RR017

Engineering the impossible with Quantum Computing, Jonathan Owens, GE Vernova

Capgemini

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(00:00.44) Video is not included here. No, no. We're all very ugly, so we don't like to bring it out.

(00:19.948) I'm Dave Chapman. I'm Esmee van de Giessen I'm Rob Kenahan. And this is Reality's Remixed, an original podcast from Capgemini. And joining us later in the show is Jonathan Owens. He's the senior scientist in computational materials physics at GE Vernova. If you want to jump right to our conversation with Jonathan, please do. You will find the timecode as usual in the show notes in the TLDR. But actually, you might want to hang around for this one because we're going to get into a little bit about. Some scene setting. We're returning to quantum for the first time this season. And we're going to look at it from a point of view of a case study. So how do you use quantum technology in action? Now, Robert. Very exciting, David, what you've just said there. Quantum in action. That's a very positive phrase. Very positive. Future technology delivering something useful for humanity. You've set us up there for excitement. Before we get into the detail of it. I'm going introduce somebody who is going to help us navigate this topic. We have and this is rare for our show, but we've got an expert in the field. First cyber every year. Joining us, we've got Phalgun Lalur, he's the head scientist at Capgemini's Quantum Lab. Phalgun, good to see you. How are you today? Doing very well, thank you. Apart from the heat, but yeah, good otherwise. It is. Now you've got a a heady job. The quantum lab, but he's the big thing. He's the question I want to ask us before we get into quantum. Have you heard of the wet bulb? No, what what you mean the wet bulb thermometer? Yes. Do you know what the wet bulb thing is? Yeah, I know exactly what the wet bulb thermometer is. Right now. I paid attention at school. I didn't know, and then I saw a weather forecast. Yeah. As we were in one of these hot hot spells at the moment, giving a warning because it was a particularly high measure on the wet bulb. Now what is it? What's a wet bulb? So you basically you literally wrap the bulb that does the temperature measurement to cause the mercury to go up in a in a moist towel. Moist. Moist. And then that measures temperature when evaporation is taken into account. If you have extremely high humidity w when you sweat essentially, you can't s d the evaporation doesn't work. (02:38.39) That's it. As as well as you would. So therefore, where the wet bulb temperature is very close to the actual temperature, it's hot and bothering for the human. So it's a way of understanding the evaporation effect on the t temperature. It's a bit of science in there, Dave. See, that was a I mean kudos. That was a much better explanation than I was expecting. Have you just re have you just recently looked that up? I no. I I I it's it's funny, but I remember doing this type of thing back at at school when I did ph physics and So that stuff that's a semi scientific explanation as to why I did I did actually as soon as you touched it, I went I know exactly what that is. Yes. See, so it's it's actually science. Now, science is where we're staying today. So we are gonna look at as I said in the intro, we're gonna we're gonna return to quantum. We touched on it a couple of times on the show, partly attempting to get our heads around what quantum actually is as a compute platform versus classical. And you can hear some of our conversations with Cambridge consultants and you can hear our a couple of conversations we've had with Google's quantum team on trying to understand that and the potential of quantum. But we've come at this from a different perspective. We're gonna have the senior scientist from GE Venova, who's gonna come in and talk to us about computational material science and how that is being used to further the energy transition. So the move from traditional fossil fuels into into clean energy and how quantum might be leveraged in that. Now, it's quite a dense subject. So Falcon, d try and help us understand how all of these things come together to create an interesting state of the art picture around quantum. Yeah. This is a really interesting area where we are living in today. So what we are actually witnessing is a convergence of different technologies. And quantum has a very big role to play. Because if you want to design a new material, first of all, there is a problem in understanding how do we even pick the material, how do we start designing something which doesn't exist. The combinations are practically infinite. So to do this in a really smart way, there are lots of approximations people have come up with. But if we really have this huge space that we are exploring, we can't just (05:03.466) Do trial and error experiments all the time. You need a little bit of computation to guide experimentalists to know where to start. And to do something like this, we need to have really advanced methods which are based on fundamental equations guided by quantum mechanics, which has been around for 100 years now. But only now, because we have this convergence of technologies, we're having better and better ways of solving these kind of problems. And quantum has a role to play over there because. We still have to make a lot of approximations, but can we understand and get this insight