Optics and Photonics News "Year in Review"	2011
Laser Focus World Commendation for Excellence in Technical Communications	2007
Consolider Ingenio 2010	2005
Physics World "Highlights of the year"	2004
National Science Foundation Fellowship	1991-1994
Hertz Foundation Fellowship (declined)	1990
Phi Beta Kappa	1990

Languages

English (native), Spanish, Italian, French, Catalan

Publications

Books

[1] A. Predojević and **M. W. Mitchell**. *Engineering the Atom-Photon Interaction: Controlling Fundamental Processes with Photons, Atoms and Solids*. Nano-Optics and Nanophotonics. Springer International Publishing, 2015.

Book chapters

[1] **M. W. Mitchell**. Generation, characterization and use of atom-resonant indistinguishable photon pairs. In A. Predojević and **M. W. Mitchell**, editors, *Engineering the Atom-Photon Interaction: Controlling Fundamental Processes with Photons, Atoms and Solids*, Nano-Optics and Nanophotonics. Springer International Publishing, 2015.

Peer-reviewed journal articles

[1] Y. Liu, et al. Experimental measurement-dependent local Bell test with human free will. *Phys. Rev. A*, **99**, 022115 (2019)

[2] M. Rudé, C. Abellán, A. Capdevila, D. Domenech, **M. W. Mitchell**, W. Amaya, and V. Pruneri. Interferometric photodetection in silicon photonics for phase diffusion quantum entropy sources. *Optics Express*, **26**, 31957 (2018)

[3] R. Jiménez-Martínez, J. Kołodyński, C. Troullinou, V. G. Lucivero, J. Kong, and **M. W. Mitchell**. Signal tracking beyond the time resolution of an atomic sensor by Kalman filtering. *Phys. Rev. Lett.*, **120**, 040503 (2018)

[4] D. Braun, G. Adesso, F. Benatti, R. Floreanini, U. Marzolino, **M. W. Mitchell**, and S. Pirandola. Quantum-enhanced measurements without entanglement. *Rev. Mod. Phys.*, **90**, 035006 (2018)

[5] C. Abellán, et al. Challenging local realism with human choices. *Nature*, **557**, 212 (2018)

[6] S. Palacios, S. Coop, P. Gomez, T. Vanderbruggen, Y. N. M. de Escobar, M. Jasperse, and **M. W. Mitchell**. Multi-second magnetic coherence in a single domain spinor Bose-Einstein condensate. *New J. Phys.*, (2018)

[7] J. A. Zielińska and **M. W. Mitchell**. Atom-resonant squeezed light from a tunable monolithic pprktp parametric amplifier. *Opt. Lett.*, **43**, 643 (2018)

[8] G. Vitagliano, G. Colangelo, F. Martin Ciurana, **M. W. Mitchell**, R. J. Sewell, and G. Tóth. Entanglement and extreme planar spin squeezing. *Phys. Rev. A*, **97**, 020301 (2018)

[9] M. N. Bera, A. Acín, M. Kuś, **M. W. Mitchell**, and M. Lewenstein. Randomness in quantum mechanics: philosophy, physics and technology. *Reports on Progress in Physics*, **80**, 124001 (2017)

[10] S. Coop, S. Palacios, P. Gomez, Y. N. M. de Escobar, T. Vanderbruggen, and **M. W. Mitchell**. Floquet theory for atomic light-shift engineering with near-resonant polychromatic fields. *Optics Express*, **25**, 32550 (2017)

[11] F. Martin Ciurana, G. Colangelo, L. Slodička, R. J. Sewell, and **M. W. Mitchell**. Entanglement-enhanced radio-frequency field detection and waveform sensing. *Phys. Rev. Lett.*, **119**, 043603 (2017)

[12] G. Colangelo, F. Martin Ciurana, G. Puentes, **M. W. Mitchell**, and R. J. Sewell. Entanglement-enhanced phase estimation without prior phase information. *Phys. Rev. Lett.*, **118**, 233603 (2017)

[13] G. Colangelo, F. M. Ciurana, L. C. Bianchet, R. J. Sewell, and **M. W. Mitchell**. Simultaneous tracking of spin angle and amplitude beyond classical limits. *Nature*, **543**, 525 (2017)

[14] J. A. Zielińska and **M. W. Mitchell**. Self-tuning optical resonator. *Optics Letters*, **42**, 5298 (2017)

[15] V. G. Lucivero, A. Dimic, J. Kong, R. Jiménez-Martínez, and **M. W. Mitchell**. Sensitivity, quantum limits, and quantum enhancement of noise spectroscopies. *Phys. Rev. A*, **95**, 041803 (2017)

