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[00:00:00] Honestly, I have no opinion. I'm not really a, a, uh, audio producer myself. I'm a scientist.

Welcome to Cloud Realities, a conversation show exploring the practical and exciting alternate realities that can be unleashed through cloud driven transformation. I'm David Chapman. I'm Sjoukje Zaal, and I'm Rob Kernahan.

In this week, we're gonna be diving again into the quantum realm and getting a view from Google on their development and where they see the first quantum applications hitting the market.

Joining us this week is Alex del Toro, quantum Computing and Machine Learning practice Lead at Google Cloud. And Catherine Vollgraff Heidweiller. Product manager on Google's quantum computing team, which is part of Google Research. [00:01:00] Welcome Alex. And Catherine. Thanks so much for spending some time with us today.

Do you wanna just say a word about yourselves and what you do on a day-to-day basis? Sure. I'm on the Google's research team and, uh, our team really invents and builds the quantum stack both on the hardware and the software side. So I currently lead the product management effort, which means I think about how we can make quantum computers ultimately.

Useful to the world. And as we move along the r and d timeline, how we can go from scientific proof of concept to an actual compute capability, which can be offered as a product. And in practice this means I work on things like the technical strategy and roadmaps and system requirements. Alex? Yes. I'm Alex.

I'm, uh, working at Google Cloud and we are working together with customers. So when they come to us with requests regarding ma machine learning or quantum computing, then we help them. To, uh, find an orientation with clarify questions, build POCs with them and, uh, help them along their journey. So let's start with how do you get into the world of quantum?

So Catherine, what's your career journey to the [00:02:00] point where you are building quantum stacks? I. So perhaps to start from the beginning, I was always really interested in science. I guess as a little girl, I always had an overwhelming volume of questions about, you know, how the world works and why things in the universe are as we observe them.

But university is really where I was, um, introduced to the academic field of quantum computing. I studied theoretical physics and mathematical physics. And I was introduced to quantum computing by one of my professors in the Netherlands, actually, funnily enough. So yes, he specializes on quantum gravity, but he suggested quantum algorithms as a topic for me to explore, and I always really admired his work.

And so took up the suggestion right away and ended up writing my dissertation about quantum algorithms for the hidden subgroup problem. And after finishing my studies, I joined Google first in a business strategy team in Google's core business where I learned what it means to, uh, have a p and l and earn revenues and all of that.

All of the dirty side. Exactly. And then I [00:03:00] moved over to the quantum team, uh, in Google Research, um, uh, where I'm a product manager ever since. Amazing. And Alex, what about you? What's your journey to being involved in this, uh, amazing field? My journey is a bit more unusual than Catherine's, so I actually have a PhD in, in economics.

As a child, I was always both interested in, in financial markets how, how economists work and in astrophysics, At some point after school, I had to make a, a decision in which direction I go. And yeah, I found financial markets very interesting, how they work and how sensitive they are and what, what can you do there in, in different countries.

So I made a PhD here in Germany in, uh, financial market, uh, theory and, uh, how to apply machine learning. I was very lucky that I found a job in asset management at the same time, and it was like in the early mid of the last decade. And they were asking themselves the same question. How can they apply machine learning to financial market forecasting?

Um, so I could actually do my PhD [00:04:00] hands-on with people that worked in this field for a few decades. And while at the end of this, then I joined Google, and then they come already the first question around how can you, what is quantum machine learning? How can you apply this? And that was the first point where I got into this.

I started with something called topological data analysis topology. I learned later that topology is a very big topic in, in physics, uh, not in economics. Um, yeah. And then, uh, from, from there, I just dive deeper. And as Catherine, I was also as a child, always very, very curious and think this, this curiosity, this driven that is, uh, the common line also in my life.

And, um, That's why I'm here, where, where I am now. I just connected with the quantum team. I asked them, what do we have? What are you doing in this field? Customers are asking me also in Google Cloud about this. What can we say, uh, what I can learn about this? And then, um, they connected me with people, they gave me material, and I just did the other 95% of the work to dive deep into this.[00:05:00]

Two very interesting journeys to this point. So let's start off with some basics. I think Quantum and what does it actually mean? So Catherine maybe. Give us maybe your perspective and if it's different Google's perspective on what Quantum actually is. Yeah, sure. So I think to understand this conceptually, it's important to realize that only the laws of nature can place an upper bound on what can be achieved in in computing.

