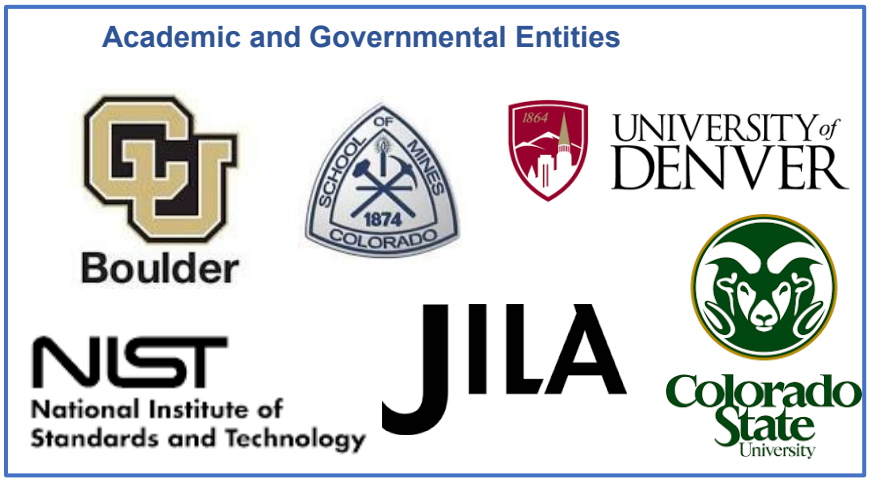
The Quantum Leap
May 12, 2023

The Denver-Boulder Quantum Ecosystem

During the height of the cold war, when the fear of a nuclear attack by the USSR was palpable, a large number of important government agencies were established in and around Boulder, Colorado. Given its position just east of the Rocky Mountains (often referred to as the Front Range), the area was thought to be protected from nuclear missiles launched from Russia. This led to several important national labs and government agencies tracing their origins to the shadows of the Flatirons and the 50+ "14ers" (peaks exceeding 14,000 feet in elevation) abutting them. Today, some of those entities still thrive, including the National Institute of Standards and Technology (NIST), the National Oceanic and Atmospheric Administration (NOAA) and the National Center for Atmospheric Research (NCAR), which were formed via the consolidation of legacy agencies, many of which were established in Boulder and nearby communities during the Eisenhower administration.

NIST at the foot of the Rocky Mountains

These common roots and the associated important technologies they developed seeded an important technological ecosystem in the area. As some readers of T*he Quantum Leap* may know, I've long been intrigued by the interconnected quantum ecosystem. A post entitled "Collaboration is Dominating Quantum Computing" covered some of the dynamics and synergies among Classiq, Strangeworks, Infleqtion (f/k/a ColdQuanta) and others. And if you'll permit a small personal digression, I recently relocated to the Boulder area and have been struck by the vibrant quantum footprint here, so wanted to provide some details on this local quantum environment. Today, Boulder and the surrounding towns enjoy a concentration of quantum-focused government entities, academic institutions, large corporations and growing entrepreneurial firms. Additionally, as Kenna Hughes-Castleberry, Science Communicator for JILA and science and technology journalist noted, "Colorado boasts a highly educated workforce, with over 42% of its population holding a bachelor's degree or higher. While many quantum players within the state are smaller start-ups, we also have branches of Microsoft and Google in Boulder and Denver, adding more layers to the diverse technological ecosystem." There are many obvious synergies, such as having the universities produce qualified quantum professionals and spin out technologies and companies, having the commercial players offer jobs to graduates, and cooperation and trade among neighboring companies. Given the highly complex nature of quantum science, and its position as a bleeding edge technology, it makes sense that certain companies specialize in very specific areas so that collaboration among companies can enable broader approaches to physics challenges. [Note to readers: If I've missed any local quantum companies, please contact me and I will add to the post as appropriate].



NIST (National Institute of Standards and Technology):

NIST is a non-regulatory federal agency within the U.S. Department of Commerce. For more than a century, NIST has helped to keep U.S. technology at the leading edge. Their measurements support the smallest of technologies to the largest and most complex human-made creations. NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards and technology in ways that enhance economic security and improve our quality of life — from nanoscale devices so tiny that tens of thousands can fit on the end of a single human hair up to earthquake-resistant skyscrapers and global communication networks.

