The Quantum Leap
January 17, 2023

Quantum Computing with Neutral Atoms

In an early Quantum Leap post back in December 2021, I wrote about the various qubits being used to drive Quantum Computers (QC) and neutral atoms didn't make it into the post. When I revisited the QC landscape in October of last year, four neutral atom companies made the list, representing a significant advancement in that modality. There are numerous strengths to this approach, which I'll describe in greater detail below, but to pique your interest in learning more, consider the following recent announcements by neutral atom companies:

- Infleqtion (f/k/a ColdQuanta) completed a **$110 million Series B equity round**
- Professor Alain Aspect, a co-founder of PASQAL, was awarded the **2022 Nobel Prize in Physics**
- Atom Computer had a ribbon-cutting ceremony for the opening of its **new $100 million facility** in Boulder, Colorado
- QuEra's 256-qubit Aquila **QC was made available on Amazon's Bracket**, its cloud-based QC platform

Why the recent surge in jaw-dropping announcements? Why are neutral atoms seeming to leapfrog other qubit modalities? Keep reading to find out.

The table below highlights the companies working to make Quantum Computers using neutral atoms as qubits:

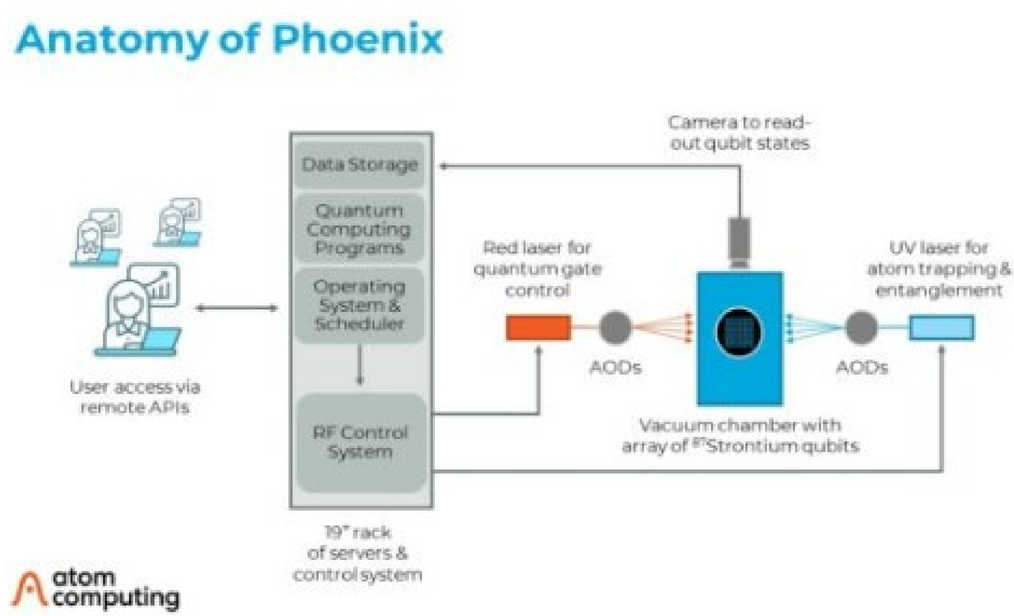
Company	QC Modality	Note/Comment
PASQAL	Analog	324 qubit processor gaining increasing commercial success but not yet generally available
QuEra	Analog	256 qubit machine publicly accessible via Bracket
planqc	Analog	Early-stage spin-out from Max Planck Institute; access to their machine not yet available
atom computing	Digital/Gate Based	100 qubit processor not yet generally available, but select beta customers utilizing
Infleqtion	Digital/Gate Based	100 qubit processor not yet generally available, but select beta customers utilizing

And as an added feature I am writing this post to be "entangled" with the posts of Brian Siegelwax, a respected colleague and quantum algorithm designer. My focus will be on the hardware and corporate details about the companies involved, while Brian's focus will be on actual implementation of the platforms and what it is like to program on their devices. Unfortunately, most of the systems created by the companies noted in this post are not yet available (other than QuEra's), so I will update this post along with the applicable hot-links to Brian's companion articles, as they become available.

