Benjamin N. Spaun

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EDUCATION

HARVARD UNIVERSITY, Graduate School of Arts and Sciences **Cambridge, MA**

- **PhD in Experimental Atomic, Molecular, and Optical Physics**. *August 2008 – May 2014*
- Conducted thesis research under Dr. Gerald Gabrielse.

WHITWORTH UNIVERSITY **Spokane, WA**

- **Bachelor of Science in Physics and in Mathematics**, 3.96/4.0 GPA. *August 2004 – May 2008*
- Named "Most Outstanding Student" for graduating class of 2008.

EXPERIENCE

JILA, University of Colorado at Boulder *August 2014 – present*

- Worked as a postdoc in Dr. Jun Ye's group to detect trace amounts of large volatile organic compounds (VOCs) in a gaseous mixture by combining, for the first time, the techniques of buffer-gas cooling and cavity-enhanced directed frequency comb spectroscopy.
- Used a mid-infrared frequency comb to simultaneously perform tens of thousands of high-precision direct absorption measurements on large, cold molecules over a broad optical bandwidth. This novel technique allowed thousands of absorption features of large molecules, containing dozens of atoms, to be spectrally resolved within 10-minute timescales.
- Results of research recently published in *Nature*.
- Designed and constructed a cryogenic gas mixing chamber inside a high-vacuum apparatus.
- Designed and built a high-finesse optical enhancement cavity around a 4 Kelvin buffer-gas cooling chamber, filled with VOCs, in order to increase laser absorption path lengths, and thus spectral sensitivity, by many orders of magnitude.
- Designed and implemented a multi-level servo system to allow thousands of optical frequency comb modes to be simultaneously locked on resonance to a high-finesse optical enhancement cavity.
- Operated and maintained a ytterbium-fiber-based frequency comb, a 15 W ytterbium fiber amplifier, and a mid-infrared optical parametric frequency comb oscillator.

Harvard University *August 2008 – May 2014*

- Led a team of seven students from three collaborating research groups to measure the electron's electric dipole moment (EDM) ten times more precisely than it had previously been measured. This experiment probed fundamental symmetries of nature and constrained new physics beyond the Standard Model.
- Results of research featured on cover of *Science Magazine*.
- Constructed and tested advanced optical systems integrated with a cryogenic molecular beam apparatus. These include a high efficiency fluorescence collection system, and an optomechanical system to precisely control and rapidly switch laser frequency, polarization, pointing, and beam shape.
- Designed and built narrow linewidth diode lasers and high-power fiber and tapered laser amplifiers.
- Used laser-induced fluorescence spectroscopy to study unique quantum features of thorium monoxide useful for EDM measurements.
- Systematically studied over 40 unwanted effects that could potentially jeopardize EDM measurement accuracy.
- Developed data analysis algorithms to extract EDM value *in situ* from many terabytes of fluorescence data.
- Presented research at multiple international physics conferences.

Colorado University (JILA) *Summer 2007*

- Designed and built a highly stable external-cavity diode laser made of Zerodur, to be used in a miniaturized magneto-optical trap (MOT).

Triangle University Nuclear Laboratory (TUNL) at Duke University *Summer 2006*

- Measured partial neutron-scattering cross sections of lead and copper as part of a large-scale effort to search for exotic properties in neutrinos.

NASA Marshall Space Flight Center *Summer 2005*

- Helped develop a thrust stand capable of micronewton precision to ground test plasma thrusters; results published in *Review of Scientific Instruments.*

TECHNICAL SKILLS

- Extensive background in design, construction, and operation of visible and infrared laser systems, including optical frequency combs, external-cavity diode lasers, fiber lasers, and fiber and tapered amplifiers.
- Expertise in non-linear optics, including parametric oscillation, harmonic generation, and supercontinuum generation with photonic crystal fibers.
- Expertise with optomechanics, high-finesse optical cavities, and reflectometry techniques.
- Expertise in design and operation of cryogenic and room temperature vacuum apparatus.
- Extensive background with a variety of spectroscopic techniques, including Fourier-transform infrared spectroscopy (FTIR), cavity-enhanced spectroscopy, laser-induced fluorescence, and photon counting.
- Eight years of experience designing control systems and developing control and analysis algorithms.
- Expertise with radio-frequency (RF) signal processing.
- Expertise in laser and microwave frequency stabilization, servo systems, and mechanical noise suppression.
- Eight years of experience with a variety of machining equipment: lathe, mill, diamond saw, water jet cutter, and laser cutter.
- Experience with electronic circuit design.
- Highly competent with MATLAB, Mathematica, LabVIEW software programs for analysis of large data sets, device automation, and modeling of optical processes.
- Strong written and oral communication skills: first-authored scientific journal publications, and presented research at numerous international science conferences.

HONORS AND AWARDS

- National Research Council (NRC) Postdoctoral Research Fellowship ($69,000 per year value).
- Harvard Goldhaber Prize (awarded to two physics graduate students each year for outstanding research).
- Harvard An Wang Fellowship ($29,000 per year value).
- Barry M. Goldwater Scholarship (national undergraduate scholarship for students pursuing careers in science).
- Rhodes Scholarship Finalist.

SELECTED PUBLICATIONS

- "Continuous probe of cold complex molecules with infrared frequency comb spectroscopy," *Nature,* vol. 533, 2016.
- "Order of Magnitude Smaller Limit on the Electric Dipole Moment of the Electron," *Science*, vol. 343, 2014.
- "Direct Frequency Comb Measurement of OD + CO → DOCO Kinetics," submitted for publication.
- "Shot-Noise Limited Spin Measurements in a Pulsed Molecular Beam," *Physical Review A*, vol. 88, 2013.
- "Magnetic and Electric Dipole Moments of the $H\,^3\Delta_1$ State in ThO," *Physical Review A*, vol. 84, 2011.
- "A cryogenic beam of refractory, chemically reactive molecules with expansion cooling," *Physical Chemistry Chemical Physics,* vol. 13, 2011.