that we do not have from previous year or two? Because now we are able to look at problems much, much bigger than what people used to look at. So on one hand, that's where it initially helps. But there is one more side of this story as well. So it's not enough that you actually just design a new material. You also want to understand how do they behave? How does the material degrade? How does something break down? And to understand this chemistry, again it's really understanding what the electrons are doing. And the equations are still more or less the same. They've been around for decades, close to a century. But to solve this kind of a problem is massive. To do this really, really accurately for large problems. We don't have enough computing power on the entire earth right now. And this is where quantum computers can make a difference. Now what was very interesting there, Dave, did you spot there that Falcon, an intelligent person involved in quantum, used the C word. Did you hear it? Did you pick it up? It was convergence. It was convergence again. It's another example. It's another example. I know. It is. That's the point. We're living in a world of convergence. Quantum, AI, digital coming together, making magic. It's making magic. That's actually such an excellent point there though, Rob. No, don't say that. feel complicated now, Dad. Honestly. Look at that. No, because you know, what what we don't need is mod models predicting things quickly. And today, I mean AI is also rightly so the talk of the town. Everyone's talking about AI. And quantum has a really big role to play over there, especially for chemistry and materials. Because again, as I said earlier, it's not about having one more model that can predict and give us a number, because the number is not gonna help make a decision. If you have to make a business decision, you have to trust all the engineering decisions that come underneath it. And that you need to trust it. How do you trust something? (07:29.62) If it's just a number that's coming out, what we really are doing here is having this first principles way of understanding the nature around us. And what's the best way to understand nature around us is using this quantum mechanics to explain nature around us. And that's where quantum computers can also work hand in hand with AI models by adding this area, by adding this layer of trust, that way we actually can validate what we're seeing. So I never think of AI and quantum as two separate things. They actually can work and should work hand in hand if you really need to have a future where we're able to design this new reality that we are interested in. you see, Dave, I've said two clever things on the start of a podcast. I think that's the first ever. I think this is a moment to remember. Because it's the only time it's ever gonna happen. And then I'm off. That's it. I'm gone now. I can just stop recording. I've hit me zenith. That's it. It it doesn't get better than this. Had to happen sometime or other. just sheer luck. Blind luck led me into it. Sorry, go on. But before we dive in to the actual conversation with John Falcon, I just want to actually zoom out a little bit and and just t just talk about something you touched on very briefly as you were as you were talking there, which was like about making business decisions about this stuff, like business decisions about use of quantum. we're obviously right at the very beginning of productionised quantum. I think you can get it by special request now in the Google Cloud and you might be able to in in others. So no bias there. Just that's the one I've spotted and I'm sure you can get it in different places. Just generally with quantum, what are you seeing the uptake like across industry now? And are people starting to seriously factor it in and make business decisions around it? Or is it still a little bit far out? I think right now people are beginning to consider the possibilities Quantum would enable. So I'll also say one other thing too. I tell this when I'm talking to other people as well that say I have the perfect quantum computer available right now. Can I get the best use out of it? My answer is no, because there's still a lot to be done. And it takes a long time for any kind of new technology to be embedded in a workflow. Many of the industries that we work with have this legacy workflows that it takes a long time to change. And (09:56.982) It's also part of our role here to understand what's the overall workflow, where does computation actually fit in, and within the computational workflow, where does quantum simulations, quantum computing fit in? And to understand that entire process also takes a long time. And you just talked about Google Cloud being available. I will also point out that IBM Cloud, Quantum Cloud, has I mean, they've just celebrated 10 years. So it has been around for a long time for people to like test what a workflow might look like. But having said all of that, there have also been pretty impressive hardware roadmaps where people are expecting in the coming three to five years to have these quantum devices that can look at problems which are beyond today's capabilities. Whether they actually get there or not, maybe it's not a question of if anymore. It's just a question of when. It might not be three years, maybe it's five, maybe it's ten. But that's the horizon that we're looking at. And it's really exciting to actually be designing solutions where you think about where does this piece actually fit in. And that's where we are at right now. Well, a great point, I think, to jump into the reality of it. So let's go to our conversation with John Owens. He's a senior scientist in computational materials physics at GE Vernova. (11:30.51)