Neutral Atoms as Qubits

Neutral Atoms, sometimes referred to as "cold atoms," are built from an array of individual atoms that are trapped in a room-temperature vacuum by using lasers as optical "tweezers" to restrict the movement of the individual atoms and thereby chill them (hence the "cold atom" reference). These neutral atoms can be put into a highly excited state by firing certain laser pulses at them which expands the radius of the outer electron(s) (a Rydberg state), which can be used to entangle them with each other, among other features.

While there are a few notable differences among the approaches the neutral atom players use, there are also many similarities. The graphic below highlights the Atom Computing set-up which is representative of the broad cold atom approach. It includes two sets of lasers and related controllers and AOD's (acousto-optic deflectors), a vacuum chamber, and a photon-sensitive camera to read results.



Let's drill down a bit further to explain a bit more of the underlying science.

Each of the players focused on neutral atoms uses elements from either the first column of the atomic periodical table (alkali metals such as Rubidium or Cesium) or second column (alkali earth metals such as Strontium). In either case, there are equal numbers of electrons and protons among those elements and so the electrical charges balance out, hence the "neutral" label. The alkali metals have a single electron in the outer orbit whereas the alkali earth metals have two electrons in the outer orbit (some believe the two valence electron configuration, which is a "closed shell", provides greater stability and protection from external noise). It is the focus on these outer electrons which produce the quantum-mechanical effects that drive the algorithms or desired analog activity.

In a neutral-atom quantum processor, atoms are first heated to a gaseous cloud and then suspended in an ultrahigh vacuum via arrays of tightly focused lasers of specific wavelengths, often referred to as "optical tweezers." Every element reacts to very specific wavelengths of light, so can be manipulated by lasers tuned to those specific wavelengths. These optical tweezers can also be used to configure the atoms into specific geometric arrays. For digital, gate-based computation, single-gate and multiple-gate implementations can be programmed via differing light pulses. Rob Hays, CEO of Atom Computing (and a deep veteran of the computing industry as former Chief Strategy Officer of Lenovo and a 20-year leadership tenure at Intel where he led the Xeon processor roadmap) explained that "every element has a magic wavelength of light that allows atoms to be captured by optical tweezers." He further noted that "with a different wavelength of light, we can effectively control the spin of the nucleus in any position in three dimensions…and that's how we create single qubit gates…and then what we can do is create entanglement with two qubit gates by using different wavelengths of light to excite the electron cloud into what's called a Rydberg state where the radius of the electron orbit gets much larger to the point where it crosses paths with neighboring atoms and gets entanglement." This is the foundation for one of the key strengths of neutral atoms QC, namely its strong connectivity. For analog operations the tweezer moves the atoms into the desired configuration and other laser or microwave pulses then trigger the atoms into performing Hamiltonians (more on this as well as the various differences between the digital and analog approach below). In both cases, the final results are read out optically.

Some important characteristics of neutral atom-based qubits include:

- **Exceptionally Long Coherence Times**: Leading super-conducting and photonic Quantum Computers have achieved coherence times measured in microseconds (millionths of a second), which doesn't provide much time to run algorithms (although they also have very fast gate speeds). Neutral atom players generally enjoy coherence measured in full seconds and, in fact, Atom Computing published a paper in *Nature Communications* in May 2022 touting **coherence times exceeding 40 seconds**.
- **Strong Connectivity**: The topography of the neutral atom structure is quite flexible, and these modalities typically enjoy robust connectivity among qubits, often achieving all-to-all connectivity. In fact, neutral atoms can also implement multi-qubit gates (involving more than 2 qubits such as a CCNOT or Toffoli Gate) and can even implement 3-level qubits or "Qutrits".
- **Scalability**: Because neutral atom players use "atoms" and since all atoms of a given element isotope are intrinsically identical, all qubits based on such elements are identical to each other. In addition, since there is no ionic charge contained in the elements being

used, the atoms can be packed into tight arrays, often only microns apart. Also, rather than a sperate laser for each qubit, since the atoms are manipulated by common wavelengths, lasers of a specific wavelength can be split into "beamlets" in order to control multiple atoms.

