TESTIMONY OF DR. CHRISTOPHER MONROE

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“Accelerating Discovery: the Future of Scientific Computing at the Department of Energy”

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Mr. Chairman and members of the Subcommittee, thank you for this opportunity to testify before you today.

My name is Chris Monroe, and I’m here on behalf of IonQ, a company that builds quantum computers. IonQ is headquartered in College Park, Maryland, and was spun out of the University of Maryland and Duke University in 2016. I’m also a Professor of Electrical & Computer Engineering and Physics at Duke University, and a member of the National Quantum Information Advisory Committee, coordinated by the White House Office of Science and Technology Policy.

I have over two decades of experience in the field of Quantum Computing Technology, from both academic and industrial perspectives, and I am here to talk about the future of computing in terms of Quantum Information.

Quantum computers are as revolutionary as they are challenging to grasp and build. Their might, given these challenges, demands special attention. As you know, the 2018 National Quantum Initiative (NQI) was initiated by the House Committee on Science, Space, and Technology, to ensure the US remains at the forefront of this technology. The NQI endowed the Department of Energy, National Science Foundation, and National Institute of Standards and Technology, to stimulate foundational research in quantum computing and translate this technology from laboratory to industry.

So how does a quantum computer work? It’s not hard – it’s just that quantum computers follow laws of physics that have no analogy in everyday life. Information in quantum computers can exist in superposition – multiple values stored and processed simultaneously in a single memory device. But each time you expand a quantum computer by just a single bit (we call them quantum bits), its power essentially doubles. With just 300 quantum bits, a quantum computer can process more possibilities than there are atoms in the entire universe! This massive parallelism in quantum computers allows certain computations to be performed that can never be accomplished using regular computers.

Here are some far-reaching applications from this new mode of computing:

1. Optimization of complex problems dealing with huge data, including logistics and pattern recognition
2. Molecular and material design for energy, medical and defense applications
3. Security, including secure communication and code-breaking.

IonQ has collaborative projects in all these areas. For example, we are just starting a collaboration with Breakthrough Energy Ventures, a fund backed by Bill Gates and others, to investigate how Quantum Computers can be applied to issues associated with climate change.

It's no surprise that one of the most important applications of Quantum Computers is Energy, and that DOE is an important player in advancing Quantum Computing.

IonQ machines, and those built by others, are still too small to beat regular computers on these types of problems, but we are just at the beginning of the commercial phase of quantum computers, and this situation will change soon.

The core of a quantum computer is exotic, and its key attribute is ISOLATION. It involves devices either cooled to nearly absolute zero temperature (-460 degrees F) or, in the case of our technology at IonQ, individual atoms suspended in a small vacuum chamber and poked with laser beams. (Incidentally, this so-called "ion trap" technology was originally developed at NIST in the 1990s, where David Wineland and I demonstrated the first quantum logic gate. Wineland was later awarded the Nobel Prize in Physics, partly based on this work.)

Exotic as it is, our core technology is not necessarily the main challenge -- atoms are perfectly identical and sufficiently isolated from the environment, so we have a good idea how to scale our systems at IonQ. Instead, the challenge is that the way quantum computers process information is totally different – programming them, controlling their "bits", interpreting results, is a radical departure from regular computation. The challenge is that we need to bring up a generation of builders and users together to "think quantum" as the technology matures.

I see this juxtaposition every day, at both IonQ and in my academic research laboratories. At IonQ, our systems can be accessed by anybody via Amazon and Microsoft cloud servers; we also have more intimate partnerships with users and companies wishing to get up to speed in quantum for their future commercial needs. At Duke University, we are standing up a Quantum Computer User Facility, following programs funded by the National Science Foundation, the Intelligence Advanced Research Projects Activity, and the Department of Defense. The Duke Quantum Center will host researchers from across the US to spend weeks or months at our facility in downtown Durham NC, to use the most advanced quantum computers in the academic community. Like IonQ, the Duke machines are based on atomic qubits. Unlike IonQ, the Duke machines will be used for scientific purposes – from understanding black holes to investigating models of exotic materials. This "co-design" process, integrating users and builders for both commercial and scientific applications, will be key to unlocking the power of quantum computers.

At both IonQ and Duke, we have vital partnerships with several DOE labs, including Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories. They are all interested in using our devices and fielding their own, but these labs also supply key components for our machines.

As a member of advisory boards for Canadian, European, and Asian quantum centers, I am well aware of the outsized and coordinated investments overseas, especially from China. The US must lead the race to build quantum computers and other quantum technologies. We must train and place the next generation of quantum scientists and engineers. We already have the best higher education and attract the best minds in the world. Through the opportunities presented by our policies, we should seek to keep these scientists and engineers in our universities, laboratories and industry and thereby accelerate our progress in Quantum.

Now is a critical time for DOE, NSF, NIST, the DOD and the Intelligence Community to redouble and coordinate their efforts in translating quantum computers to real-world applications such as energy production and climate science. This will create vast opportunities for workforce development, and economic growth in Energy, Medicine, and Security.

The Endless Frontiers Act, which would endow the NSF with a technologically-driven division and mandate, is a particularly good way to ensure this emerging technology will be used for scientific applications and that scientific developments will continue to inform the fabrication of commercial and academic devices and systems. Another example is the Quantum User Expansion for Science and Technology or “QUEST” program (also under consideration as HR 1837), which would subsidize users to get access to commercially available quantum computers right now, to stimulate their future co-design.

These programs and continued stewardship of the National Quantum Initiative by the DOE, NSF, NIST, and the DOD and IC, are critical to continued American leadership in quantum computing and the future of advanced computing.

I again thank the Chairman and Committee for its leadership and for the opportunity to testify today. I look forward to answering your questions and working with you in the future.

Dr. Christopher Monroe

CEO and co-Founder at IonQ, Inc., a start-up company that is developing and commercializing the world's first fully-expressive, full-stack quantum computer, based on trapped atomic ions.

Lead a large experimental research group at Duke University, fabricating and using quantum computers and for fundamental studies of quantum physics and quantum entanglement. Investigate the storage and processing of quantum information using individual electromagnetically confined atoms and photons, the communication and teleportation of quantum information, and the use of quantum systems to simulate the complex behavior of magnetic materials. Tools include advanced laser sources, photonic technology, fast electronics, semiconductor structures, and stable microwave and radiofrequency sources.