

## RESEARCH INTERESTS

My primary interests are in the development of engineered quantum devices, including next generation nanoscale sensors, spintronic transducers, quantum simulators and non-invasive quantum-assisted imagers.

Applications of my work include single molecule and nanoscale MRI, hyperpolarization for signal enhanced NMR, the development of solid-state spin gyroscopes and the quantum control of mesoscopic spin systems.

## EDUCATION

**University of California Berkeley**, Berkeley, CA Sep 2016 – Present  
**Postdoctoral Associate**

- ◊ Advisor: [Alexander Pines](#), Glenn Seaborg Professor of Chemistry

**Massachusetts Institute of Technology**, Cambridge, MA Sep 2010 – Sep 2016  
**Ph.D. Nuclear Science & Engineering**

- ◊ Advisor: [Paola Cappellaro](#), Esther and Harold Edgerton Associate Professor
- ◊ Thesis: [Quantum Assisted Sensing, Simulation and Control](#)
- ◊ Thesis Committee: [Alan Jasanoff](#), [Seth Lloyd](#), [Ju Li](#), [Ronald Walsworth](#)
- ◊ Awarded [Del Favero Thesis Prize](#) for Ph.D. thesis judged to have made the most innovative advance in the field.

**Technische Universität, Dortmund**, Dortmund, Germany Jan 2010- Apr 2010  
**Masters Thesis Research**

- ◊ Advisor: [Dieter Suter](#), Professor of Physics
- ◊ Thesis: *Experimental study of dynamical decoupling in Nuclear Magnetic Resonance*
- ◊ Thesis work was carried out in Prof. Suter's group, and submitted to BITS-Pilani for a Masters in Physics.

**Indian Institute of Science**, Bangalore, India Sep 2009- Dec 2009  
**Masters Thesis Research**

- ◊ Advisor: [Anil Kumar](#), Professor of Physics
- ◊ Thesis: *Novel algorithmic method to decompose unitary operations in Nuclear Magnetic Resonance*
- ◊ Thesis work was carried out in Prof. Anil Kumar's group, and submitted to BITS-Pilani for a Masters in Physics.

**Birla Institute of Technology and Science-Pilani**, Goa, India August 2005-May 2010  
**M.Sc. Physics**  
**B.E. Electrical Engineering**

- ◊ Course CGPA : 9.37 / 10.00 ; Ranked 2/30

## RESEARCH EXPERIENCE

**Postdoctoral Research** October 2016 – present  
**University of California Berkeley**, Berkeley, CA

- ◊ New methods of *hyperpolarization* for signal enhanced NMR and MRI using lasers and without the need for large magnets.
- ◊ Developed new techniques for the optical  $^{13}\text{C}$  hyperpolarization in diamond nano- and micro-particles with applications in hyperpolarized imaging for disease detection and dynamic nuclear polarization of liquids at room temperature.
- ◊ Led the construction of ultraportable low-cost room temperature hyperpolarizers employing optical pumping.
- ◊ Developed novel field cycling technology capable of ten orders of magnitude switching in magnetic field allowing one to harness the unique and complimentary advantages of high and ultralow magnetic fields for various applications in quantum information and sensing.

**Massachusetts Institute of Technology**, Cambridge, MA

- ◊ Experiments employing shallow NV centers in diamond for high-resolution structure determination in single molecule MRI applications.
- ◊ Developed methods for the dispersionless transport of quantum information in spin networks, especially arbitrary networks of NV centers and P1 centers in diamond lattices. Experimentally studied quantum transport and decay of spin coherences in linear chains using solid-state NMR.
- ◊ Proposed NV centers as sensitive rotation sensors (gyroscopes). Developed the idea of a hybrid device consisting of NV centers and a MEMS gyroscope for long time stable operation for inertial sensing.
- ◊ Developed a new Hamiltonian engineering technique with applications in quantum simulation. The method allows the construction of target Hamiltonians by a time-domain filtering action of experimentally realizable Hamiltonians.

**Masters Thesis**

January 2010- May 2010

**Technische Universität, Dortmund**, Dortmund, Germany

- ◊ Experimentally and theoretically compared the performance of several dynamical decoupling protocols in the context of solid state NMR.
- ◊ Developed an optical analogy to dynamical decoupling and Bragg grating filters, which allowed the construction and understanding of decoupling control sequences as filter problems

**Masters Thesis**

September 2009- December 2009

**Indian Institute of Science**, Bangalore, India

- ◊ Developed a novel algorithmic technique to decompose arbitrary unitary operations into experimental pulse sequences for NMR. This allowed efficient implementations of several quantum algorithms in a liquid-state NMR quantum processor.
- ◊ Experimentally simulated Ising-type Hamiltonians that drive quantum transport in 1D linear chains in a liquid state NMR QIP.
- ◊ Theoretically developed the Svetlichny inequality as a measure of multipartite entanglement.