- **External Cryogenics Not Required**: Modalities which require cryogenic chillers are burdened with significant added overhead and must typically contend with long chill-up/chill-down cycles.
- **Reduced Wiring Complexity**: All of the functions to control the neutral atoms are performed via light propagating through free space. This is opposed to superconducting qubits which require multiple electrical cables for each qubit.
- **Can be Operated in Analog or Digital Mode (or both)**: Digital or gate-based operations are required for full algorithm development, but some early quantum advantages may be achieved utilizing qubits geometrically or in analog mode. This is an important distinction, so I will elaborate further in the next section.
- **Leveraging Three Decades of Legacy Research**: While using neutral atoms in quantum computing is relatively new, the neutral atom technology has been successfully deployed in other physics research, and has powered the word's most accurate atomic clocks for many years. The laser-cooling technology is based research that led to the 1997 Nobel Prize and optical tweezers are based on research that led to the 2018 Nobel Prize.

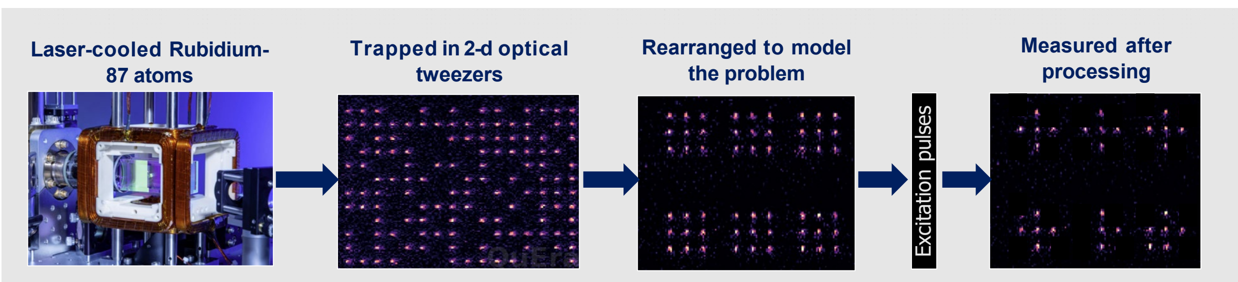
While this is an impressive feature list, neutral atom quantum computers are relatively new to the Quantum Computing landscape and have yet to showcase important real-world results. There are also meaningful technological challenges in refinement of the lasers and the ultra-high vacuums. Dr. Mark Saffman, Chief Scientist for Quantum Information at Infleqtion and Professor of Physics at the University of Wisconsin-Madison, had tremendous insights for me regarding the differences among analog and digital mode for neutral atom QC, and noted that Infleqtion has "recognized the challenges of some of the specialized laser systems being used," and noted that they are "working with partners on developing more integrated laser technology…with a real challenge currently being developing faster calibration and tuning routines in order to keep the machines in a calibrated state." That said, Infleqtion and their netural atom peers are advancing at a furious pace, and I expect significant progress to be made in 2023.

Analog vs Digital/Gate Mode

Richard Feynman is often cited as the father of quantum computing and he is credited with saying "…trying to find a computer simulation of physics seems to me to be an excellent program to follow… and nature isn't classical dammit, and if you want to make a simulation of nature, you'd better make it quantum mechanical…" While Feynman said this in 1981, well before today's Quantum Computers were possible, he was quite prescient. He wasn't referring to algorithms or gates or quantum computer code, he was talking about literally simulating nature and that is what some of these neutral atom companies are offering today in analog mode.

Many of you are likely familiar with "digital quantum" algorithms where the information is encoded into single and multiple-qubit functions which are driven by a series of commands or gates, much like traditional computers are currently programed. The specific steps and their order are vital to a successful code or algorithm and there is an art to how such commands are created and sequenced. Most press about QC covers this "digital" mode, and the fidelities and speeds of the gates as well as the length of coherence are two of the bigger hurdles being addressed by today's players. The challenges facing current digital QC approaches are rooted in the fidelities of the systems, which are quite fickle today and subject to many disruptive factors or "noise" *(see a prior post about this noise here).