[16] J. A. Zielińska, A. Zukauskas, C. Canalias, M. A. Noyan, and **M. W. Mitchell**. Fully-resonant, tunable, monolithic frequency conversion as a coherent UVA source. *Optics Express*, **25**, 1142 (2017)

[17] **M. W. Mitchell**. Number-unconstrained quantum sensing. *Quantum Science and Technology*, **2**, 044005 (2017)

[18] C. Abellan, W. Amaya, D. Domenech, P. Muñoz, J. Capmany, S. Longhi, **M. W. Mitchell**, and V. Pruneri. Quantum entropy source on an InP photonic integrated circuit for random number generation. *Optica*, **3**, 989 (2016)

[19] F. M. Ciurana, G. Colangelo, R. J. Sewell, and **M. W. Mitchell**. Real-time shot-noise-limited differential photodetection for atomic quantum control. *Opt. Lett.*, **41**, 2946 (2016)

[20] V. G. Lucivero, R. Jiménez-Martínez, J. Kong, and **M. W. Mitchell**. Squeezed-light spin noise spectroscopy. *Phys. Rev. A*, **93**, 053802 (2016)

[21] J. Kofler, M. Giustina, J.-A. Larsson, and **M. W. Mitchell**. Requirements for a loophole-free photonic Bell test using imperfect setting generators. *Phys. Rev. A*, **93**, 032115 (2016)

[22] C. Abellán, W. Amaya, D. Mitrani, V. Pruneri, and **M. W. Mitchell**. Generation of fresh and pure random numbers for loophole-free Bell tests. *Phys. Rev. Lett.*, **115**, 250403 (2015)

[23] L. K. Shalm, et al. Strong loophole-free test of local realism. *Phys. Rev. Lett.*, **115**, 250402 (2015)

[24] M. Giustina, et al. Significant-loophole-free test of Bell's theorem with entangled photons. *Phys. Rev. Lett.*, **115**, 250401 (2015)

[25] C. Budroni, G. Vitagliano, G. Colangelo, R. J. Sewell, O. Gühne, G. Tóth, and **M. W. Mitchell**. Quantum nondemolition measurement enables macroscopic Leggett-Garg tests. *Phys. Rev. Lett.*, **115**, 200403 (2015)

[26] B. Hensen, et al. Loophole-free Bell inequality violation using electron spins separated by 1.3 kilometres. *Nature*, **526**, 682 (2015)

[27] T. Vanderbruggen, S. P. Álvarez, S. Coop, N. M. de Escobar, and **M. W. Mitchell**. Spontaneous PT symmetry breaking of a ferromagnetic superfluid in a gradient field. *Europhys Lett*, **111**, 66001 (2015)

[28] Y. N. M. de Escobar, S. P. Álvarez, S. Coop, T. Vanderbruggen, K. T. Kaczmarek, and **M. W. Mitchell**. Absolute frequency references at 1529 and 1560 nm using modulation transfer spectroscopy. *Opt. Lett.*, **40**, 4731 (2015)

[29] J. Kong, V. G. Lucivero, R. Jiménez-Martínez, Ricardo, and **M. W. Mitchell**. Long-term laser frequency stabilization using fiber interferometers. *Rev. Sci. Instrum.*, **86**, 073104 (2015)

[30] M. Curty, M. Jofre, V. Pruneri, and **M. W. Mitchell**. Passive decoy-state quantum key distribution with coherent light. *Entropy*, **17**, 4064 (2015)

[31] F. A. Beduini, J. A. Zielińska, V. G. Lucivero, Y. A. de Icaza Astiz, and **M. W. Mitchell**. Macroscopic quantum state analyzed particle by particle. *Phys. Rev. Lett.*, **114**, 120402 (2015)

[32] **M. W. Mitchell**, C. Abellan, and W. Amaya. Strong experimental guarantees in ultrafast quantum random number generation. *Phys. Rev. A*, **91**, 012314 (2015)

[33] N. Behbood, F. Martin Ciurana, G. Colangelo, M. Napolitano, G. Tóth, R. J. Sewell, and **M. W. Mitchell**. Generation of macroscopic singlet states in a cold atomic ensemble. *Phys. Rev. Lett.*, **113**, 093601 (2014)

[34] F. A. Beduini, J. A. Zielińska, V. G. Lucivero, Y. A. de Icaza Astiz, and **M. W. Mitchell**. Interferometric measurement of the biphoton wave function. *Phys. Rev. Lett.*, **113**, 183602 (2014)

[35] J. A. Zielińska, F. A. Beduini, V. G. Lucivero, and **M. W. Mitchell**. Atomic filtering for hybrid continuous-variable/discrete-variable quantum optics. *Opt. Express*, **22**, 25307 (2014)