Congress established the agency to remove a major challenge to U.S. industrial competitiveness at the time — a second-rate measurement infrastructure that lagged behind the capabilities of the United Kingdom, Germany and other economic rivals. From the smart electric power grid and electronic health records to atomic clocks, advanced nanomaterials and computer chips, innumerable products and services rely in some way on technology, measurement and standards provided by NIST.

Even before "quantum" was the catchall descriptor, this area was home to crucial "AMO Physics" (Atomic, molecular and optical) research. In fact, the very first quantum computing gate was realized nearly 30 years ago by Chris Monroe and David Wineland at NIST, where they demonstrated a CNOT gate on an early trapped ion computer which contributed to Wineland's Nobel Prize in physics in 2012. His colleague, Jan Hall, has been doing AMO/Quantum research at CU Boulder since 1964 and he was awarded a Nobel in 2005 largely for the creation of the optical frequency comb which has been instrumental in advancing atomic clock precision. And the 2001 Nobel Prize in physics was awarded to CU Boulder affiliated researchers Carl Weiman and Eric Cornell who received the award for the creation of Bose-Einstein condensate, a new type of matter which helped scientists better understand quantum behavior. Additional Nobel prizes have been earned by NIST researchers Dan Schechtman (2011 in Chemistry for Quasicrystals) and Bill Phillips (1997 in Physics for Laser Cooling). This concentration of Nobel talent/research has helped spur the current Boulder-centric quantum ecosystem and many of the co-workers and collaborators with these Nobel winners have gone on to form or take important roles in local quantum companies.

In addition, the Quantum Physics Division of NIST is part of JILA, the joint research and training institute between NIST and the nearby University of Colorado Boulder (CU Boulder).

JILA:

Founded in 1962, its name was originally an acronym for "Joint Institute for Laboratory Astrophysics". However, for many years JILA has been a world-renowned and award-winning physics institute delving into frontier bending research in quantum information science & technology, atomic & molecular physics, laser physics, biophysics, chemical physics, nanoscience and precision measurement, so the name is no longer an acronym.

Collaborations among JILA Fellows, JILA research associates and students, CU Boulder professors, NIST staff members, and other world-leading scientists from around the globe play a key role in generating JILA's renowned pioneering research. JILA's CU members hold faculty appointments in the Departments of Physics; Astrophysical and Planetary Science; Chemistry and Biochemistry; and Molecular, Cellular, and Developmental Biology as well as Engineering. JILA's Quantum Physics Division of NIST members hold joint faculty appointments at CU Boulder in the same departments.

Many of the quantum companies in the area such as Vescent Photonics, Octave Photonics, Stable Laser Systems, KM Labs, ColdQuanta and others can trace their roots directly to NIST and/or JILA.

Regional Academic Institutions

University of Colorado Boulder: As noted above, CU Boulder has strong direct ties with NIST, which is part of the reason for its leading reputation in quantum science. CU is well positioned to be a national leader in quantum research and education and their physics department is ranked among the top 15 in the world (per Academic Rankings of World Universities, 2020). Heather Lewandowski, Associate Chair of the Physics department at CU Boulder and Fellow at JILA noted: "We are partnering with many of the local quantum related companies to both enhance the research and to bring additional opportunities to our students. For instance, we have a new capstone course, where students work on a team on a project sponsored by a local company. The students get insights into what it's like to work in the quantum industry, and are able to develop the skills to make them well prepared to enter the workforce." The University has also established CUbit (pronounced "Q-Bit") which is an interdisciplinary hub that reinforces Colorado's prominence in quantum information science and technology by partnering with regional universities and laboratories and linking closely with quantum-intensive companies. Through CUbit, CU Boulder has a strong focus on quantum research in sensing & measurement, networks & communication, and computing, which it leverages through:

- *Quantum Systems through Entangled Science and Engineering (Q-Sense)*: led by CU Boulder in partnership with seven universities, three national labs and NIST. Prominent quantum researchers collaborate to explore how advanced quantum sensing can reveal new fundamental physics, develop and apply novel quantum technologies, provide tools for a national quantum sensing infrastructure, and train a quantum-savvy workforce.
- *Quantum System Accelerator (QSA)*: a multiorganization initiative established to design and deliver scalable quantum computers within five years.
- *Joint Quantum Engineering Initiative (JQEI)*: Faculty from the College of Engineering & Applied Science and scientific staff from NIST Boulder Labs establish and operate a lab cluster at CU Boulder. JQEI empowers research and development to deliver quantum innovations for adoption by industry and use in society.