"Analog quantum" computing also uses qubits and the various quantum mechanical properties that power digital quantum computers (superposition, entanglement and wave properties, etc.) but there are no gates. The exquisite control required to execute gates is one of the major hurdles facing QC development and by circumventing the need to utilize gates, analog quantum computing has surpassed the digital mode on a number of fronts. By transforming certain problems into a "geometric" structure (like Feynman suggested) instead of a sequential gate-based formula, results can be derived without gates. As Alex Keesling, CEO of QuEra told me, "…whereas in gate-based [digital] quantum computing the focus is on the sequence of the gates, in analog quantum processing it's more about the position of the atoms and where you place them so they can mirror real life problems. We arrange the atoms and define the forces that drive them and then measure the result…so it's a geometric encoding of the problem itself."



It took me a while to appreciate this difference, and it is only useful for a certain subset of problem type but given that analog quantum computers require less engineering overhead versus digital Quantum Computers, they are already providing meaningful results and can operate with a larger number of qubits (such as QuEra's Aquila QC with its 256 qubits and PASQAL's Fresnel with 324 qubits). So let me explain this further.

Analog quantum computers utilize a paradigm of quantum computing which utilizes the conversion of a problem into a mathematical object known as a Hamiltonian. The Hamiltonian is an operator that corresponds to the total energy of a system, including both kinetic and potential energy. It is somewhat similar to how some companies, such as D-Wave, are using quantum annealing as a way to measure the global minimum energy of a system to get useful output from today's noisy Quantum Computers. The "Traveling Salesman Problem" is a typical optimization problem (e.g., finding the shortest or least expensive route for the salesman to follow to cover all of his customers, or finding the best placement of cell-phone towers to cover a given area). However, in addition to optimization problems, quantum analog computers can also solve for problems in chemistry simulation and material engineering. Specifically, geometrically creating a "digital twin" of the systems under study and then using the Hamiltonian functionality of the analog processing, users can better understand underlying physics, phase transitions of materials and dynamics of particle collisions, among other features. Further, given the analog mode's ability to parse sets of data into subsets via Hamiltonian simulations, it is also showing increasing promise in machine learning.

In summary, Analog mode for neutral atom Quantum Computers is showing near-term utility for certain classes of optimization and material engineering problems as well as accelerating quantum machine learning. Currently, each of QuEra and PASQAL are using 2D arrays of neutral atoms in their analog processors. They also have the capability of using 3D arrays (as the technology further evolves), which would provide even greater power from their geometric approach and can also eventually use an analog-digital hybrid approach with the same neutral atom technology. It will be fascinating to watch as the analog and digital approaches scale, and to see which company is able to provide the fastest path to quantum advantage.

The Leading Neutral Atom Players

A special thanks to Yuval Boger and Brian Siegelax and to Georges-Olivier Reymond of Pasqal, Alexander Keesling of QuEra, Rob Hays, Mickey McDonald, and Kortny Rolston-Duce of Atom Computing and Mark Saffman, Max Perez and Sarah Schupp of Infleqtion for their patience and insights about their companies as well as Quantum Computing more generally. Many of the details in this post were derived from my conversations with them.

PASQAL

Year Founded:	2019
Headquarters:	Paris, France
Funding to Date:	$44 million
CEO:	Georges-Olivier Reymond
Neutral Atom:	Rubidium
Current Quantum Mode:	Analog

The Nobel Prize in Physics for 2022 was awarded to Alain Aspect, John Clauser and Anton Zeilinger "for their experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science." Professor Dr. Aspect eventual shifted his research focus from photons to neutral atoms and partnered with Georges-Olivier Reymond and Chrstophe Jurczak to create PASQAL. In fact, PASQAL is the first quantum computing company with a Nobel Prize winning co-founder. In September of last year, PASQAL unveiled "Fresnel", its 324-qubit quantum processor, and they expect a 1000-qubit machine to be available next year.