## AWARDS AND HONORS

- ◊ [Del Favero Thesis Prize](#) for Ph.D. thesis judged to have made the most innovative advance in the field, MIT 2017
- ◊ [Manson Benedict Award](#), for excellence in academic performance and professional promise, MIT 2014
- ◊ [Co.Co.Mat Exchange Scholarship](#) to visit Institute of Quantum Optics, Ulm (Prof. F. Jelezko) 2013
- ◊ BITS-Pilani Merit Scholarship, awarded for highest GPA in a semester 2010
- ◊ [JNCASR Summer Research Fellowship](#) 2009
- ◊ [Rajiv Gandhi Science Talent Research Fellowship](#) 2008
- ◊ [IIA Summer Research Fellowship](#) 2007
- ◊ [KVPY Scholarship](#), National Science Fellowship for top students by Govt. of India 2005
- ◊ [National Talent Search Scholarship](#), prestigious National Scholarship by Govt. of India 2003

## PUBLICATIONS

24. **A. Ajoy**, R. Nazaryan, E. Druga, K. Liu, B. Han, J. T. Oon, M. Gierth, R. Tsang, J. H. Walton, C. A. Meriles, J. A. Reimer, D. Suter and A. Pines, “Realization of portable room temperature nanodiamond <sup>13</sup>C hyperpolarizer,” *Submitted* (2018).
- 23 Y. X. Liu\*, **A. Ajoy\*** and P. Cappellaro “Nanoscale vector DC magnetometry via ancilla assisted frequency up-conversion,” *Phys. Rev. Lett.*, (in press) (2019).
22. **A. Ajoy**, X. Lv, E. Druga, K. Liu, B. Safvati, A. Morabe, M. Fenton, R. Nazaryan, S. Patel, T. Sjolander, J. Reimer, D. Sakellariou, C. Meriles and A. Pines “Wide dynamic range magnetic field cyler: Harnessing quantum control at low and high fields,” *Rev. Sci. Instru.*, **90**, 013112 (2019).
21. **A. Ajoy\***, U. Bissbort\*, D. Poletti and P. Cappellaro *Phys. Rev. Lett.*, **122**, 013205 (2019).
20. P.R. Zangara, S. Dhomkar, **A. Ajoy**, K. Liu, R. Nazaryan, D. Pagliero, D. Suter, J. Reimer, A. Pines, C. Meriles, “Dynamics of frequency-swept nuclear spin optical pumping in powdered diamond at low magnetic fields,” *Proc. Natl. Acad. Sci.*, 1811994116, (2019).
19. **A. Ajoy**, R. Nazaryan, K. Liu, X. Lv, B. Safvati, G. Wang, E. Druga, J. A. Reimer, D. Suter, C. Ramanathan, C. A. Meriles and A. Pines “Enhanced dynamic nuclear polarization via swept microwave frequency combs,” *Proc. Natl. Acad. Sci.*, 1807125115 (2018).
18. **A. Ajoy**, K. Liu, R. Nazaryan, X. Lv, B. Safvati, G. Wang, D Arnold, G. Li, A. Lin, P. Raghavan, E. Druga, D. Pagliero, J. Reimer, D. Suter, C. Meriles and A. Pines “Orientation independent room-temperature optical <sup>13</sup>C hyperpolarization in powdered diamond,” *Science Advances*, **4**, eaar5492 (2018).