CU Boulder also offers a "Quantum Scholars Program" which provides a scholarship and learning opportunities connecting with local industry and quantum applications in the Colorado community.

Colorado School of Mines (Mines): Located in Golden, Colorado, Mines boasts a robust Quantum Engineering Program. Mines launched one of the nation's first quantum engineering programs at the graduate level in the Fall of 2020 with hands-on training on quantum hardware on campus and direct student access through the cloud to Google's quantum computer. The program offers an undergraduate minor and graduate master's degrees (thesis and non-thesis), with specialization tracks in quantum hardware and software, as well as professional upskilling via a graduate certificate for experienced engineers and scientists in industry. Doctorates in the quantum engineering program can be obtained in any of six departments on campus, who all contribute jointly to the program. In 2021 Mines received a $3m grant from the National Science Foundation in the form of a NSF Research Traineeship to support the development of rigorous, integrated and interdisciplinary training programs preparing both master's and doctoral students for careers in the burgeoning field of quantum information science and engineering (QISE), whether for industry, government, academia or national labs. In 2019 the work of Mine's Mark Lusk and University of Denver's Mark Seimens on the possibility of using a laser beam as the medium for quantum science received a $1m grant from the W.M. Keck Foundation. Then in 2021, two physicists at Mines and CU Boulder also received a $1 million grant from the W.M. Keck Foundation to develop a first-of-its-kind quantum simulator that could be used to develop novel materials and, in the future, lead to the development of a high-performance quantum computer. These grants highlight both the importance of quantum research in the area as well as the collaborative nature of these institutions.

University of Denver: Offers Bachelors, Masters and Doctoral degrees in physics. As noted above, in 2019, the W.M. Keck Foundation awarded a grant to fund a collaboration between University of Denver's Mark Siemens and his colleague Mark Lusk at Mines. This inter-university project focuses on the possibilities of using laser light technology to conduct quantum experimentation at room temperature, rather than at ultra-low temperatures. "This new connection is really exciting for us," Siemens said. "It could launch a new age of accessibility for quantum science and, ultimately, computing. Imagine doing quantum measurements and calculations with a glorified laser pointer!"

Colorado State University (CSU): located in Ft. Collins and also situated in the Front Range, still refers to its "quantum" physics department as Atomic, Molecular and Optical Physics, a throwback to this field's early roots, however their quantum work is quite current. Professors and researchers are working on laser spectroscopy of trapped ions and other atoms, single atom detection, ultracold neutral atom plasmas & novel ultracold cooling, atomic clocks, and quantum computing among other areas.

Atom Computing: Atom's headquarters and original R&D machine are in California, but they recently opened a new facility in Boulder where they are creating their production units and have pledged $100 million in investment. Atom has an impressive roster of employees and consultants including Dr. Ben Bloom, a co-founder and CTO, who has deep connections in the Boulder quantum ecosystem including a PhD from CU Boulder, Dr. Jun Ye, a Scientific Advisor, who is a physics professor at CU Boulder, Fellow of JILA and NIST and was recently named member of President Biden's National Quantum Initiative Advisory Committee, and Scientific Advisor Dr. Eliot Kapit who is currently an associate professor of physics and director of quantum engineering at Colorado School of Mines.

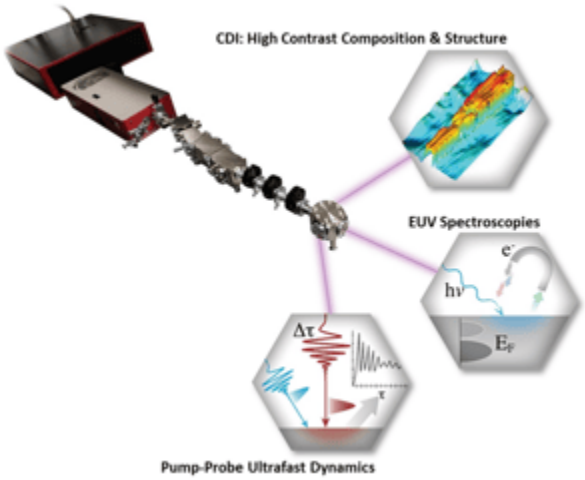
Atom Computing is building scalable quantum computers with atomic arrays of optically trapped neutral atoms. They have published some impressive results using their 100-qubit prototype system and are working on their second-generation systems. They are actively collaborating with software and application developers and were recently selected by the Defense Advanced Research Projects Agency (DARPA) to develop a next-generation system through its Underexplored Systems for Utility-Scale Quantum Computing (US2QC) program.