Jonathan, let's start by just telling us a little bit about GE Vernova. GE obviously an enormous organization, so how does Vernova fit in? Paint us a picture. a couple of years ago, the old conglomerate of General Electric split into three completely separate companies, Healthcare, Aerospace, and Vernova. And so Vernova is sort of the collection of energy generation and transmission companies that the old General Electric used to operate. but we are completely independent. You know, we have our own stock ticker and and we are a new company, GE Vernova. Very cool. And specifically in Vernova, what do you guys focus on? So the the company as a whole works on power generation, gas power. nuclear fission power wind. We also work on kind of all of the components of the electric grid, you know, so the the transformers, the control of the electric grid, so allocating, you know, how energy moves through it, the software that allows that to happen. We work on energy storage, so, you know, large batteries or or reservoirs of of energy to pull and and put on the grid. and and then we also work on a lot of the enabling material technologies that that kind of support all of these components as well. And and then you know we we have our research center, which is what I am part of, that is focused on hey, what are what are the future technolog technological developments that GE Vernova should care about? and I'm specifically interested in the materials that that will enable those things. E Well, before we go into materials specifically, just set out the energy transition. It's a it's a phrase that gets used a fair amount. Maybe it's being used a little less at the moment, but in your mind, yeah, f I'll I'll let the listeners come to their own conclusions about that. Sure. But the w what what's the general gist of energy transition and where are we up to on that as an industry? Mm-hmm. I I think the the energy transition globally is focused on (13:48.04) moving towards zero CO2 emissions while at the same time dealing with the very real fact that the world needs more power than it did five, ten years ago and will continue to need more power as you know we electrify more things, as data centers come online, all of these things. So the energy transition is is really balanced on, you know, how do we make sure that the the kind of legacy technologies or historical technologies that we've used to generate energy like natural gas can be decarbonized while at the same time working on renewable ways to generate new power like wind turbines, nuclear fusion, things like that. So it's it's kind of finding this balance and particularly doing it in a way that we think is economically feasible in in the near term and hopefully continues to grow and and move toward net zero emissions. So Jonathan, it'd be really good to understand just a little bit about material science and also why quantum is so important to material science and what the advantages. So if you could sort of explain that, that would be I think useful then to set up the where are we going next? (15:13.44) Material science from a a discipline perspective is really just the science of understanding how matter, you know, all of the the objects around us behave and how we I like the way you said that's really just basic everything around us. Yeah, yeah. It's just understanding everything around the physical world around us like That's it. Right. Yeah. Just everything. Just everything. Yeah, yeah. It's all right. It's a bit like when you go into the status report and they say is the project on track? And they go, Yeah, apart from everything else is wrong. But yeah, we're all good. Yeah. And and that that is true, but it it really is the goal, right? We want to understand the the f underlying physics that dictate why materials have the properties that they do, why some things conduct electricity and why some things don't. Why some things conduct heat and why some things don't. Why can you see through glass but you can't see through metal? And and you want to material science is an offshoot of physics, is really just focused on understanding how can we unify the governing principles of nature that dictate how materials behave. And how can we do it in a way That is as predictive as possible without kind of having to lean on pure phenomenology, parameterized models, things like that. So the ultimate goal of material science really is that, right? It's it's kind of a fundamental science in that regard. But it's very ambitious. When computers came online in serious in a serious fashion, people started thinking about how we can use all of the knowledge we have, all of the physical laws and equations that we have to describe how materials behave that are hard to solve, right? They're difficult to solve by hand. Most of them you cannot solve by hand. How can we use computers to solve those things and predict material properties of new materials and and better explain, you know, all the phenomena in the world around us. That's always been the goal of computational material sciences (17:35.266) You know, how can we we take our fundamental understanding of