And this is because information processing has to be done with physical processes and what we refer to as. Classical computers. So these are the computers in our phones, in our laptops, in our data centers, and even in the world's most powerful supercomputers. These are all programmed using the language of Boolean logic, which is the language of zeros and ones.

And in a way, we handicap ourselves by limiting ourselves to this language of zeros and ones. And quantum computers are really different from these classical computers because they are programmed using the language of quantum mechanics, you know, the language of nature. And [00:06:00] this introduces a whole new way of encoding information.

I. And a broader set of computing, uh, operations. I mean, I can, I can tell you a bit more about sort of what makes the quantum computer tick, but maybe this is a sort of good place to start. I guess the core question is what difference does it make? Mm-hmm. So if you apply a different way of thinking and a different architecture in the way you've described it, what, what difference does that make?

Well, ultimately a quantum computer is just a generally programmable computer, and so if you, uh, are given more operations than a generally programmable computer, then you're bound to be able to new ki do new kinds of things. And ultimately, I think the world needs an, a next generation of computers need something more powerful than we have today.

And I think building quantum computers is our way of, of taking this next step of just building the next generation of computers. So Alex, just picking up that thought from Catherine. Why does the world need this? Oh, that's a, that's a very good question. I also get that a lot here in, in Google Cloud from, from customers.[00:07:00]

Some customers actually asked me though, why don't we make the computers? We have faster, we have super computers, we have these GPUs. Why don't we make them faster and faster and faster? And, um, I always give, gave this example from fertilizer production where you have a certain catalyst that you, that you use and that production of this fertilizer.

Um, can contribute up to 4% of global carbon emission. Mm-hmm. We need the fertilizer to feed the world, so we cannot get around this. Um, but we can try to figure out how can we make the production more efficient? And we know that there's a bacteria that can, that, that has this catalyst and can do this very efficiently.

We just don't know how. And if we want to simulate that, which we would need, um, only for one atom in this process, we would need a size of a computer of our solar system. So this is something, and there's just one atom. So, and there are like at least nine different atoms in this. So we know that this is, that would be difficult to house somewhere, wouldn't it?

Exactly. That's one. I love a data center [00:08:00] bill. If you did build it, wouldn't it? So, yeah. And they, they have, uh, shown theoretically, That you can do this on a, uh, quantum computer for a given, not the size that we have at the moment, but the size that we hopefully have in the near future. Um, and then this has like 4% up to global carbon emission from one source.

This has a huge impact for world, for for our world. So it has a big impact and it's infeasible for classical computing and that's why I really like this example. There are others from battery research and so on, but this is the one that I like the most. And Catherine, why is that different? So big? So on a classical computer, it would be a computer the size of the solar system to crack that problem.

But a quantum computer, presumably more like a room-sized device, or certainly smaller than a planet size device, what's going on that's different between those two things that allows the quantum computer to be that much more powerful. So we are relying on two really important, uh, phenomena of quantum physics.

And these are the kind of, uh, quantum physics [00:09:00] phenomena that really make the quantum computer tick. The first is, uh, what we call super position, and this means that rather than just being zero or one, The bit is in a probabilistic combination of zero and one. So you can imagine that instead of being able to encode just two points, the bit can actually encode an infinite number of pin points on the sphere.

You can, you can Google this, you want to see it visually. Uh, it's called the blocks sphere. This is how we kind of. Uh, visualize this idea of how we encode information differently just on a single quantum bit. Uh, the second really important principles called entanglement and the quantum bits can, uh, basically entangle together, which means that the system, so the bits on your chip can form this kind of super state of probabilistic combinations of zeros and ones.

And if you use this intelligently in your algorithm, you can achieve exponential, uh, speedups, you know, for specific kinds of, uh, problems. Right. So what's going on here is both a new type of hardware and a new [00:10:00] style of algorithm. Yes. Is that the right way to put that? Exactly, exactly. If you would just run a normal classical algorithm on a quantum computer, you would really not get any, um, advantage.

Right? Right. Try to do like three, class three on a quantum computer. It's not the ideal task for it. We had a great joke from a colleague of ours at, uh, Cambridge Consultants who said, what's the fastest way to get a quantum computer to add three and three together? Do it on a classical computer and if you, I'm not sure the repertoire of quantum jokes goes down at the dinner party.

That's the only one I've got. Only one I've got put out next. But just thinking about the practicalities of being able to say, solve the fertilizer problem. What's the timeline we are looking at for something that would be available to organizations to be able to deploy new algorithm. Quantum computing engine and get an answer.

