IEEE Quantum – Podcast Episode 19 Transcript with Alex Keesling

**Brian Walker:** Welcome to the IEEE Quantum Podcast series, an IEEE Future Directions digital studio production. This podcast series informs on the landscape of the quantum ecosystem and highlights projects and activities on quantum technologies. In this episode, we speak with Alex Keesling, CEO of QuEra Computing. Alex shares his insights on the current state of the quantum ecosystem, the challenges and potential benefits, and explains his company’s unique approach to quantum computing. He also offers advice to students and young professionals who might be exploring quantum as part of the career track. Alex, thank you for taking time to contribute to the IEEE Quantum Podcast series. To get started, can you share a little information on your background?

**Alex Keesling:** Yeah, absolutely. Thank you so much, Brian, for having me here. I love the podcast, and I’m very happy to be spending time chatting with you. My name is Alex Keesling. I am the CEO of QuEra Computing. We are a leader in quantum computing, based here in Boston. QuEra is a company that was formed as the outcome of groundbreaking research at Harvard and MIT over the past 10 years or so, that I was a part of. We are now building hardware, software, and developing applications for quantum computers to make them as useful as possible today and at every step along the evolution of the technology.

**Brian Walker:** So, Alex, can you tell us a little bit more about your company and how your approach differentiates from others in the quantum space?

**Alex Keesling:** Yeah, there’s several things that I can talk about. I’m going to start, first, with the platform that we developed and that we are using for our hardware. We are using neutral atom qubits for our quantum computers. We have built the first and, so far, only publicly available neutral atom quantum computer to the general public on the cloud. This is our product, Aquila, that is available to users through the Amazon Braket service. This is leveraging technology that was developed before the formation of the company at Harvard and MIT. Neutral atoms are a fantastic platform for building quantum computers because of the flexibility in not having to use cryogenic systems, and not having to rely on complex manufacturing techniques. We effectively build the processor every time that we run a computation, and we can do this in a mode that we have come to call an FPQA. Similar to in classical computing, FPGAs, or Field Programmable Gate Arrays, allow users to very efficiently use the hardware by programming the hardware itself. In our case, we use a field programmable qubit array that allows us to embed problems directly in the geometry of the processor and the connectivity of it. This leads to very low overhead in encoding problems of interest for our users. The next part of it is that we are taking a different approach for how we perform the quantum computation itself. We are using an analog way of programming the device that gives users access to a very flexible mode of programming that brings them very close to the hardware, again, to make the best use of the hardware platform. So, all of these things in combination are the starting points of what we’re doing, that is already different from most other quantum computing providers out there. The next portion of it, of course, is our Roadmap, and how we’re looking at the future to integrate digital quantum computing capabilities into the same platform that we have nowadays, to expand it into a hybrid mode of quantum computation that gives people the ability to combine and get the
best out of the performance of both analog and digital ways of quantum computing, and really thinking about the next set of technological challenges that will lead to very large and powerful systems that are able to perform quantum error correction. So, there's a lot there. Overall, it's the underlying technology, and along with it, our approach and our team. We have an amazing team that we've been growing over the past few years, of incredibly smart, talented people that are committed to making quantum computing a useful reality soon.

**Brian Walker:** What would you say are some of the advantages your approach to quantum enables?

**Alex Keesling:** So, one of the things that we are very focused on for this generation of technologies, reducing all kinds of overhead that end up wasting quantum resources. So, the first step towards that is by allowing users to directly encode problems into the shape of the processor. What I mean by this is that there are many problems that our users are interested in, and that we've heard from our users, especially now that they are running these applications on the cloud. The problems that they're trying to solve fall in one of two categories, either in optimization, or in simulating other physical systems. For these two categories specifically, it matters a whole lot that when you're trying to, for example, solve a graph problem, that you can encode that graph problem directly into the processor. If you have a graph that has 200 nodes, you don't want to have an overhead that requires 10,000 qubits to be able to represent those 200 nodes, you just want to use 200 qubits. That is exactly what we do with our processor, Aquila. We can take some of these hard combinatorial optimization graph problems and encode them directly on the hardware, because we have this flexibility of placing our qubits in arbitrary configurations relative to one another. So, we're reducing the overhead in encoding problems, and that gives users the ability to use the quantum resources much more efficiently. This also gives users the ability to play with different problem sizes. While they have access to up to 256 qubits with our processor, they don't have to always run a problem of that size. Therefore, when users are developing applications and looking at comparing different quantum algorithms, they can see not just how well these algorithms perform on a particular problem instance, but also how does this particular algorithm scale in performance relative to the size of the problem. This is helpful because it guides users in their understanding of what works best in the development of their algorithms. Of course, this is work that we support, and it allows us together to project into the future, once we have larger systems with better performance, when do we expect inflection points for different use cases, where customers will prefer to use a quantum hardware available, relative to classical counterparts. That's a big advantage to our customers. The second one is today, with the mode of programming that we offer with the analog, with the analog mode of programming, this allows users to reduce the impact or mitigate the impact of errors that happen throughout the computation. In general, there are algorithms that can be developed in this analog mode of operation, where errors throughout the computation don't compound as much as they would if we were to take the same problem and to break it up into discrete digital time evolution. So, there's a lot of benefits that users are seeing already from this alternative approach to the first generation of quantum computers in the market. We are getting their feedback through the cloud access, and we are also using this to inform the next set of capabilities and tools that we are prioritizing at the company.