nature that is is hard to solve because the equations are hard, and how can we put that on a computer and do something useful to design new materials or better understand the the materials that we do have? What you realize is when you boil it down fundamentally, that electrons sort of dictate most of these things from a from a very low-level perspective, right? Electrons form the chemical bonds that make up solids that make up molecules, and how they interact with each other determines things like the mechanical strength of materials or how well something conducts. And we actually know the equation that governs that behavior very well. It's called the Schrdinger equation. And and you can write it down and it's quite simple to write down. But buried in that simplicity is an extreme complexity. And the complexity arises from the fact that electrons themselves interact with other electrons. And so if I want to understand what electron A is doing, I have to understand what electron B is doing. But to really figure out what electron A is doing. Or what electron B is doing, I also have to understand what electron A is doing, right? So you have this tightly correlated physics where you know each each electron affects the behavior of the others. And in that complex physics is kind of where classical computation gets lost because you have to store a lot of information about the different ways that every electron in a system can interact. And this is sort of boils down to the fundamentals of quantum. Mechanics. Now, what quantum computing can do is actually in a single qubit for certain classes of problems, it can encode all the ways that an electron can behave. And if you put two electrons together, actually two qubits can encode all of the information and the ways those two electrons can behave, and so on and so on. It scales linearly. Whereas on a classical computer, if you try to do this, it actually (19:55.392) scales factorially. So after just like 20 electrons, I'm I'm doing a rough estimate here. You know, you're talking about you need say the age of the universe to solve that on on current, you know, high performance computing. So this is where we really see that that quantum can make an impact is if we need to solve these problems exactly without approximations or kind of heuristics, we need a different paradigm to do that. And And the hope and the dream of of quantum is that it will allow us to do that in ways that we can. Cool. Now, Phalgun with us as well. Let's bring you into the conversation at this point. Before we dig into the materials discovery aspect a bit further with Jonathan, just set up for us quantum. Remind us what it is, where we're up to. the j sort of general state of productization of of of quantum platforms. Sure. So when people talk about quantum, they're usually talking about different things. So let me start by saying that quantum technologies in itself, there are different parts to this. So one is quantum computing, which is what Julian and myself have been involved in for the past several years, where the idea is can we use quantum computers, which is A different paradigm of computing to solve problems that we cannot solve today. And the way it works, so the fundamental part of a quantum computer is called a qubit. So if you think about existing computers, you have bits, which is a zero or a one, or in other way, heads or tails. But a qubit is different. It's like you know, you flip a coin, it's a combination of heads or tails, and that's what a qubit is, and that's one of the many properties. that makes a quantum computer different. It uses this quantum mechanics principles. So quantum mechanics itself has been around for hundreds of hundreds of years right now. So last year we celebrated hundred years of quantum. But the technology has now matured to a stage where we are able to use a different way of setting up problems by themselves. And we are using this to solve certain problems. Not every problem, but the idea is (22:17.826) You can solve certain problems in a way that you cannot solve efficiently in today's classical world. And for us, the context is the problems that we are interested in for materials and chemistry. Quantum computers have a promise to be solving problems which are far, far beyond the reach of today's computers and supercomputers, even. So that's the place that we're aiming for. So Jonathan, in your mind. as somebody who is engaged with us at the moment, what's the what's the line between useful ambition and hype when it comes to material science? I think this is this is a really good gut check for for all of us working in the space to do, because, you know, we we want to be ambitious, right? This is a new technology that's that's very exciting and has a lot of promise. and and we want to make sure that we're exploring all the ways that it will be impactful and careful. and I I think ambition sort of means that we are open and excited about using new technologies and materials discovery, including quantum, and we're actively exploring how and where it may be useful. So for example, a statement like, Hey, we're testing whether quantum methods may help simulate certain materials that we can't do classically. And then there's kind of the obvious hype that some people peddle. Right. And it frames quantum computing as a solution to all problems and and it will replace all classical compute, which is, you know, not not a very reasonable