17. D. Burgarth and A. Ajoy “Evolution-free Hamiltonian parameter estimation through Zeeman markers,” *Phys. Rev. Lett.*, **119**, 030402 (2017).
16. F. Rajabi, S. Motlakunta, C.-Y. Shih, N. Kotibhaskar, Q. Quraishi, A. Ajoy, and R. Islam “Dynamic Hamiltonian engineering of 2D rectangular lattices in a one-dimensional ion chain,” *arXiv:1808.06124* (2018).
15. J.C. Jaskula, K. Saha, A. Ajoy, D. J. Twitchen, M. Markham, and P. Cappellaro “Cross-sensor feedback stabilization of an emulated quantum spin gyroscope,” *arXiv:1808.04494* (2018).
14. D. Pagliero, K.R. Koteswara Rao, P.R. Zangara, S. Dhomkar, H.H. Wong, A. Abril, N. Aslam, A. Parker, J. King, C.E. Avalos, A. Ajoy, J. Wrachtrup, A. Pines, C.A. Meriles “Multi-spin-assisted optical pumping of bulk  $^{13}\text{C}$  nuclear spin polarization in diamond,” *Phys. Rev. B*, **97**, 024422 (2018).
13. L. Marseglia, K. Saha, A. Ajoy, T. Schroder, D. R. Englund, T. Teraji, J. Isoya, F. Jelezko, R. Walsworth, J. L. Pacheco, D. Perry, E. Bielejec and P. Cappellaro “A Bright Nanowire Single Photon Source,” *Optics Express*, **26**, 80 (2018).
12. A. Ajoy, Y. X. Liu, K. Saha, L. Marseglia, J.-C. Jaskula, U. Bissbort and P. Cappellaro “Quantum Interpolation for High Resolution Sensing,” *Proc. Natl. Acad. Sci.*, **114**, 2149 (2017).
11. A. Ajoy, U. Bissbort, M.D. Lukin, R.L. Walsworth and P. Cappellaro “Atomic-scale nuclear spin imaging using quantum-assisted sensors in diamond,” *Phys. Rev. X*, **5**, 011001 (2015).
10. G. Kaur, A. Ajoy and P. Cappellaro “Decay of spin coherences in one-dimensional spin systems,” *New J. Phys.*, **15**, 093035 (2013).
9. A. Ajoy and P. Cappellaro, “Quantum simulation via filtered Hamiltonian engineering: application to perfect quantum transport in spin networks,” *Phys. Rev. Lett.*, **110**, 220503 (2013).
8. A. Ajoy and P. Cappellaro, “Perfect quantum transport in arbitrary spin networks,” *Phys. Rev. B*, **87**, 064303 (2012).
7. A. Ajoy and P. Cappellaro, “Stable three-axis nuclear-spin gyroscope in diamond,” *Phys. Rev. A*, **86**, 062104 (2012).
6. A. Ajoy and P. Cappellaro, “Mixed-state quantum transport in correlated spin networks,” *Phys. Rev. A*, **85**, 042305 (2012).
5. A. Ajoy, R.K. Rao, A. Kumar and P. Rungta “Algorithmic approach to simulate Hamiltonian dynamics and an NMR simulation of Quantum State Transfer,” *Phys. Rev. A Rapid Comm.*, **85**, 030303(R) (2012).
4. A. Ajoy, G.A. Álvarez and D. Suter “Optimal pulse spacing for dynamical decoupling in the presence of a purely-dephasing spin-bath,” *Phys. Rev. A*, **83**, 032303 (2011).
3. G.A. Álvarez, A. Ajoy, X.Peng and D. Suter “Performance comparison of dynamical decoupling sequences for a qubit in a rapidly fluctuating spin-bath,” *Phys. Rev. A*, **82**, 042306 (2010).
2. A. Ajoy and P. Rungta “Svetlichny’s inequality and genuine tripartite nonlocality in three-qubit pure states,” *Phys. Rev. A*, **81**, 052334 (2010).
1. A. Ajoy and A. Kumar “Hierarchical Genetic Algorithm Approach to Determine Pulse Sequences in NMR,” *arXiv:0911.5465* (2009).

## PATENTS

1. P. Cappellaro and A. Ajoy “Stable three-axis nuclear spin gyroscope”, U.S. Patent 2014/0327439 A1 (2014).
2. A. Pines, A. Ajoy, R. Nazaryan, X. Lv, C. Meriles, *Orientation independent, room temperature, hyperpolarization of diamond micro- and nano-particles*, US provisional application no. 62/581,238, (filed 3 Nov 2017).
3. A. Pines, A. Ajoy, E. Druga, K. Liu, *Wide Dynamic Range Magnetic Field Cycler Capable Of Sweeping of approximately 10 Orders of Magnitude of Magnetic Field from 1nT-7T*, US provisional application no.B18-055-1-7869-0015 (filed 3 Nov 2017).
4. A. Pines, A. Ajoy, E. Druga, R. Nazaryan, K. Liu, *Ultra Portable Optical Nanodiamond Hyperpolarizer and Enhanced Dynamic Nuclear Polarization Via Swept Microwave Frequency Combs*, US provisional application no. 62/641,532 (filed March 12, 2018).

## SELECTED TALKS

1. “Quantum Assisted Sensing Across Length Scales: A New Revolution in MRI,” *Del Favero Prize Lecture*, MIT. 2018
2. “Room-temperature optical  $^{13}\text{C}$  hyperpolarization in powdered diamond,” *59th Experimental NMR Conference (ENC)*, Orlando. 2018
3. “Optical hyperpolarization in diamond particles: avenues in physics and imaging,” *QDiamond ’18*, Tel Aviv. 2018
4. “Quantum Interpolation for High Resolution Nanoscale NMR,” *ISMAR& Rocky Mountain EPR Conference*, Quebec. 2017
5. “Quantum Interpolation for high resolution sensing,” *Mainz Magnetic Resonance Seminar*, Mainz. 2016