PASQAL is advancing neutral atom Quantum Computers focused on Analog mode and has already amassed an impressive roster of customers (including BMW, Airbus, LG, Siemans, Saudi ARAMCO and others) and use cases. For example, the company has developed a Quantum Machine Learning algorithm applicable to smart grids, aiming to improve the efficiency of electricity distribution. As noted above, Analog quantum computing has interesting applications in problems that can be structured graphically, such as for material design and for optimization. According to PASQAL, some of the world's most interesting data is relational and can be encoded in graphs: nodes and links in a network, financial indicators (for portfolio risk optimization) and atoms in a molecular diagram. Graph structures can be rich sources of information, allowing the system to uncover hot spots in a network, clusters in a dataset, or infer function from structure in chemical compounds. Such problems are extremely hard to solve with classical computers but lend themselves to Analog quantum computing. As Georges Reymond told me, "you just need quantum developers that are smart enough to design the specific Hamiltonian that you need. Alternatively, we have a team that can help you do that." He added that "since you are programming very close to the qubits, you can change the geometry of the register into any shape you want." He also noted that their Pulsar tool, which is a Python library of applicable primitives, and related Pulsar Studio which uses a no-code graphical interface to help address the given problem and then automatically generates the line code required, making utilization of analog QC mode more accessible.

While Fresnel is not available other than to existing customers (and so my colleague Brian Siegelwax was not able to test it out himself although he has access to Pulsar and Pulsar Studio), the strong client roster is testament to its general utility. I look forward to PASQAL making its machine(s) more broadly available and to seeing how Brian gauges its utility.

QuEra

Year Founded:	2018 – with roots based at Harvard and MIT
Headquarters:	Boston, MA
Funding to Date:	$17million
CEO:	Alexander Keesling
Neutral Atom:	Rubidium
Current Quantum Mode:	Analog

Full-stack Quantum Computing firm QuEra, based in Boston, traces its roots to quantum research performed at nearby Harvard University and MIT. Their signature 256-qubit Quantum Computer known as "Aquila" is available now for general use on Amazon Braket, and is complemented by their Bloqade open-source software and GenericTensorNetworks algorithm platform. The management team is quite strong and the fact that they are the first neutral atom player to broadly offer access to their QC, gives them a bit of a front-runner status in the neutral atom field. While their underlying technology and approach can apply to digital gate-based algorithms, they have opted instead to focus on analog processing. Their field programmable qubit arrays (FPQA) offer near-arbitrary configurations of atoms and highly flexible connectivity. Aqila promises rapid development cycles, easy geographic encoding of problems and the exploration of exotic topologies.

The Company has generated 11-figures of R&D and development income from a broad array of government agencies and commercial customers and is the only neutral atom quantum computing company that has made its systems generally available to the public (albeit at a somewhat limited 10 hours per week). Management encourages users to try the platform and they are interested in real-world feedback, including error analysis, so they can utilize the input to further evolve their technology. Brian Sieglewax is generally bullish on Aquila as he describes in a recent post [hyperlink will be added once Brian publishes the companion piece]. I applaud QuEra's accessibility focus and firmly believe that QC makers will learn the most, and gain the quickest technological progress, with diverse direct feedback from users, warts and all. The mix of QuEra's strong management team and current availability of their system, suggests they will continue to make rapid and important progress. I look forward to following progress along their roadmap and to learning what novel applications users are able to execute.

Atom Computing

Year Founded:	2018
Headquarters:	Berkeley, CA (with key new facility in Boulder, CO)
Funding to Date:	$80 million
CEO:	Robert Hays
Neutral Atom:	Strontium

I recently had the benefit (and pleasure) of spending some time with Rob Hays, via video call, as well as an on-site tour of the new Atom Computing facility in Boulder, led by Mickey McDonald (Principal Quantum Engineer) and Kortney Rolston-Duce (Director of Marketing and Communications), who also indulged me with a private white-boarding session where they did their best to answer all of my Quantum neutral atom 101 questions, and which (finally) helped connect many of the dots that had been swimming around my head. All of these interactions were immensely informative, and I was impressed with the team and with what I learned. Atom's headquarters and original R&D machine are in Berkeley, but they are using Boulder to create their production unit(s). In fact, they have an interesting approach in simultaneously creating twin machines with the intention of always maintaining customer access to one, while any upgrades or maintenance are performed on the other. Given their lack of requiring cryogenic freezers, their QC's are not the usual chandeliers many of us are familiar with, but instead are room-sized "black boxes" housing all their optics and the majority of the controllers in various modularized sections.