FieldLine: This Boulder based company was founded by by Orang Alem, Svenja Knappe, and Jeramy Hughs, each with NIST and CU Boulder backgrounds. Dr. Knappe continues her affiliation with CU Boulder as an Associtate Research Professor. The FieldLine HEDscan system is a non-invasive, wearable magnetoencephalography (MEG) device based on their optically-pumped magnetometer (OPM) sensor technology. Small quantum sensors are placed directly on the head to record and map neural activity with high fidelity. These ulta-high sensitivity magnetic field sensors are well suited for recording magnetic brain signals for basic neuroscience or clinical diagnosis and should help improve our understanding of diseases such as Parkinson's or psychiactric disorders. Their lightweight, wearable HEDscan helmets can accommodate people of all ages and head sizes and can be used in any room of any medical facility, without the need for expensive building modifications.

Infleqtion: Infleqtion (f/k/a ColdQuanta) was co-founded by its current CTO Dr. Dana Anderson who is a Fellow of JILA and a Professor in the Dept. of Physics and Electrical & Computer Engineering at CU Boulder. He was a collaborator with Drs. Eric Cornell and Carl Weiman who created the first ever Bose-Einstein Condensate (BEC) at UC Boulder in 1995, a feat for which they were awarded a 2001 Nobel Prize. BEC is a new form of matter, which is created when atoms are cooled close to absolute zero. Infleqtion uses lasers to arrange either cesium atoms (cooled to a few microKelvin, or millionths of a degree for qubits) or rubidium atoms (cooled to nanoKelvin or billionths of a degree to make BEC, where the atoms act as a single quantum object and are used most notably in sensing) and hold them in place. Infleqtion uses this cold atom method across multiple quantum applications including gate-based quantum computers as well as a variety of quantum sensing and signal processing applications such as High Precision Clocks, Quantum Positioning Systems (QPS), Quantum Radio Frequency Receivers (QRF) and Quantum Networking and Communications.

Infleqtion and CU Boulder recently announced a formal collaboration to advance quantum sensing through machine learning techniques focused on applications that require unprecedented positioning and navigation capabilities in real-world environments. Machine learning-enabled quantum signal processing provides a means of leveraging the quantum mechanical aspects of ultracold atom sensors. As Anjul Loiaconoa, VP of Quantum Signal Processing at Infleqtion noted in the press release describing the collaboration: "At Infleqtion, we pride ourselves on our long-standing history of developing deployable compact quantum hardware. Our expertise in this area is unparalleled, and now, by combining it with the cutting-edge capabilities being developed at CU, we are poised to lead in the field of software-defined quantum sensors, a revolutionary solution for today's challenges in navigation."

KMLabs: has deep roots in the area having been spun out of the Kapteyn-Murnane group at JILA. Henry Kapteyn, the co-founder and CTO, is an award-winning researcher in the area of ultrafast optical science. He is a Professor of Physics at CU Boulder and a Fellow of JILA. CEO Daisy Raymondson, received her PhD from CU Boulder and was a graduate research assistant at JILA. KMLabs focuses on delivering the optimized tabletop ultrafast laser sources that span the vacuum ultraviolet (VUV) to extreme ultraviolet (EUV) to soft X-ray (SXR) range of the electromagnetic spectrum—about 1 to 150 nm. Because laser technology has generally been limited to wavelengths only as short as 193 nm, scientific research in the VUV to SXR range has been relatively less explored. With recent developments in high harmonic generation (HHG), research in this area is coming of age and opening up exciting new opportunities for scientific discovery. Specifically, the potential for nanoscale imaging, spectroscopy, and probing ultrafast dynamics are extending the domain of nano and quantum experimentation.