What's are we, is it five years, 10 years, you know, round the corner? Just a viewpoint on when this type of capability will be more wide scale. [00:11:00] Um, well, I'm thinking more 10 years. Uh, much really still, uh, has to be done. We've already achieved a few really important scientific breakthroughs, but we still have a long research and development.

You know, what I would call ultra marathon, uh, ahead of us. And, you know, you have to think about the fact that we are, in a way reinventing computers at every level. So we need to work on each hardware component and every layer of the stack. And there are fascinating, uh, research and engineering problems and challenges in each of these.

And maybe to give you, to give you also a number. So, uh, typically people that work in quantum computing, they hesitate to give clear numbers because we don't know, you know. Um, but what we know from research is, for example, the this famo fertilizer problem. Uh, you may be able to solve that with 2 million physical qubits.

We have on our roadmap that we hope to achieve a million qubits in 10 years. Then you get kind of a timeframe, the source algorithm for, uh, breaking [00:12:00] security, what everyone is talking about. Um, the, the, the last official from Google Research was, uh, 23 million physical qubits. 23 million. Wow. Yeah. Okay. And, uh, it might be, you might get that down.

And now we come to a very interesting point that the, the research is not only in hardware to improve that on software, on the computer, but also in the algorithms. So for example, for source algorithm, it can be that we can actually improve that towards, uh, we only use only, uh, need, uh, 10 million physical cubits instead of 20 million.

So there's also a lot of research to make these algorithms more efficient. And, uh, this way, you know, you get from both sides closer to a potential date, but just that you see where we are actually. And in traditional computing, we're used to the concepts of like Moore's Law where speed and capability double every period.

Do you see the same sort of thing in quantum happening? You see that lift occurring or is it more linear? So there's just thinking about there, or is the paradigm completely [00:13:00] different and we need to think about it in a different way? 'cause a lot of is put on the amount of qubits available for processing.

So can, can you see that type of curve occurring? Well, this gets into a kind of interesting conversation because a lot of people say that we are going to replace Moores Law by Nevins Law, and what are the challenges ahead? When you look down that roadmap, that 10 year roadmap to get to a million, what makes that so tough and why is it taking 10 years?

So there are a lot of challenges, as I said, in every layer of the stack, but um, I think it's important, uh, you know, at high level to realize that a quantum computer needs to be both large and, you know, accurate and reliable. I heard you Rob mentioning, you know, numbers of qubits and that's all great if you have a lot of qubits, but.

If you do not error, correct them adequately, then they're going to be pretty useless to you. So, uh, we need to scale up the com, uh, the system, and we need to error correct it. And while we have made some really important first steps towards doing this, the challenge is still monumental, right? Quantum systems are inherently prone to be noisy.

[00:14:00] And the idea of error correction is to deal with this by introducing redundancy into the system in an intelligent way. So we encode the state of one. Perfect. You know, what we call logical cubit into a larger number. Let's say a thousand of imperfect physical cubits. And all these physical qubits are made to work together to keep that one sort of abstract, logical qubit.

Uh, perfect. Right. And when you say physical qubit without maybe getting too far into it, is that literally if you have, is that a constructed physical machine or is that a separate thing happening at relatively micro level? Just give us a mental image of. What is, what is that? So physical qubit is just what the bit is on the normal computer.

So that is physically the bit, the thing that is one or zero or a probabilistic combination of one or zero. And then you have a lot of these bits that together encode one sort of abstract bit that doesn't, uh, you know, fail and, and get noisy is getting this thing right and [00:15:00] getting it to a million qubits.

Getting that error correction technique down to a point where it doesn't require so many. Noisy qubits around the perfect abstract one. So I mean, there, there are lots of things that we need to achieve in error correction. And I think it's also not just about, you know, how many physical qubits do you need to encode one logical cubit.

But it's also about, uh, like how well are you actually encoding that one logical cubit. And so we have these, uh, you know, error correction. Researchers and experimental or correctional researchers, and they're all working together to try to, as best as possible, encode this one logical qubit information into these, into these, uh, sets of physical qubits.

It feels like the early days of digital computing where I. We were trying to get communication networks up, and there was a huge focus on error correction because the error rate was extremely high. And over time the mastery of those techniques and communications have improved the performance of how computers work and how they communicate, et cetera.

And it feels like there's a similar journey [00:16:00] happening in the content spheres. I mean, and, and, and just there'll be a, a level of mastery that occurs that just as we understand more and more, we'll just get incrementally better. It feels like it, it's a similar start point to where we were many moons ago in digital.