**Brian Walker:** So, Alex, what do you think are some of the key challenges facing the quantum space today?
Alex Keesling: Yeah, I guess there's a lot to discuss here. There are problems, for example, with all of us looking for more talent, and have a more developed workforce. There are problems with misunderstandings of the technology, its capabilities, its future progress. There are even problems that are arising with collaboration, and particularly with ways of working with international counterparts. There's also a problem that we will face as an industry in building bigger and more powerful computers that can be available to customers. But thinking about customers, I think that one of the things that we have heard that I think is a-- it's a challenge that is worth thinking about, and figuring out how to overcome, and that is that there's been a lot of work on creating small proof of concept demonstrations that have been run on a lot of different hardware. I think that everyone recognizes that the progress in the field has been quite fast, but not necessarily fast enough to get us to a point where widespread adoption is yet happening. So, what we've heard from customers is that they are looking for a different approach to quantum computing, and we're hearing this from customers that are using our system already in several different fields, in finance, in chemistry, government users, academics. The challenge is how do we enable value sooner, and how do we get faster to systems that really make a difference? That is really what has informed our approach to developing these larger processors that work in this FPQA plus analog mode, and that is an immediate challenge that I think that we need to face.

Brian Walker: So, looking out over the next decade, how do you see quantum evolving?

Alex Keesling: I think that over the next 10 years, we're going to see quantum computing evolving at an ever-increasing rate, and we're going to see its effect become more and more prevalent in different areas. However, I don't expect there to be a singular point in time when quantum computing will suddenly turn a switch and become a technology that has widespread use everywhere. I actually think that there will be multiple inflection points in which we'll find new uses for quantum computing and the ability to solve ever more complex problems with them. I think we will start with a few niche applications, and we will continue expanding into different industries, and by 10 years from now, I do expect that quantum computing will be much more integrated into society than it is now, and most likely in ways that-- well, first of all, are not necessarily visible to the everyday person, but that may be affecting how we all live our lives, and point number two, probably in ways that none of us can really predict right now. I think that looking back at the evolution of technology, trying to predict the way in which we will use quantum computers in 10 or 20 years, to me, feels like trying to predict the impact of the internet in the modern world in the 1990s. There are things that we'll get right, but I think that there is a lot more creativity and ingenuity that is yet to come that will guide how we use this technology.

Brian Walker: So, Alex, you mentioned earlier the human resource challenges related to quantum. So, do you have any advice for students or young professionals who might be interested in pursuing an education or career track in quantum?

Alex Keesling: Well, my advice is to do it <laughs>. There are many different ways of getting involved with the exciting and growing quantum ecosystem for students, particularly getting exposed to quantum computing, quantum mechanics in general, and the underlying concepts, I think it's important, but not even necessary. There are a lot of online resources out there to learn more about the concepts in quantum computing, but even just starting to get involved with the activities that are happening in the
space, listening to podcasts like this one, getting involved, for example, with hackathons. For us, of course, we’re always looking for talented people to join our team. Not everyone needs to have a physics background. This is a growing ecosystem that is bringing people together from very different backgrounds in electrical engineering, and computer science, and mechanical engineering, and all sorts of different areas in STEM, and even beyond that. So, looking for internship opportunities, for example, this has been something that has been particularly helpful for us here at the company to help develop talent, and also to look for programs that are emerging across the country. We see this also here in the Boston area that are focused on quantum engineering and other programs that start to have more overlap with quantum computing.

Brian Walker: So, Alex, I know you're familiar with the IEEE Quantum initiative. What role do you see it playing in helping to advance quantum technologies?

Alex Keesling: Yeah, I think it's very similar to my point a moment ago. I think that IEEE Quantum is doing a fantastic job bringing in different stakeholders, different people within the growing workforce with a diverse set of backgrounds, encouraging conversations, and basically acting as a melting pot for all of us to imagine what the future of the technology is going to be like, to make connections, and to find each other so that we can build better things together.

Brian Walker: Thank you for listening to our podcast with Alex Keesling. To learn more about the IEEE Quantum initiative, please visit our web portal at Quantum.IEEE.org