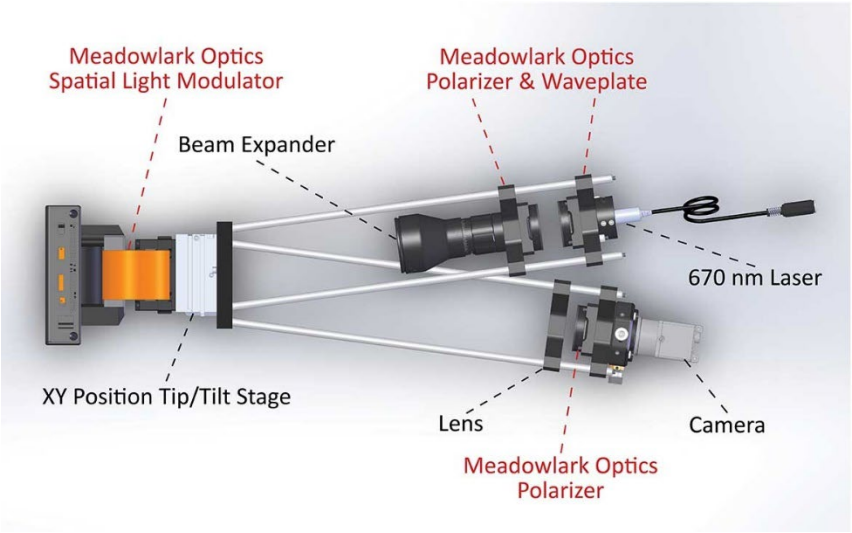


Quantum Microscope

Longpath Technologies: Longpath was co-founded by a group professionals from CU Boulder including Greg Rieker (CTO) who is also an Associate Professor at CU Boulder, Caroline Alden (VP Products and Markets) who spent 7 years at CU Boulder and also worked at NOAA, Robert Wright (VP Engineering) who spent nearly 6 years at CU Boulder as a researcher, and Sean Coburn (Senior Research Scientist) who received his PhD from CU Boulder and has been a Senior Research Associate there for the past 16 years. The core laser technology in the LongPath system was the basis of Nobel Prize-winning work at the University of Colorado and NIST. Their eye-safe, long-path laser systems probe the distinct absorption 'fingerprint' of many different molecules (methane, H_2S, CO_2, H_2O, and more) across 50,000+ wavelengths (colors) of light. LongPath, CU Boulder, and NIST engineers were the first ever to make outdoor fielded measurements using this groundbreaking technology. In addition to applications in energy, LongPath's technology is well suited to penetrate other large markets including agriculture, waste management, mining, and urban monitoring.

Maybell Quantum Industries: Denver based Maybell Quantum has a number of locally grown scientists on its staff. They build the hardware for the quantum revolution, including sub-Kelvin cryogenic systems and superconducting quantum I/O. Many quantum computers must be cooled to nearly absolute zero to operate in a device called a dilution refrigerator (DR). Typically, DRs require hundreds of square feet of specialized lab space. Maybell launched their first product, "The Fridge," in 2022. The Fridge can cool 4X the qubits to 10mK in 1/10th the space of competing platforms and can operate in any space with the right electrical outlet. This year, they followed it up with their "Big Fridge," which has double the cooling power and can fit 10x the qubits in 1/8th the space of competitor's systems. They also offer a line of ultra-high-density superconducting RF ribbon cables or "Flexlines" which reduce the thermal load and vibrational noise common in traditional cryogenic wiring. Maybell's products are critical hardware to many qubit modalities, including superconducting, topological, and some photonics-based systems, as well as condensed matter physics, low temperature physics, quantum sensing and other applications.

Meadowlark Optics: In 1979, Tom Baur, a researcher at the nearby NCAR (National Center for Atmospheric Research), needed a solution that resulted in manufacturing his own custom Pockels cells. With that flagship product, word spread and Meadowlark Optics quickly became a place to turn to for custom polarization optics. Today Meadowlark Optics designs, develops and manufactures an extensive range of high-quality polarization systems and components including liquid crystal devices from ultraviolet to Middle-wave infrared. Standard products include shutters, rotators, waveplates/retarders, spatial light modulators, tunable optical filters, tri-color filters, polarizers, polarimeters and more.