It's true. There are many parallels with the journey towards, uh, developing the qu, the, the classical computers that we have today. And the same is, is indeed true for error correction. It's just that we have to do error correction in a slightly different way in quantum computers. Since we are dealing with these, uh, quantum systems that have properties that normal bits, uh, don't have.

Well, let's zoom out of the quantum realm for a bit and talk about, uh, use cases. So, Alex, as quantum computes start to come into commercial usage, what do you think are the first industries that are gonna benefit from it? Uh, that's a very good question. So what most experts in this field think it's, that will be chemistry and material science, probably also physics or [00:17:00] most probably also physics research.

Then a little bit later, pharma than security, because that we have an algorithm, but that takes a bigger computer and. It looks like very far in the future we see, uh, finance, retail logistics, unless we don't have a very, very good algorithms for this. I see. Which is actually ironic because I, I come from finance and I came actually through this door, quantum machine learning, quantum computing and finance, because this at the moment going on a lot of hype in this.

Um, many, many asset managers looking into this for portfolio optimization for risk management, but it looks much better in chemistry because you have a quantum system already there. You can use quantum phenomena to simulate, um, you can work with smaller data. The natural science are much closer to quantum computing than, uh, if you work with classical data in traditional industries.

I see. And if you. Roughly timeline that out. Obviously not holding you to any of this because it's all about exploration and discovery to get there, but what are the sort of timeframes you're talking about? So for sciences and life [00:18:00] sciences, how close are we to that? And then when you look further out to, you know, retail and finance and things like that, how far away from that rough, just roughly, roughly.

So we cannot predict the future. We don't know if something in between happens. Someone comes up with a super smart algorithm or with a new approach like Evan Tang when she ized an algorithm even. But, uh, probably in the next 10 years, we will have a step-by-step increase of potential cases in chemistry and material science.

So it'll not be the one day, suddenly we have the 1 million and now we can do everything, but rather we can do. Uh, better and better systems for retail logistics and logistics. The very famous example is the traveling salesman problem. We don't know if we can solve it on a quantum computer and it doesn't really look good.

Um, and for any kind of quadratic optimization problem, the typical cases that you have in retail or finance, you need a very, very, very large problem size until you get a quantum advantage compared to a classical computer. So we are talking maybe 20, [00:19:00] 25 years, maybe later, right? So the classical compute is not going anywhere soon.

Then by the sounds of it, and, and even when quantum is ramping up, we're probably gonna be in a hybrid world between classical computing and quantum computing, complementing each other. Absolutely. I don't see the classical computer going away, uh, you know, at all in the next, uh, decades or maybe ever, because maybe it's always just going to remain, uh, a useful, simpler but fast tool.

Just like in programming languages, we have some programming languages, which are quite simple, but that means that they can, you can build really high performance. Uh, systems with them. And then you have other programming languages which are, you know, complex and allow you to do more complicated kinds of things, but they also take longer to, uh, you know, to run and to compile.

So, you know, I think that we will probably see, uh, different uses for both of these kinds of computers, you know, possibly indefinitely. You said quantum computers are quite small. What do we actually mean by that? Because it. Seems very big and huge to me. [00:20:00] Yes, that's true, but that is because they are sitting in an enormous refrigerator and, uh, these, these quantum bits that at Google we, we build, they only work well if they're cooled down to almost absolute zero.

So few milli Kelvins. So zero kelvin is where everything in nature approximately stops to move. And we need to be just above that. So this kind of temperatures. Even colder than outer space. It's very, very cold. And build this kind of refrigeration capability is a massive innovation challenge and also just requires quite a large physical system.

But the quantum processor that sits inside of it is quite small. And when I, but when I'm talking small computer, I just actually am counting, uh, you know, the, the number of, uh, bits and at the moment, You know, we just, um, the, the quantum computers that most algorithms people use just have like a hundred, uh, quantum bits in them.

And, um, how many you would use, of course also depends on, on how good they are and if these are logical error corrected qubits or not. And so, [00:21:00] you know, there's, there's a lot of nuance there, but still how you measure it, they're too small at this point to do so. Alex, when you look forward to the next 15 years, and you can see some significant innovations happening at speed at the moment.