statement. Right. but then there's also this sort of sneaky hype that I think enthusiasts like myself may fall into. There's a phrase. I love that phrase. Sneaky hype. That's a new one. I'm gonna use that. That's a cracker. It sounds kind of British, actually, right? Sneaky hype, it is very British actually. It's like click trickery and sneaky hype. Remember that phrase, click trickery, where you get tricked into clicking a link on the internet. Yeah. Sneaky hype. Go on anyway. Sorry, I interrupt. No, no, no. It's so so sneaky hype is extremely focused on what quantum computing is likely to be good at. And then it sort of becomes this hammer looking for a nail. Right. So for example, quantum computing will likely be useful for certain types of problems. So now (24:33.73) we have to map all of the problems we care about onto those problems as opposed to vice versa. Well I was gonna c I was actually gonna come onto appropriate problem types. So it's a a perfect bridge for that, which is th there's some really fantastic ways to frame you know, how powerful quantum can be on certain problem types versus traditional computers like certain problems. It would take a computer the size of the solar system, classic computer, to be able to solve something that a quantum computer can s can solve in minutes. Is that the sort of distinction we're talking about here? And have got any examples that might bring that a bit alive? Yeah, I think we we definitely have examples where it it can be argued in good faith that a quantum computer will likely be able to solve a certain problem that that classical can't. And there there's actually there was a whole DARPA, which is a government agency in the US program on exploring benchmarking these different applications. in a very rigorous manner. So not sort of hand wavy, but very much like this is the resource, this is the number of qubits you would need, right? And this is what it would look like. I think from from my perspective, a lot of it is in the near term going to be simulating electrons and materials, which you know, the behaviour of electrons and materials really dictates most material properties at the fundamental level. And and quantum computers are are very likely going to be good at that because as Falgan had mentioned, you know, qubits are are a quantum system, right? They're fundamentally quantum and they store quantum information. And electrons are quantum objects, right? So so you're kind of simulating a quantum object with another quantum object, and you can pack all of that information and all of the dynamics into a qubit. And and so I think that's really where we'll see near term gains of of capability, of accuracy, of things like that. How productionized are you guys at the moment? Are you still at a point where you are experimenting with the use like R and D, or are you actually running real simulations on quantum computers at the moment? So I would say we're very much in the experimental phase. You know, we we've (26:58.646) We've spent a good amount of time over the past, I don't know, decade kind kind of trying to come to terms with what people say quantum might be useful for, keeping up with the literature on on those developments, and then you know, seeing how if quantum really is better for a certain application, how would that affect the way that We design materials or make decisions about our overall workflow in in materials design itself. And and so I think it's early right now because quantum computing is in the early stages itself. I think with quantum as well, it's one of those technologies a bit like battery technology, where it feels like we've been on the break, the threshold of a breakthrough for like, I don't know, maybe five plus years, but we can't quite get to a point where it's operationalized in a way that it really, really does what we expect it to be able to do it. It feels like maybe we're still there, but it it's getting ever closer, but it's still just it just out of touching distance, isn't it? I mean I'd love your view on the idea about the maturity of the ability to use this type of technology. And if you think it's gonna go mainstream, well not you know, mainstream in inverted commas for the types of problems we we we we discussed the timeline, I suppose, for listeners would be useful as well from your perspective. Yeah, quantum is definitely a technology similar to fusion and then it's been ten years out for fifty years or whatever, right? Yeah. and I think up until maybe three to five years ago, I agreed with that characterization and that, you know, it's it's always imminent and it's never imminent. I would say over the past yeah, really just past few years, you've seen some real developments in in the hardware. (28:57.718) Where the qubits which which are in these delicate quantum states that are are very prone to collapse, they have become more stable. We've been able to bring more of them together, right? Because you need a certain number of qubits to do anything useful. So you're starting to see the numbers of qubits that we can reliably build increase. And then you've also seen some advances in error correction, which is this idea that Yeah, we we just have to accept the fact that that any quantum system will be fragile, and we have to figure out ways to deal with with errors that arise in our computations, just like we do in classical computers. And and then lastly, there has been some