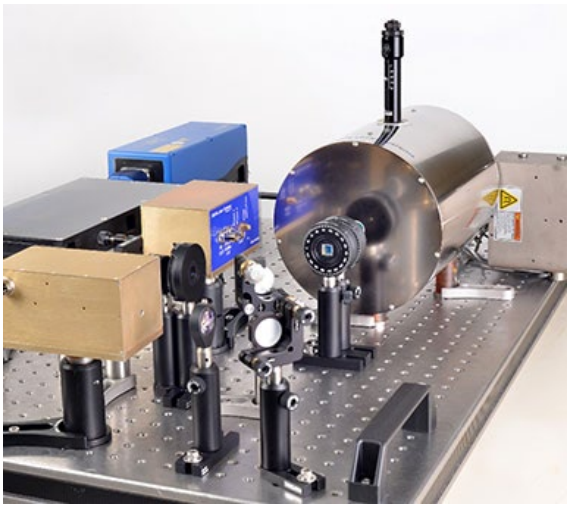
Octave Photonics: is another company with deep local quantum-DNA. Octave Photonics was founded in 2019 by David Carlson and Zach Newman when they were postdocs in the Time and Frequency Division at NIST. They were joined in 2021 by Daniel Hickstein, another former NIST post-doc and CU Boulder PhD, who worked at nearby KMLabs for three years before moving over to Octave. In addition to the NIST origins, the Company continues to collaborate with the QNS group at NIST and the Diddams group at CU Boulder, as well as local companies Vescent Photonics and Infleqtion. Octave Photonics enables next-generation laser systems by packaging nanophotonic chips into ready-to-use devices. Their nonlinear photonic devices provide precise control over the optical spectrum of a laser system, allowing laser frequency combs to be constructed with unprecedented compactness and robustness. Their products are used for supercontinuum generation, low-power frequency combs, and optical atomic clocks.

Device for Supercontinuum Generation Powered by Nanophotonic Chip

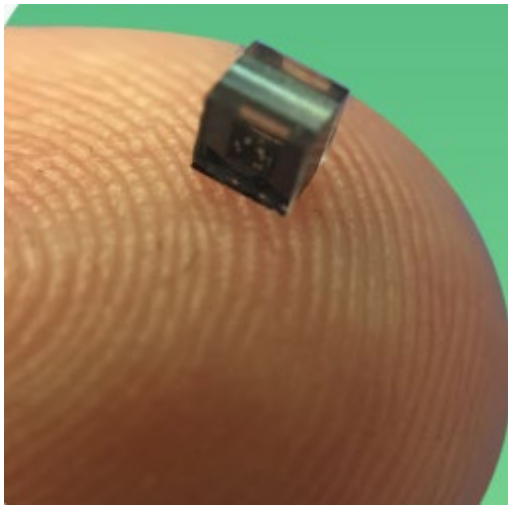
QuSpin: Louisville, Colorado based QuSpin was founded by Vishal Shah, another UC Boulder PhD. The current team includes Daniel Barry, an engineer from CU Denver and Jeff Orton a Senior Engineer educated at Colorado State University. QuSpin builds optical atomic magnetometers for biomedical and geophysical applications. Their technology is based on optically pumped magnetometers (OPM's) which are passive field sensors comprised of a laser source, glass vapor cell containing 'sensing' atoms in a gaseous state, and a photodetector. Their recently released Neuro-1 is a state-of-the-art, integrated OPM sensor system designed for high-channel biomagnetic applications such as Magnetoencephalograpy (MEG).

Quantinuum: is the world's largest standalone quantum computing company, formed by the combination of Honeywell Quantum Solutions' hardware and Cambridge Quantum's middleware and applications. Quantinuum accelerates quantum computing and the development of applications across chemistry, cybersecurity, finance and optimization. Its focus is to create scalable and commercial quantum solutions to solve the world's most pressing problems in fields such as energy, logistics, climate change, and health. This past week Quantinuum announced the release of their trapped-ion System Model H2 which was built in their Broomfield, Colorado U.S. Headquarters. This second-generation system currently features 32 fully connected qubits with impressive performance metrics including a world record Quantum Volume of 65,536 (2^{16}), 99.997% single-qubit gate fidelity and 99.8% two-qubit gate fidelity. [Watch *The Quantum Leap* Blog for an upcoming post featuring Quantinuum].

Stable Laser Systems (SLS): was formed in 2009 by Mark Notcutt, who trained with Jan Hall (2005 Nobel Prize winner) at JILA and for which Hall remains a consultant. Their aim is to provide best-in-class frequency stabilization products to the market. SLS offers complete systems which deliver narrow, stable linewidth lasers right "out of the box." Their 1 Hz Stabilized Laser System provides < 1 Hz linewidth at 1530-1575 nm and less than 20 kHz daily drift from a relatively modest footprint (19" 6U rackmount box) with a convenient single-switch lock function. They also offer customized breadboard-based systems for various R&D requirements. Their products are used for atomic clocks, atomic laser cooling and trapping, high-precision spectroscopy, long-range radar and sensing, time distribution and a number of other applications.