[36] **M. W. Mitchell** and F. A. Beduini. Extreme spin squeezing for photons. *New Journal of Physics*, **16**, 073027 (2014)

[37] J. A. Zielińska and **M. W. Mitchell**. Theory of high gain cavity-enhanced spontaneous parametric down-conversion. *Phys. Rev. A*, **90**, 063833 (2014)

[38] V. G. Lucivero, P. Anielski, W. Gawlik, and **M. W. Mitchell**. Shot-noise-limited magnetometer with sub-picotesla sensitivity at room temperature. *Rev. Sci. Instr.*, **85**, 113108 (2014)

[39] R. J. Sewell, M. Napolitano, N. Behbood, G. Colangelo, F. Martin Ciurana, and **M. W. Mitchell**. Ultrasensitive atomic spin measurements with a nonlinear interferometer. *Phys. Rev. X*, **4**, 021045 (2014)

[40] Y. A. de Icaza Astiz, V. G. Lucivero, R. d. J. León-Montiel, and **M. W. Mitchell**. Optimal signal recovery for pulsed balanced detection. *Phys. Rev. A*, **90**, 033814 (2014)

[41] C. Abellán, W. Amaya, M. Jofre, M. Curty, A. Acín, J. Capmany, V. Pruneri, and **M. W. Mitchell**. Ultra-fast quantum randomness generation by accelerated phase diffusion in a pulsed laser diode. *Opt. Express*, **22**, 1645 (2014)

[42] L. Tagliacozzo, A. Celi, P. Orland, **M. W. Mitchell**, and M. Lewenstein. Simulation of non-abelian gauge theories with optical lattices. *Nat Commun*, **4**, 2615 (2013)

[43] F. A. Beduini and **M. W. Mitchell**. Optical spin squeezing: Bright beams as high-flux entangled photon sources. *Phys. Rev. Lett.*, **111**, 143601 (2013)

[44] N. Behbood, G. Colangelo, F. Martin Ciurana, M. Napolitano, R. J. Sewell, and **M. W. Mitchell**. Feedback cooling of an atomic spin ensemble. *Phys. Rev. Lett.*, **111**, 103601 (2013)

[45] R. J. Sewell, M. Napolitano, N. Behbood, G. Colangelo, and **M. W. Mitchell**. Certified quantum non-demolition measurement of a macroscopic material system. *Nat Photon*, **7**, 517 (2013)

[46] N. Behbood, F. M. Ciurana, G. Colangelo, M. Napolitano, **M. W. Mitchell**, and R. J. Sewell. Real-time vector field tracking with a cold-atom magnetometer. *Applied Physics Letters*, **102**, 173504 (2013)

[47] F. Wolfgramm, C. Vitelli, F. A. Beduini, N. Godbout, and **M. W. Mitchell**. Entanglement-enhanced probing of a delicate material system. *Nat Photon*, **7**, 28 (2013)

[48] G. Puentes, G. Colangelo, R. J. Sewell, and **M. W. Mitchell**. Planar squeezing by quantum non-demolition measurement in cold atomic ensembles. *New J. Phys.*, **15**, 103031 (2013)

[49] G. Colangelo, R. J. Sewell, N. Behbood, F. M. Ciurana, G. Triginer, and **M. W. Mitchell**. Quantum atom–light interfaces in the gaussian description for spin-1 systems. *New Journal of Physics*, **15**, 103007 (2013)

[50] T. Vanderbruggen and **M. W. Mitchell**. Near-resonant optical forces beyond the two-level approximation for a continuous source of spin-polarized cold atoms. *Phys. Rev. A*, **87**, 033410 (2013)

[51] P. Hauke, R. J. Sewell, **M. W. Mitchell**, and M. Lewenstein. Quantum control of spin correlations in ultracold lattice gases. *Phys. Rev. A*, **87**, 021601 (2013)

[52] F. Steinlechner, S. Ramelow, M. Jofre, M. Gilaberte, T. Jennewein, J. P. Torres, **M. W. Mitchell**, and V. Pruneri. Phase-stable source of polarization-entangled photons in a linear double-pass configuration. *Opt. Express*, **21**, 11943 (2013)

[53] I. Urizar-Lanz, P. Hyllus, I. L. Egusquiza, **M. W. Mitchell**, and G. Tóth. Macroscopic singlet states for gradient magnetometry. *Phys. Rev. A*, **88**, 013626 (2013)

[54] R. J. Sewell, M. Koschorreck, M. Napolitano, B. Dubost, N. Behbood, and **M. W. Mitchell**. Magnetic sensitivity beyond the projection noise limit by spin squeezing. *Phys. Rev. Lett.*, **109**, 253605 (2012)