proof in the pudding in the sense that there have been papers that have started to hint at, you know, we've we've obtained some results that you probably could not get classically, at least with state of the art algorithms. and there's still argument about that, right? That's not that's not a complete that's not a statement that everyone would agree with, but I think it's not demonstrably false either. So I I think we're starting to move there. Just going back to the problems that that can be solved with quantum for a second, how would teams judge which computational platform is better? So what would make a problem better for quantum versus classical? This is definitely an open question. And I think when you when you talk to a lot of folks, they will talk about the accuracy or the time advantage, you know, the time to solution advantage for a quantum computer. But I I will say that from an industrial perspective, accuracy alone is never enough to determine if something is useful, right? It it absolutely has to change a practical decision and how you design or discover materials. And and accuracy, at least in a quantitative sense, is not required to do that. What it really needs is it needs to be able to capture qualitative trends in a predictive and reliable manner, better than existing methods that we have. And then ultimately it needs to do that at a lower time cost or a lower monetary cost. (31:19.67) than say just doing the experiments or just using the methods we do now. Jonathan, there there seems to be a dilemma for leaders, like invest too early and you might waste money, invest too late and you miss the next AI moment. How do you think organizations should navigate that tension?" I think leadership is pretty open to quantum because there there's a lot of talk about it in in the media and also from the government, right? From a funding perspective. So the government has been investing in quantum for decades and it will continue to invest in quantum. But I think these signals are important for industrial leadership because they they kind of signal that there's something there. I think also leadership is Becoming more eager to fund and support longer term risky technologies so that they don't miss the boat or so that they can be early adopters. I think a lot of people feel like AI is obviously a a big example where for some people it seems like it just came out of nowhere. And it it it did not, right? There are lots of organizations who steadily invested and and used it. But I I think leadership is now much more eager to say, hey, what are the next big trends? How could they affect our products and in our industries that we care about? And how can we use them and be early adopters to gain some competitive advantage over our kind of rivals in the market? Could quantum make us more tolerant of organizational complexity? Instead of simplifying systems, we might simply compute our way through them. Is that a risk? (33:33.708) I think it's very possible. I I think that quantum is has the potential to let us look at problems that for a long time seemed intractable. And some examples of that are superconductors, right? Superconductors are this very special type of material that when you run an electric current through them, they have no resistance. And and so that means they're very efficient. Right. And and you don't suffer losses when you transmit energy. Superconductivity is partially understood from a scientific perspective, but there's still a lot we don't know about the different materials that are superconducting, why they are, and how we can design better ones. I think for a while, maybe after the initial hype of superconductivity, people started to be much more cautious about. We don't understand it. We're never gonna be able to build a superconductiv. So we're just not gonna we're not gonna look at it. But maybe you s you're starting to see that word come up more. And the reason is because superconductivity is one of the areas in which people think quantum will have an impact in in the physical understanding of the phenomenon and ultimately designing better superconducting materials. So I I think that's a real possibility for sure. Phalgun, when when you listen to the potential of that, what occ what occurs to you? First thing I think of is at the end of the day, it's important to realize that at the quantum technologies, it's a tool. Quantum computing that we talk about, it's a tool that we do want to use. And Jonathan, you mentioned this earlier. It's really important that we understand where does quantum computing fit in as a part of a pipeline. And this is something I did wanna pick pick up on. So when it comes to like innovation and materials, even if It's not really important that we have the best of solutions. We don't need the most accurate one as long as we identify the trends as a starting point. But then maybe it's worth hearing your thoughts on what what is the role of experiments and theory and compute, including quantum compute and even outside of it, and how do they all come together? Yeah, I similar to to the earlier point about, you know, maybe in the past few years we've seen a lot of movement on quantum. (35:55.286) I think also in the past few years we've we've seen a lot of movement on self-driving labs, high throughput experimentation, and then of course integrating AI into materials design and discovery workflows. I think that again there are very