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, and Dr. Jun Ye, their Scientific Advisor, who is a physics professor at nearby CU Boulder, Fellow of the Joint Institute for Laboratory Astrophysics (JILA) and the National Institute of Standards and Technology (NIST) and was recently named member of President Biden's National Quantum Initiative Advisory Committee. They also have an enviable roster of investors including Venrock, Innovation Endeavors, Prelude Ventures, Prime Movers Lab, and Third Point Ventures, among others.

While they have published some impressive results from their Quantum Computers including "Phoenix", their first-generation platform, they have opted not to make Phoenix publicly available (although it is accessible by select early customers). However, they are working furiously on their second-generation systems which they plan to make available online via a Quantum Computing as a Service (QCaaS) model. They are actively collaborating with software and application developers and I look forward to feedback from users (including Mr. Siegelwax), once Atom makes their systems more widely available.

Infleqtion (f/k/a ColdQuanta)

Year Founded:	2007
Headquarters:	Boulder, CO
Funding to Date:	$182 million
CEO:	Scott Faris
Neutral Atom:	Cesium

Infleqtion, located a bike-ride away from Atom Computing, traces its roots to 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 neutral atoms 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 as well as some of the fundamental components used by others (i.e., ultra-high vacuum cells). While Quantum Computing steals most of the "quantum" headlines these days, these other devices bring enormous advances in their fields and, importantly, current revenues. I have been fortunate to know a number of management members of Infleqtion and have been closely following their progress since an original blog post in April 2022 about Collaborations and a follow-up dedicated to ColdQuanta in May 2022.

Infleqtion had a number of important milestones noted in 2022 including:

- Completion of a $110 million B-round, including A$29 million earmarked to create a Quantum Technology Centre in Australia.
- Acquisition of Super.tech, a leading developer of quantum software and related platforms, and announced collaboration with Morningstar to integrate Super.tech's SuperstaQ software into Morningstar Direct.
- Participation as a subcontractor on the Office of Naval Research's Compact Rubidium Optical Clock program, valued at up to $16.2m.
- "Albert," their BEC design device, was named one of TIME's Best Inventions of 2022 and winner of the 2022 Prism Award, Quantum.
- Won the 2022 Best of Sensors Award, for their high performance test and calibration instrument known as "Maxwell."
- Dr. Fred Chong, Chief Scientist for Quantum Software, was named IEEE Fellow for his Enabling Practical-scale Quantum Computing (EPiQC) project.
- Dr. Bob Sutor, VP and Chief Quantum Advocate, testified at Senate committee hearings regarding the importance of Quantum Computing technologies.

While neither Albert (BEC design platform) nor Hilbert (their 100 qubit QC unit) are regularly available to the public, they continue to make progress advancing both systems and I look forward to an update from Mr. Siegelwax once those systems can be tested. In the meantime, Infleqtion continues to generate meaningful revenues and advance the technologies of its broad quantum-related components and I'm certain they are leveraging their learnings across their portfolio.

[Note: "**planqc**", a recent graduate of the Creative Destruction Lab startup incubator, is the newest entrant to the neutral atom field, and is included in table of players, but was not covered in detail in this post due to its very early stage. I look forward to providing more details on planqc in future posts.

Conclusion

While neutral atom Quantum Computing is not without its shortcomings, has yet to supply consistent and robust performance, and lags being other modalities that have been accessible longer (i.e., superconducting and ion trap modalities), they are gaining strong momentum and feature important theoretical advantages. If the speed of innovation in 2022 is a harbinger of the rate of progress we should expect in 2023, I am excited to the prospect of reporting on this progress and look forward to providing updates.

Disclosure*: The author does not 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.*

References:

Hays, Rob, CEO of Atom Computing, Interview conducted by author on Nov. 17, 2022.

Keesling, Alex, CEO of QuEra, and Boger, Yuval, Consultant, Interview conducted by author on Nov. 10, 2022.

McDonald, Mickey, Principal Quantum Engineer Atom Computing and Rolston-Duce, Kortny, Director of Marketing and Communications Atom Computing, Interview conducted by author during site tour on Nov. 17, 2022.

Reymond, Georges-Olivier, CEO of PASQAL, Interview conducted by author on Nov. 15, 2022.

Saffman, Mark, Chief Scientist for Quantum Information, Infeqtion, Interview conducted by author on Dec. 16, 2022.