So Quantum is really finding its feet. And yes, there's a lot of work to do, but the level of understanding there now seems really quite profound to me. Um, so it's gonna happen. It's just a matter of progress that needs to be made. And then you've got ai, which seems to be just. Accelerating at a level. I think that was, even this time last year was probably unforeseeable and, and therefore it's maybe a flawed question, but actually what, what do you see happening in the next 10 to 15 years with, with these technologies coming together?

Oh, interesting question. First of all, I'm really an advocate of we should not underestimate the human mind. I remember in 2016, 17 when there was a deep learning hype, very big going [00:22:00] on, and um, the big question was always, they're not interpretable. You cannot use them because in, in industry, because you cannot interpret them because they have millions or billions of parameters.

And I was already at that point thinking, I don't know, like I think if you think strong enough, you will find a way to make them interpretable and exactly that happened for vision models, for language models and so on. So when I say for example, that in finance, maybe in 20 years or so, we don't know if someone.

In the middle comes up with an extremely interesting new approach, how to deal with, uh, quadratic speedups, and suddenly boom, you have the next day a complete new, uh, branch in, in quantum algorithms and you can actually solve many interesting problems in retail or finance. So I first, I just wanna make sure that I don't wanna demotivate anything.

Actually, it is important that people look into it and, uh, my, my previous boss, he was a physicist. He also said in, in cosmology, if you look at a certain. Region and universe, and you don't find a particle there, [00:23:00] that is also a result. So even if, uh, you look into this and you cannot find a speed up, it is a result.

But you should at least look at it and find out that that's, that's, uh, what I want to underline. That's very important that, uh, customers, even in industries outside of chemistry or pharma, are still looking into us. You never know the learning. And with Evan Tang, by the way, there's also. You can also speed up classical algorithms when you de quantize them.

So there's also a learning in the classical direction, just when you try to deal with quantum algorithms. So, yeah, but I'm still sticking to it. If I would bet money on it, then I would probably bet on chemistry and material science, smart materials, uh, all these areas. It's just so much closer. And for example, in quantum machine learning, they're working with machine learning methods already.

They're using machine learning in quantum simulations to differentiate properties of molecules and so on. And uh, for portfolio optimization, there are still other challenges. How, for example, how do you feed classical data into a quantum [00:24:00] computer? The different approaches, but that slows down the process.

If I have a quantum simulation in chemistry, I'm already in the quantum system, I don't need to feed in any classical data. So there are more challenges and that's why if I would be money on it, I would. Rather bet on chemistry and material science. I really agree with that. I think that quantum computers are a powerful, generally programmable computer, and so that means they will be a new, powerful, broadly applicable tool.

And you know, I think that this means that in the end you can do as much good as evil, uh, with it as the human mind, uh, allows. And I, I really do not think that we can. Predict precisely what ultimately the applications, uh, will look like because it'll depend on what clever applications we come up with.

We are still in the very early stages of developing quantum algorithms, and I think it's great that we already have a good sense of the problem space, the problem sort of areas where we should be looking to apply quantum computers. But when you are looking at the [00:25:00] details, you'll realize that actually the specifics, finding the specific algorithms that will be the foundation of the, of the sort of future applications that will allow quantum computers to have an impact are still very much under development and we still need many, many brilliant algorithms, people to, to work on that area to make quantum computers useful.

All right, Sjoukje, what you've been looking at this week. So each week I will do some research on what's trending in tech, and this week I want to focus on quantum computers could finally be made at large scale. So there are different approaches to quantum computers and these different approaches also have different benefits and drawbacks.

So a question to you, Alex and Catherine. When someone says quantum, what does it mean for its commercial use? That's a very important questions because, uh, there are a lot of publications going around and in the industry, customers are [00:26:00] reading parts of these publications and then they wonder if it's applicable to their industry.

And uh, I give you one example. There was one asset manager. Um, that published a paper or like a research they did in portfolio optimization, and they showed that there is a potential speed up with a quantum computer. But if you look at the details first, they made the problem very, very tiny because it doesn't fit on any current bigger computer at the moment in quantum field, in in the quantum area.

So it's not really comparable to a real world problem because it's too small. And, um, it was a variational approach with a hybrid, like half a classical computer, other half quantum. Um, we don't know if it scales on a real, uh, universal quantum computer that we are, for example, building. And if you mix these things up, then you get a wrong impression of what this technology can deliver now or in the future in your field.

So that's why it's always important when someone says, Hey, I, I saw a speed up in quantum in our industry. What was this approach? Was it a kneeler, [00:27:00] was it universal quantum computer? Was it variational with a hybrid, uh, setup? And how, how big was this problem? Can you scale it to a bigger computer or, uh, can you not say if you can scale it because it's, for most problems at the moment, you don't know if it works for a real, for example, portfolio optimization case.