prominent examples of success cases where people have coupled AI computation, robotic labs, high throughput experimentation and characterization. To really do a closed loop material design and discovery workflow. And ultimately, if you want these technologies to reach their full potential from a productivity perspective, right? Lower the time to solution of finding a new material, you need to string them all together in a very coherent way that they can leverage each other's Strengths, right? And and that means with AI, hopefully helping determine where in the material space to look for solutions with high throughput labs actually running the experiments and characterizing the results, and with quantum potentially enhancing the experiments that we do by kind of reducing. maybe the the number of experiments we have to do in figuring out novel search spaces that we wouldn't have otherwise considered in an accurate manner. So I think they they will all sort of come together in in the next decade and and people will kind of see them as as pieces of a greater whole. There must be must be quite an exciting time for you from your you know you know your work perspective and your field of study, because you've got quantum landing, which could revolutionize the field that you're in. And you've got AI getting to a maturity level with the ability to design drugs and discover things that are novel and humans wouldn't think about. And you kind of take those two as a force multiplier and you go fundamentally rebooting a lot of the way we might approach solving the problems that you face. And it it it must be like, (38:07.906) Two great big changes landing on you at the same time. So it's exciting but also hugely disruptive at the same time. How are you is it is it generally s relatively straightforward to cope with, or is it causing a load of chaos on the ground about we have to change the way we think about these things? I don't think it's relatively straightforward at all. in fact, AI is almost existential because it it is such a paradigm shift in how many people are thinking about the way they do science from from very basic things as far as I now use not me personally but but individuals use chatbots to do literature reviews, right? To draft papers, to bounce ideas. they they want these agentic AI entities to kind of direct experiments, propose ideas, you know, analyze data, all these things. And to me that's very existential because, you know, when I was Doing my PhD, these things, that that isn't how it was done, right? So you're having someone come in, probably similar to how people felt when computers really took off. You know, you can find some interesting letters from physicists maybe back in the 70s, where you know, they were thinking, computers aren't aren't doing physics, right? And and probably I I am the same about AI, but but I I do think that's that's hard. That's hard to grapple with. With quantum. it's easier to grapple with for me personally because I'm as a physicist the the notion of the technology really appeals to me and and the way I I think about the world and and appreciate the way that we use computation to solve problems and hopefully better understand the physics. So I I I think the the sort of paradigm shift using quantum is is going to be in the results, but maybe not how you do the work. Right. You you run your calculations somewhere else, but ultimately you're still running a calculation like you used to. Now you couple that with AI, right? And suddenly you've got an AI agent running the calculations for you, improving your algorithms, suggesting what calculations to do. And it does them better. You know, that that to me is is the most disruptive part. Yeah, I think you said this really well where AI as a tool combining really well with quantum. (40:34.58) And working together. But I wanted to bring the attention on one other aspect because we talked about the discovery aspect and the search space where quantum has this impact. But on the other end of the spectrum, John, you and I have also some experience looking at understanding some of the chemistry which cannot be explained. It's not just searching through things, but explaining natural phenomena and understanding nature around us that we are unable to do so right now. Do you have any thoughts on how that would actually impact materials characterization and development process overall? There are kind of at least in the in the the way we work at G Vernova, there are kind of two main approaches to materials discovery. One is the so-called Edison approach, which, you know, being legacy general electric, there's some bias towards that. Where you try a bunch of things and and you see what works, and eventually you converge to a solution. And that is effective and it's solved a lot of problems. But the other one is you flip it on its head and you say, I really, I really need to understand at the physical and the chemical level, the properties of my material, and how maybe compositional changes affect the the final properties that we care about. And I think