6. "Hamiltonian engineering for quantum simulation and metrology," JQI Special Seminar, Joint Quantum Institute. 2015
7. "Hamiltonian engineering for quantum simulation and metrology," Quantum Nano Seminar, Dartmouth College. 2015
8. "High resolution quantum metrology via Quantum Interpolation," CUA 10-minute talk, MIT. 2015
9. "Quantum assisted sensors," MIT Center for Ultra Cold Atoms (CUA) Retreat, NH. 2015
10. "Selective nuclear decoupling via NV centers in diamond," HQOC/ITAMP Student Seminar, Harvard University. 2015
11. "Towards atomic scale nuclear spin imaging with quantum assisted sensors in diamond," Quantum Innovators Workshop, University of Waterloo, Canada. 2014

## SELECTED COURSE WORK

- ◇ 8.422 Atomic & Optical Physics II
- ◇ 22.51 Quantum Theory of Radiation Interactions
- ◇ 8.511 Theory of Solids I
- ◇ 6.301 Solid-State Circuits
- ◇ 6.632 Electromagnetic Wave Theory
- ◇ 6.763 Applied Superconductivity
- ◇ 22.101 Applied Nuclear Physics
- ◇ 2.S997 Optomechanics

## PROFESSIONAL SERVICE

- ◇ Referee for Nature Communications, npj Quantum Information, New Journal of Physics, Journal of Applied Physics, Quantum Information Processing, PLoS One, INJP, Euro Physics Letters, IEEE Trans. Aero and Elec. Sys.

## REFERENCES

### Alexander Pines

◇ **Postdoc Advisor**

*e-mail:* [pines@berkeley.edu](mailto:pines@berkeley.edu)

Glenn T. Seaborg Professor of Chemistry  
University of California, Berkeley  
208C Stanley Hall,  
Berkeley, CA, 94720-3220, USA.

### Paola Cappellaro

◇ **Ph.D. Thesis Advisor**

*e-mail:* [pcappell@mit.edu](mailto:pcappell@mit.edu)

Esther & Harold Edgerton Associate Professor  
Department of Nuclear Science and Engineering, MIT  
26-303, Research Laboratory of Electronics MIT,  
77 Massachusetts Avenue,  
Cambridge, MA 02139-4307, USA.

### Ronald Walsworth

◇ **Thesis Committee Member and Collaborator**

*e-mail:* [rwalsworth@cfa.harvard.edu](mailto:rwalsworth@cfa.harvard.edu)

Senior Lecturer  
Department of Physics and Center for Astrophysics,  
Harvard University  
P156, Harvard CfA, 60 Garden St,  
Cambridge, MA 02138, USA.

### Seth Lloyd

◇ **Thesis Committee Member**

*e-mail:* [slloyd@mit.edu](mailto:slloyd@mit.edu)

Nam Pyo Suh Chair Professor  
Department of Mechanical Engineering, MIT  
3-160, 77 Massachusetts Avenue,  
Cambridge, MA 02139-4307, USA.

### Fedor Jelezko

◇ **Collaborator**

*e-mail:* [fedor.jelezko@uni-ulm.de](mailto:fedor.jelezko@uni-ulm.de)

Professor  
Institute for Quantum Optics, Universität Ulm  
Albert-Einstein-Allee 11 D-89081 Ulm, Germany.

### Dmitry Budker

◇ **Collaborator**

*e-mail:* [budker@berkeley.edu](mailto:budker@berkeley.edu)

Professor  
Department of Physics, University of California, Berkeley  
203 Birge Hall, Berkeley, CA, 94720-3220, USA.

### Dieter Suter

◇ **Masters Thesis Advisor**

*e-mail:* [Dieter.Suter@tu-dortmund.de](mailto:Dieter.Suter@tu-dortmund.de)

Professor  
Department of Physics, Universität Dortmund  
Experimental Physik III, Otto-Hahn-Strasse 4,  
D-44221, Dortmund, Germany.

### Jeffrey A. Reimer

◇ **Collaborator**

*e-mail:* [reimer@berkeley.edu](mailto:reimer@berkeley.edu)

Warren and Katharine Schlinger Distinguished Professor  
Department of Chemical Engineering, UC Berkeley  
101C Gilman Hall,  
Berkeley, CA 94720, USA.

### Carlos Meriles

◇ **Collaborator**

*e-mail:* [cmeriles@ccny.cuny.edu](mailto:cmeriles@ccny.cuny.edu)

Professor  
Department of Physics, CUNY - City College of New York  
85 St. Nicholas Terrace, New York, NY 10031, USA.

### Sunil Bhawe

◇ **Collaborator**

*e-mail:* [bhave@purdue.edu](mailto:bhave@purdue.edu)

Associate Professor  
School of Electrical and Computer Engineering,  
Purdue University  
475 Northwestern Ave., West Lafayette, IN 47907, USA.