Vapor Cell Technologies: Vapor Cell Technologies (VCT), based in Boulder, specializes in designing, manufacturing, integrating, and selling chip-scale vapor cells, the core components of quantum 1.0 technologies such as atomic clocks and atomic sensors. By harnessing the unique, quantum-noise-limited properties of atomic and molecular vapors, VCT's aim is to create robust, reliable, and consistent vapor cells that can transition quantum technologies from laboratory demonstrations to market-ready applications.



VCT's work has garnered the support NIST, the National Science Foundation (NSF), the Department of Defense (DoD), the MEMS & Sensors Industry Group (MSIG), as well as various small businesses and publicly traded companies. Utilizing semiconductor techniques and methodologies, VCT leverages the highly evolved materials, processing, and analytics found in the semiconductor industry to produce "bulletproof" devices. This approach enables them to integrate thin films for optical, electrical, and anti-corrosive properties essential for customizable quantum systems. They provide wafer-level services and multi-project wafers to clients, and have successfully produced Rubidium, Cesium, Iodine, and exotic species of vapor cells in mm-scale geometries.

Doug Bopp, VCT's founder, who received his PhD from UC Boulder and worked as a research assistant at NIST, confirmed the Company's local connections noting "above all, we are committed to fostering a thriving quantum ecosystem. Building on our extensive experience at NIST, we apply state-of-the-art metrology and fabrication solutions to produce chip-scale vapor cells. We recognize the diverse range of atomic technologies, each requiring high-fidelity components, and are dedicated to supplying these essential elements to quantum engineers as they develop next-generation products with pioneering components."

Vescent: was founded by Mike Anderson, Scott Davis and Scott Rommell, each of whom has strong Colorado lineage. Drs. Anderson and Davis received their PhDs from JILA at CU Boulder and Scott Rommell studied physics at nearby University of Northern Colorado. Dr. Davis is particularly well entrenched in the local quantum infrastructure, serving on the Steering Committee of the Quantum

Economics Development Consortium (QED-C) and Vescent is active with CUbit and the Colorado Photonics Industry Association (CPIA).

OEM Frequency Comb Module

Vescent specializes in precision optics that operate nearly all quantum devices. It provides the "picks and shovels," which are technologically enabling components, to nearly every aspect of the quantum ecosystem. Vescent offers a suite of technologically advanced products and has successfully evolved from providing niche R&D focused products (albeit widely admired and respected by researchers) to rugged, field deployable components and OEM products. Vescent is the leading designer and manufacturer of lasers, electro-optic tools, and control electronics used in precision optical measurements based on the quantum nature of physical systems. They focus on providing low-SWaP (size, weight and power), truly field-deployable products which enable state-of-the-art timing, time transfer, frequency transfer, quantum computing, precision navigation in both GPS-enabled & GPS-denied environments, next-generation spectroscopic techniques. Vescent recently leveraged its active local quantum connections by winning a $16 million contract from the Office of Naval Research (ONR) to develop portable atomic clocks under the Compact Rubidium Optical Clock (CROC) program in collaboration with Infleqtion, Octave Photonics and NIST.

Xairos: located South of Denver in Lone Tree, Colorado (and setting up a Boulder office), is a space and technology company that is revolutionizing time synchronization. They have successfully built a proof-of-concept (POC) demonstrating their patented quantum technology providing orders of magnitude better accuracy and security than GPS can deliver. Governments and network operators worldwide are looking for a more accurate GPS alternative to enable technologies such as 6G, autonomous vehicles, and quantum networks. Xairos' POC has demonstrated time synchronization that is >1,000x more accurate than GPS, solving a considerable problem for new technologies and applications. GPS represents a single point of failure for critical national infrastructure. Xairos's patented technology is highly advanced and secure, eliminating the hacking and signal jamming to which GPS is prone. Their system could reduce expensive outages that disrupt travel, degrade network performance, and even eliminate national threats like the interference from Russia in Ukraine. CEO David Mitlyng recently joined a Colorado quantum delegation for a trip to Finland, organized by the Colorado Office of Economic Development and International Trade, where he was joined by local colleagues from Atom Computing, Maybell, NIST and others.