[55] **M. W. Mitchell**, M. Koschorreck, M. Kubasik, M. Napolitano, and R. J. Sewell. Certified quantum non-demolition measurement of material systems. *New J. Phys.*, **14**, 085021 (2012)

[56] M. Jofre, G. Anzolin, F. Steinlechner, N. Oliverio, J. P. Torres, V. Pruneri, and **M. W. Mitchell**. Fast beam steering with full polarization control using a galvanometric optical scanner and polarization controller. *Opt. Express*, **20**, 12247 (2012)

[57] B. Dubost, M. Koschorreck, M. Napolitano, N. Behbood, R. J. Sewell, and **M. W. Mitchell**. Efficient quantification of non-gaussian spin distributions. *Phys. Rev. Lett.*, **108**, 183602 (2012)

[58] F. Steinlechner, et al. A high-brightness source of polarization-entangled photons optimized for applications in free space. *Opt. Express*, **20**, 9640 (2012)

[59] J. A. Zielińska, F. A. Beduini, N. Godbout, and **M. W. Mitchell**. Ultranarrow Faraday rotation filter at the Rb D_1 line. *Opt. Lett.*, **37**, 524 (2012)

[60] M. Napolitano, M. Koschorreck, B. Dubost, N. Behbood, R. J. Sewell, and **M. W. Mitchell**. Interaction-based quantum metrology showing scaling beyond the Heisenberg limit. *Nature*, **471**, 486 (2011)

[61] M. Koschorreck, M. Napolitano, B. Dubost, and **M. W. Mitchell**. High resolution magnetic vector-field imaging with cold atomic ensembles. *Appl. Phys. Lett.*, **98**, 074101 (2011)

[62] F. Wolfgramm, Y. A. de Icaza Astiz, F. A. Beduini, A. Cerè, and **M. W. Mitchell**. Atom-resonant heralded single photons by interaction-free measurement. *Phys. Rev. Lett.*, **106**, 053602 (2011)

[63] M. Jofre, M. Curty, F. Steinlechner, G. Anzolin, J. P. Torres, **M. W. Mitchell**, and V. Pruneri. True random numbers from amplified quantum vacuum. *Opt. Express*, **19**, 20665 (2011)

[64] M. Jofre, et al. Fast optical source for quantum key distribution based on semiconductoroptical amplifiers. *Opt. Express*, **19**, 3825 (2011)

[65] M. Napolitano and **M. W. Mitchell**. Nonlinear metrology with a quantum interface. *New J. Phys.*, **12**, 093016 (2010)

[66] G. Anzolin, A. Gardelein, M. Jofre, G. Molina-Terriza, and **M. W. Mitchell**. Polarization change induced by a galvanometric optical scanner. *J. Opt. Soc. Am. A*, **27**, 1946 (2010)

[67] M. Jofre, A. Gardelein, G. Anzolin, G. Molina-Terriza, J. P. Torres, **M. W. Mitchell**, and V. Pruneri. 100 mhz amplitude and polarization modulated optical source for free-space quantum key distribution at 850 nm. *J. Lightwave Tech.*, **28**, 2572 (2010)

[68] M. Koschorreck, M. Napolitano, B. Dubost, and **M. W. Mitchell**. Quantum nondemolition measurement of large-spin ensembles by dynamical decoupling. *Phys. Rev. Lett.*, **105**, 093602 (2010)

[69] F. Wolfgramm, A. Cerè, F. A. Beduini, A. Predojević, M. Koschorreck, and **M. W. Mitchell**. Squeezed-light optical magnetometry. *Phys. Rev. Lett.*, **105**, 053601 (2010)

[70] F. Wolfgramm, A. Cere, and **M. W. Mitchell**. Noon states from cavity-enhanced down-conversion: high quality and super-resolution. *J. Opt. Soc. Am. B*, **27**, A25 (2010)

[71] G. Tóth and **M. W. Mitchell**. Generation of macroscopic singlet states in atomic ensembles. *New Journal of Physics*, **12**, 053007 (2010)

[72] M. Koschorreck, M. Napolitano, B. Dubost, and **M. W. Mitchell**. Sub-projection-noise sensitivity in broadband atomic magnetometry. *Phys. Rev. Lett.*, **104**, 093602 (2010)

[73] C. Schuck, F. Rohde, N. Piro, M. Almendros, J. Huwer, **M. W. Mitchell**, M. Hennrich, A. Haase, F. Dubin, and J. Eschner. Resonant interaction of a single atom with single photons from a down-conversion source. *Phys. Rev. A*, **81**, 011802 (2010)

[74] D. W. Berry, B. L. Higgins, S. D. Bartlett, **M. W. Mitchell**, G. J. Pryde, and H. M. Wiseman. How to perform the most accurate possible phase measurements. *Phys. Rev. A*, **80**, 052114 (2009)

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