Barnes, Battaglino, Bloom, Casella, et. al., "Assembly and coherent control of a register of nuclear spin qubits," *Nature Communications*, May 19, 2022.

Brubaker, Ben, "Versatile neutral atoms emerge as an intriguing quantum computing platform," Physics Today, August 24, 2022.

D., Kyrlynn, "Quantum Physics – Neutral Atoms could be the next big thing in the Quantum Industry, but why," *Quantum Zeitgeist*, December 8, 2022.

Dargan, James, "Review of PASQAL's Quantum Computing Technology in 2022," The Quantum Insider, November 21, 2022.

Ebadi, Keesling, Cain, Wang, Levine, et. al., "Quantum Optimization of Maximum Independent Set using Rydberg Atom Arrays," Quantum, February 18, 2022, arXiv:2202.09372v1 **[quant-ph]**

Finke, Doug, "QuEra Launches Their 256 Qubit Analog Quantum Processor on AWS," Quantum Computing Report, November 1, 2022.

Ging, Justin, "What Developers Need to Know about our Atomic Array Quantum Computing Technology," www.atom-computing.com, October 20, 2022.

Gemelke, Nate, "Guest Post: A Different Path to Achieving Industry-relevant Results," *The Quantum Insider*, November 7, 2022.

Goudelis, Spyros, "Professor Alain Aspect, co-founder of PASQAL, receives Nobel Prize in Physics 2022," from www.pasqal.com, October 5, 2022.

Graham, Song, Scott, Poole, Phuttitarn, et al., "Multi-qubit entanglement and algorithms on a neutral-atom quantum computer," Nature, April 21, 2022.

Lee, Jane Lanhee, "Atom Computing to invest $100 mln in Colorado for quantum computer center," *Reuters*, September 28, 2022.

Leseleue, Lienhard, Scholl, Barredo, Weber, Lang, Buchler, Lahaye and Browaeys, "Quantum Simulation – Observations of symmetry-protected topological phase of interacting bosons with Rydberg atoms," *Science*, August 23, 2019.

Mohseni, Naeimeh, McMahon, Peter L. and Byrnes, Tim, "Ising machines as hardware solvers of combinatorial optimization problems," Nature Reviews Physics, May 4, 2022.

O'Shea, Dan, "QuEra makes first neutral-atom system available on Amazon Braket," *Inside Quantum Technology*, November 9, 2022.

Roberts, Siobhan, "This new startup has built a record-breaking 256-qubit quantum computer," *MIT Technology Review*, November 17, 2021.

Silverio, Henrique, "Towards quantum advantage with efficient graph implementation", from www.pasqal.com, April 10, 2022.

Silverio, Henrique, "PASQAL unveils a new quantum processor architecture with a record 324 atoms," from www.pasqal.com, September 13, 2022.

Silverio, Grijalva, Dalyac, Leclerc, et. al, "Pulsar: An open-source package for the design of pulse sequences in programmable neutral-atom arrays," *Quantum*, January 11, 2022, arXiv:2104.15044v3 **[quant-ph]**.

Smith-Goodson, Paul, "Atom Computing: A Quantum Computing Startup That Believes It Can Ultimately Win the Qubit Race," *Forbes*, November 18, 2021.

Smith-Goodson, Paul, "Atom Computing Sets A World-Record Coherence Time For Neutral Atom Qubits," Forbes, June 2, 2022.

Smith-Goodson, Paul, "Atom Computing Signals High Confidence In Its Quantum Strategy By Committing $100 Million To Future Research In Colorado," Forbes, October 27, 2022.

Swayne, Matt, "Quantum Goes No-Code with PASQAL's Zero-Code Development Platform For Neutral Atom Quantum Computers," *The Quantum Insider*, January 10, 2023.

"Harvard and MIT Scientists Launch QuEra Computing Inc. to Build Quantum Computers for Today's Impossible Problems," *HPC Wire* Press Release, November 17, 2021.

"Infleqtion Enters 2023 on Heels of Milestone Year," PR Newswire, January 11, 2023.

If you enjoyed this post, please visit my website and enter your email to receive future posts and updates: http://quantumleap.blog

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.