think that is a slower burn way to design and discover materials because it's it's very much not about the I'm gonna screen as many things as I can or try as many things as I can, but it's very much about I want to understand what's happening and and I want to use that to hopefully gain insight on ways I can improve a material or a process. And where it's more valuable, I think, is when you can translate that understanding. Because trial and error doesn't always translate, but but fundamental understanding does. And I think we're we're currently in a moment in materials design where quantity and scale matter a lot. How many compositions, materials can you screen and and in what time? But I I think there's also a push to the return to a slower type of science where we say, well (42:51.75) what do we really understand about the the things we're trying to do and how can we use that to do something new? And I think quantum will will have a role in both, because it it can enable both of those ways of solving problems. So when you cast forward a little bit, what do you see the path for this becoming less about testing, more about mainstream usage and then In your particular field, John, of material science, what are your hopes for that? over say pi I mean pick your own time frame, three years, five years, whatever you think makes best sense? For quantum to truly move from this this very early technology that we're using in research to something that's more everyday, like classical compute, we need A few things. One is scale and availability of the resources. Even as more quantum computers come online, they're still scarce. So you you just need the access, right? You also need to understand the cost model quite a bit because is is an industry we make a lot of these decisions and I alluded to this earlier based on on monetary cost and time cost. And at this point, I don't think we we have a good picture of what either of those costs will be as we scale up the problem sizes we look at. So what what I hope is that over the next couple years that we start getting clarity on the resources that'll be available and also the the cost of those resources. (44:53.708) Now we end every episode of this podcast by asking our guests what they're excited about doing next. And that might be got a great restaurant booked in the sun at the weekend, might be something to do with a World Cup, or it might be something in your professional life, or a little bit of both. So Jonathan, what are you excited about doing next? I am excited about starting to see as quantum technology matures, how it's gonna affect our understanding of materials and the physics of materials and how we can actually use that to improve materials design. And this is sort of the the juxtaposition we put forth earlier on Edison versus kind of fundamental understanding. And I I'm really hoping that with with quantum computing we'll start being able to solve really hard physics problems that we could not do before. And we can learn a lot, just not about materials that humans can use, but but really, you know, how how nature works it at its most fundamental level. Is there like a a magic wand problem in your discipline that you're like, if we could just crack that, you know, incredible things will happen. There are several. I think two two big ones are magnetism, and and designing magnets that don't have these these rare earth elements, right? We think quantum computers are are going to be very good at that. Magnetism is understood from a physical perspective in a lot of ways, but we still actually really struggle with our current methods to predict new classes of magnets that have new chemical composition families. And and I think If if we can crack that, you know, we can really start to to make an impact on designing stronger magnets, which are are crucial to the energy transition because they power electric motors, they power electric generators, they even are in actuators and robots, they power your hybrid boats, your cars, ev everything, right? And so I think that that is sort of one of the ultimate problems. (47:18.732) And how far out, if you had a gut feel, is that two years, ten years, twenty years? I feel reasonably confident that it should be within the next three years. Wow. Wow. Everybody loves the tech prediction. We'll come back to that. We'll invite you back on and goes three years, where's my new super magnet? Write it down. Come on, where's the super magnet? I I should I should clarify that I am on an RPE program That is looking at this exact problem. And the timeline is three years. So come hello high water, there will be an outcome. That's right. Hey, you're gonna deliver on time. We like it. We're on track.

Your project status report is green across the board. Exactly. Exactly. Well, John, we wish you nothing but luck with that and a fascinating insight really into both a very scientific discipline dealing with a big problem like the energy transition, but also like fascinating use of new technology. in a way that like really brings alive the potential of quantum. So thank you very much for spending some time with us today. Yeah, this was great. I really appreciate it. Thank you.

If you would like to discuss any of the issues on this week's show and how they might impact you and your business, please get in touch with us at realitiesremixed@capgemini.com. We're all on LinkedIn. We'd love to hear from you. So feel free to connect and DM if you have any questions for the show to tackle. And of course please rate and subscribe to our podcast. It really helps us improve the show. A huge thanks to Jonathan, co host Phalgun, our Sounds and Editing Wizards Ben and Louies, our producer Marcel, and of course to all our listeners.

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