Companies with Denver-Boulder Quantum Presence

LOCKHEED MARTIN

FORMFACTOR™

THORLABS

FormFactor: is a semiconductor test and measurement provider that has an office in Boulder, which it maintained after acquiring High Precision Devices, a maker of cryogenic probe systems and cryostats used in the development of quantum computing, superconducting computing and ultra-sensitive sensors.

The location now enables quantum developers to leverage FormFactor's state-of-the-art Advanced Cryogenic Lab to characterize qubits and resonators using cryostats with groundbreaking probe sockets to accelerate development cycles by more than 2X, with no up-front capital investment.

Lockeed Martin: entered into a Master Research Agreement with CU Boulder in 2019 and in 2022 broadened its local quantum presence by joining CUbit's partnership program. As noted in a press release at that time: "Lockheed Martin recognizes the value of collaborating across the entire innovation spectrum and our engagement with CUbit Innovation Partners is an important extension of our existing alliance with CU Boulder," said Valerie Browning, vice president, Research and Technology at Lockheed Martin. "This new quantum focus will provide Lockheed Martin access to cutting-edge quantum sensing research while providing CU Boulder visibility into real world applications that may benefit from a quantum advantage."

Thorlabs: is a multinational vertically integrated photonics products manufacturer. They maintain a laser manufacturing facility in Lafayette, Colorado and supply an array of photonics equipment for quantum technologies and applications including single photon sources and detectors, single-crystal diamonds with nitrogen-vacancy centers, mirror mounts, turnkey ultra-low noise lasers and related items.

Select Local Collaborations

Vescent/Infleqtion/Octave Photonics/NIST: In December 2021, Vescent Photonics was awarded a contract worth up to **$16.2 million** to develop portable atomic clocks for the Office of Naval Research (ONR) Compact Rubidium Optical Clock (CROC) program, which will be fulfilled by the consortium of local companies noted in the Vescent description above. The group aims to improve upon existing commercial atomic clocks by interrogating a two-photon optical clock transition in a warm vapor of rubidium (Rb) atoms.

CUbit: As noted above, CUbit is an agency affiliated with CU Boulder, partnering with industry to catalyze advancement of quantum information technologies and strengthen the regional quantum ecosystem. Its Innovation Partners include Atom Computing, Infleqtion and Meadowlark Optics and its Community Partners include Vescent, Maybell and Octave Photonics.

Microelectronics Commons: is a national network that will create direct pathways to commercialization for microelectronics researchers and designers from "lab to fab." It is a program of the Department of Defense funded by the recently passed CHIPS and Science Act of 2022. Vescent, Infleqtion, Honeywell, Quantinuum and Octave Photonics have teamed up to participate in this program.

Summary

I have been quite impressed with the vibrancy of this local quantum community and look forward to meeting more of the participants. I hope readers have a broader appreciation for the energy and dynamics of this environment, and I look forward to providing further updates. For ease of learning more or contacting any of the companies or people noted in this post, below is a table of entities mentioned along with hyperlinks to their websites:

Entity	Focus
NIST	Federal agency
JILA	Research institution
University of Colorado Boulder	University
Colorado School of Mines	University
University of Denver	University
Colorado State University	University
Atom Computing	Neutral atom quantum computing
FieldLine	Medical sensors
Infleqtion	Neutral atom quantum technologies
KMLabs	Laser sources
Longpath Technologies	Laser probes
Maybell Quantum Industries	Cryogenic systems
Meadowlark Optics	Optics
Octave Photonics	Optics
QuSpin	Medical sensors
Quantinuum	Trapped ion quantum computing
Stable Laser Systems	Frequency stabilization
Vapor Cell Technologies	Vapor cells
Vescent	Photonics
Xairos	Time synchronization

***Disclosure**: The author does not currently have any business relationship with any company mentioned in this post. The views expressed herein are solely the views of the author and are not necessarily the views of Corporate Fuel Partners or any of its affiliates. Views are not intended to provide, and should not be relied upon for, investment advice.*

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Russ Fein is a venture investor with deep interests in Quantum Computing (QC). For more of his thoughts about QC please visit the link to the left. For more information about his firm, please visit Corporate Fuel. Russ can be reached at russ@quantumleap.blog.