Dear Shareholders,

It has been yet another phenomenal year in IonQ's history.

In the last year alone, we have pushed the limits of quantum computing performance, achieving our 2024 target performance level of 35 algorithmic qubits (#AQ) a full year ahead of schedule and unlocking a new magnitude of quantum computer performance. Meanwhile, we sold IonQ's largest deals to date–landmark contracts with the United States Air Force Research Lab and the Swiss industry group QuantumBasel, expanding our product offerings to both compute and networking.

I want to dedicate this year's letter to discussing some of the common misconceptions and questions we get from both customers and investors.

1. Will IonQ, and quantum computing in general, achieve quantum supremacy?
2. When will the quantum market take off?
3. Why does IonQ use trapped ion qubits in its quantum systems?
4. What does IonQ think of other announced breakthroughs in quantum?
5. Do trapped ion systems have a path to scale?
6. Are trapped ions fast enough to tackle large applications in the future?
7. Will IonQ win in the quantum computing market?

We have a lot to cover, so let's jump in.

Will IonQ, and quantum computing in general, achieve "quantum supremacy"?

"Quantum supremacy" is a broadly used term in the academic circles of the quantum computing industry. Definitions of the term vary, but "quantum supremacy" generally refers to a quantum computer solving a problem that would be impossible for a classical computer to solve.

The short answer is no, I don't think IonQ–or *anyone else*–can empirically prove quantum supremacy because of how difficult it is to prove that something is "impossible". Based on history, it's a fool's errand to say something can't be done; human ingenuity is seemingly boundless. That's why I believe quantum supremacy is not a helpful proof point.

Moreover, no other commercial product has ever had "supremacy" as a bar to be successful. In the business world, for a new product to dislodge an existing one, it must provide practical advantages, such as faster time to solution, cost effectiveness, accuracy, availability, convenience, etc…or other advantages.

At IonQ, in very basic terms, we need to build a “better mouse trap” that solves a customer’s particular problem better than other options available today. We call this “commercial advantage”.

When will the quantum market take off?

Within the quantum industry, there are two camps. Some believe that a large number (think millions) of fault tolerant qubits will be required to do anything useful with quantum. This belief leads them to the conclusion that quantum is still many years away. Some quantum companies have bet all their chips on this belief.

We (and others), on the other hand, are in the camp that believe that it is possible to build useful NISQ (noisy intermediate-scale quantum) era applications that provide commercial advantage. To achieve this, high quality gate fidelities are required. We believe that gives us an advantage in the short term because IonQ’s trapped ion systems have naturally higher fidelities than competing systems. We can also leverage IonQ’s sizeable cash position and cash from early sales to fund further development towards fault-tolerant systems.

It is worth noting that over the last couple of years, several companies originally in the first camp have come over to our point of view, acknowledging the potential power of NISQ applications.

Within IonQ’s application group, we are increasingly focused on finding and building these applications.

Why does IonQ use trapped ion qubits in its quantum systems?

Trapped ions are a relatively mature technology with the highest native gate fidelities known to the industry. IonQ’s systems are also uniquely capable of all-to-all connectivity and have a comparatively easy path to room temperature quantum computing and networking. We believe that with our new barium ion qubits, it is possible to get close to 99.99% average two-qubit gate fidelity. We also believe that as applications become larger, the all-to-all connectivity enabled by our unique architecture will allow larger applications to run with reduced qubit count. Last, our ability to network quantum processing units using room temperature room temperature optical fiber will allow us to scale the number of qubits quickly.

You might have heard me say that in the longer term, other qubit modalities might become interesting. Each qubit modality has a unique set of challenges and risk profiles to overcome to achieve fault tolerant quantum computing at scale, and we remain highly confident in the advantages of trapped ions.

Nevertheless, I like to think we are pragmatists, similar to the early days at Apple. At the time, Macs used a Motorola 68K family processor. After several years, they moved to PowerPC. I assume that Apple thought the Motorola processor was the best available in that particular time period, but evolved to use the PowerPC when the technical and business landscape made it more advantageous.

We will continue to monitor progress of other qubit modalities as they make progress over time. And we will continue to ask ourselves, “Are we on the best horse in this race?” In our team’s opinion, that answer is a strong yes.

What does IonQ think of other announced breakthroughs in quantum?

First, it’s an exciting time in quantum. Progress is accelerating on all fronts.

In quantum newsfeeds, it seems like someone announces a breakthrough in quantum almost every day. However, the path from the lab to the market is time- and capital-intensive. And we have yet to see a silver bullet–most of the “breakthrough” announcements we see have some risk or caveat that still has yet to be overcome.

I think the word breakthrough is overused nowadays. However, we continue to monitor the progress in the industry and are unflinching in our pursuit of trapped ion quantum computing.

Do trapped ions have a path to scale?

Early trapped ion quantum computers looked a lot more like the first programmable digital computer, ENIAC. They were large, bulky with wires and optics everywhere. Like ENIAC, it was hard to imagine how they would scale.

However, our engineering team is working on ways to compact future generations of IonQ systems into a form factor designed to fit a standard data center rack. We expect our chips to run at room temperature and to use standard silicon photonics fabrication techniques used for other telecommunications and data center products today.

We have also shared at length our plans to scale the qubit count of our systems with techniques like multicore processing and photonic interconnects.

Just last quarter, we announced the first significant step in demonstrating our photonic interconnect technology, with other demonstrations planned throughout the year.

In both form factor improvements and increasing qubit count, I believe IonQ’s path to scale is clear.

Are trapped ions fast enough to tackle large applications in the future?

A successful company needs to time its investments to meet the market’s needs. Today, fast gate speeds are not critical because quantum applications are still small. However, as we scale up to larger applications, gate speeds will be increasingly important.

In previous announcements, we have explained why innovations like our barium qubits are paving the path for faster trapped ion gate speeds.

Moreover, we believe other optimizations in our technical stack could lead to substantial improvements in gate speed, such that our trapped ion qubits are not a limiting factor in gate speed yet. We expect that the next generation IonQ systems will continue to speed up to allow the commensurate applications to be run on them.

Will IonQ win in the quantum computing market?

To address this problem, most people are tempted to dive into the weeds about the different qubit modalities. I think this is a mistake.

Today's quantum market reminds me of the mid '80's where wars raged over RISC vs. CISC and NMOS vs. ECL vs. CMOS. All the competing vendors had slides and performance claims touting why their architecture and their semiconductor process and their manufacturing prowess would make them the obvious winner. Most of those companies are now forgotten because much of that noise didn't really matter. In classical computing (and all complex systems), a wide variety of factors and tradeoffs determine final performance. No one single feature determines what is "best".

And maybe more importantly, a wide variety of factors outside of the technology determine what makes a "winning" company. Things like management team experience, industry focus, access to capital, manufacturing costs, profit margins, sales channels, and much more–and sometimes just good old fashioned luck.

Here is what I believe: in the near term, trapped ion systems will win because they have the best gate fidelities allowing the largest quantum algorithms to be run. I believe that trapped ion technology will be miniaturized to fit on a handful of photonic chips that make it cheap and easy to scale.

I also believe that other qubit modalities will have to follow the same path, a path that is very capital intensive. IonQ has the advantage of a strong balance sheet and access to a non-dilutive source of cash from sales to our early customers. This will allow us to be cash flow positive early and continue to invest over the long term.

Thanks for reading and for supporting IonQ this year!

Sincerely,

Peter Chapman

CEO and President, IonQ