It works for a toy problem, but we don't know if it works for large data in, in, um, in the industry. So do we think that over time there will be different quantum platforms evolving or will everything converge onto the same quantum architecture? So I think that when you say quantum platform, that can mean many things.

Hmm. Um, there's certainly people building quantum sensors, for example, and certainly we will need those. Besides having quantum computers, when you're speaking specifically of generally programmable quantum computers, I think it is likely that ultimately, uh, you know, humanity will converge on one, uh, kind of architecture.

But you know, the time will [00:28:00] tell. Again, well that sounds broadly analogous of the way that, you know, kind of networks all eventually converged onto, you know, kind of internet protocol and things like that. Broadly the same sort of thing. It's v h s and Betamax all over again, isn't it, in quantum terms?

Yeah, exactly. Exactly. That means there's gonna be like, A platform that's actually superior, but we end up on V H s. Is that what you're saying? Lowest common Denomin. It's the same with networks. T C P I P, lowest common denominator always wins. 'cause everybody can default to it. Yeah. Well that's a note to end the show on Rob Lo lowest common denominator always wins.

Alex and Catherine, thank you so much for an amazing conversation this morning. Learned so much about the world of quantum and probably gone away with a new set of questions, which I guess is, uh, all part of the journey. So we end every episode of the show by asking our guests what they're excited about doing next, and that could be going to see Antman on the wasp quantum mania at the weekend, or it could be an exciting [00:29:00] new discovery that you are hoping to, to break through in the next, uh, few weeks.

So I'll probably stick with the quantum realm. I'm excited about three sort of broad, broad areas, uh, of, of our efforts. So the first is working towards our next major hardware milestone. So arriving at really the next generation of quantum computers that we're currently working on. And, uh, the second is making this technology.

Useful. I think we are kind of starting to see our way to how we can go beyond just having quantum computers as toy products to be used by people to sort of try out and learn from and actually have the outside world at large. Try to, uh, at some point do useful things on, on, on the quantum computers that exist today.

So that's a long journey and I think we're starting to see our way to making the first real steps in that journey. And the third thing that I'm quite excited about is nurturing the ecosystem. Um, more. I think that our team de develops a lot of amazing, uh, research tools and really clever libraries [00:30:00] and programs that we use internally.

And I think that actually there are a lot of students and researchers and, you know, maybe industry r d teams who can benefit from using those more. So I think that it'll be exciting to, to put out some of those. Fantastic. And you, Alex, I'm excited about two things. The first one is that summer is coming now in Germany, last in England, never comes.

You're lucky, Alex. Getting warmer now. And, uh, the second thing I'm very excited about within also the quantum, uh, area. Uh, there's one case I'm, I'm very, very fond of, besides the fertilizer. It's, uh, from, from astrophysics. Where it's broadly still theoretical because you need to connect a lot of these technologies, quantum sensing, quantum network, and quantum computing.

But there is this approach, you remember this image of the black hole four years ago? Mm-hmm. Where they published it and they did it with radio waves a lot from different telescopes in the world. And then they combined these images to one big as if they would head. [00:31:00] Uh, telescope of the size of the earth.

You cannot do this now with visible light because the wavelength is too small. But, um, there is the hope you could do that, uh, in the future with quantum technologies, and then you can get a super resolution image. That might be the best, what I'm excited about doing next. Yeah. Brilliant. Alex, life under the planet.

I didn’t see you going there, but you, you went there? Yeah, yeah, yeah. Fantastic. From summer. In Germany to life on other planets. Yeah. Brilliant. I’m quite excited about applying for the position of Galactic data center manager. I think that’ll be quite a good job. I’m up for that. I just gotta work out where I click the link to apply.

Brilliant. Okay, Alex, Catherine, what a fantastic conversation again. So thank you so much for your time and insight. So a huge thanks to our guests this week, Catherine and Alex, thank you so much for being on the show. Thanks to our producer Marcel, our sound and editing wizards, Ben and Louis, and of course, to all of our listeners.

We’re on LinkedIn and X, Dave Chapman, Rob Kernahan, and Sjoukje Zaal. Feel free to follow or connect with us and please get in touch if you have any comments or ideas for the show. And of course, if you haven’t already done that, rate and subscribe to our podcast.

See you in another reality next week

[00:32:00]

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