



Decode Quantum with Sabrina Maniscalco from Algorithmiq

Welcome to the 84th episode of the Decode Quantum podcast series, which has now more than five years of existence. We are welcoming today Sabrina Maniscalco from Algorithmiq.



Fanny Bouton: Sabrina Maniscalco is the CEO and cofounder of Algorithmiq, a startup developing quantum algorithms for applications in life sciences based in Helsinki. She is also a Professor of Quantum Information, Computing, and Logic at the University of Helsinki. Beforehand, she held academic positions in Sofia, Durban, Turku, and Edinburgh, before returning to Finland in 2014 to lead the Theoretical Physics Laboratory in Turku. She moved to the University of Helsinki in 2020, coinciding with the founding of Algorithmiq. She's done research on noise in quantum devices, complex quantum systems, and quantum simulations.

Fanny Bouton: Of course, you are Italian, and best of all, from Sicily!

Olivier Ezratty: I visited the whole team from Algorithmic in Helsinki in April 2024.

Fanny Bouton: when and why did you fall in love with quantum?

Sabrina Maniscalco: I have a very precise answer because I remember it very well. It didn't start exactly with quantum but with astronomy. I was 15 years old. At that time I was changing very quickly the things I wanted to do: a ballerina, then a lawyer, an interior designer and so on. There were a lot of things that were exciting for me. I had this habit of reading randomly. I was randomly reading these big volumes encyclopedia and I started to read about the origin of the universe, how galaxies were formed and so on. It was so fascinating. I asked my

parents to buy me a telescope. and I started to go in the countryside in Sicily to observe the stars with my it. After I was 18, it was easier because I had my own car so I could go. It was a bit unusual because, you know, for 18 years old to go, I was going alone with my car in the middle of the countryside. It was beautiful learning, you know, and observing not only the moon, the planets and so on. I wanted to study astrophysics initially. I went to university and the only possibility was physics actually that included a specialization in astrophysics. Then, the first course on quantum mechanics was like, wow, okay, what is this? I immediately liked quantum mechanics. This is so crazy. It sounded like the true world is beautiful. I was really in love with it. And then I did my master and then my PhD on. It was actually on quantum optics. And in particular on the generation of entangled states. It was really fundamentals of quantum physics at that time.

I went through a phase in which I just had to think about my career. It became a bit like almost “shut up and calculate”, the Copenhagen thing. But then I rediscovered quantum physics later on through public outreach. I realized that something was missing when explaining it to others. And then, obviously, there is the Algorithmiq part that comes after.

Fanny Bouton: do you remind the title of your thesis?

Sabrina Maniscalco: I don't think so. I know the topic. The exact name, I don't remember. It was about generation of Schrodinger cat states with the cavity quantum electrodynamics and treptorions. So I studied protocols to generate different types of Schrodinger cat states. They were theoretical protocols, but we were proposing applications.

Olivier Ezratty: I found a paper from you from 2006: **Non-Markovian dynamics of a qubit**, 2006. It's probably different or is it part of your PhD work.

Sabrina Maniscalco: that is a different thing. I started to work more on open quantum systems. If you study quantum superpositions, of course, you also necessarily study the interaction of quantum systems like a quantum superposition with the environment. It's one of the biggest still open problems in quantum physics, so much studied. So this is in the framework generally from the theoretical point of view is called, is under the framework of open quantum system studies. So the interaction of quantum system with the environment, this is what causes the transition from the quantum to the classical world and so on. In particular, a specific class of open quantum systems are those that for which the communication, if you want, with the environment is not one way. It's not that you just lose information from the quantum system to environment, but something can come back. And these are known as non-Markovian open quantum system. I started to get together with other physicists, working on many approaches that led to the understanding of non-Markovian open quantum system. So it was my field of expertise.

Olivier Ezratty: If I'm not wrong, it's linked to two concepts. One is the concept of memory.

Sabrina Maniscalco: Yes.

Olivier Ezratty: and the other one is the concept of non-linearity in physics.

Sabrina Maniscalco: Yes. I think that for the way in which we categorize it, one of the things that we did was to introduce the concept of non-Markovian. in quantum information terms, in terms of backflow of information. This was very new at the time. So we described non-Markovianity in terms of information backflow. And then, in a way, this was influenced by the emphasis on quantum information and dynamics of information that at the time was becoming growing and growing and that then led to many applications that now form the basics of the quantum ecosystem.

Olivier Ezratty: it rang a bell for me for another reason, which is that it was also the theme of the thesis from

Jay Gambetta (now, at IBM).

Sabrina Maniscalco: Indeed, and I've known Jay since a very long time because he was working with Howard Wiseman. At that time, we worked with Jyrki Piilo from Finland on a method called quantum jumps. He developed a formalism of this quantum transfer, non-Markovian open quantum systems, and they were studying something of the same type. And there is an old exchange of emails back then in which we claim that there is a measurement scheme interpretation.

Olivier Ezratty: Jay's thesis starts with non-Markovian stochastic Schrodinger's equation and intervention of quantum mechanics. He was trying to see if there was some non-linearity somewhere in Schrodinger's equation.

Sabrina Maniscalco: that was the so-called quantum state diffusion which includes this non-linearity.

Olivier Ezratty: I found an arXiv paper from you from 2001 on trapped ions (<https://arxiv.org/abs/quant-ph/0110063>). In your initial scientific career, you addressed a very broad spectrum of topics. And later, on quantum chemistry. So, how would you define yourself as a scientist in this world?

Sabrina Maniscalco: two things. The first one is that generally my interest has always been driven initially from the perspective of understanding the fundamental laws of nature so I'm attracted by fundamentals that's has always been like that and it just happened you know timing is everything it just happened that while I was doing my initial PhD and postdocs there was really a boom in trapped ions and cavity QED, the very first quantum logic gates, the quantum superposition gate, the Serge Haroche and David Wineland work. It was a very exciting time, So the interest in fundamentals, even to the extent of understanding, there is some sort of aesthetic as well, thanks to the beauty of the laws of nature. I liked very much looking at the stars, the galaxies, like the concept of this mysterious, beautiful, you know, thing of the universe around us has always been there.

The other point is that I get bored easily. I like changing and I like challenging myself in new directions. That is why I have been moving then on complex quantum nature systems. Complexity is another thing that I liked a lot. And this went to the extent of deciding to move really. My main job from academia to a startup is a completely different world. I need to be constantly challenged and to interact with very multidisciplinary teams, with people from different backgrounds. This has always been also a characteristic of the type of scientist I am.

Olivier Ezratty: I don't know if it's the case for all the CEOs in this world, but you have a 15-year scientist career before creating the company. So it's a long time.

Sabrina Maniscalco: and it's very radical. It can be a little bit of a scary choice. Nowadays, my work time in academia is very small. I'm really focused on the company. I shifted when I was more than 40 years old. It's a big challenge. I had to prove very different things to be CEO of a company.

It had a strong meaning for me because one shouldn't be afraid of thinking, is this really what I want to do? I want to try something completely different. Let's do it. I would recommend it to everyone. It doesn't mean that everyone should do it, but I think that everyone should be free and bold of just trying something completely different without the risk of failing, which is possible, you know.

Fanny Bouton: going outside the comfort zone.

Olivier Ezratty: statistics show that the startups created by people who are in the 40s are more successful than the younger CEOs.

Sabrina Maniscalco: I've heard the same. There is an aspect that is, you know, you grow, and you know many

things, and so.

Olivier Ezratty: when you look at the typical scheme from quantum startups, particularly in the hardware side, you have a PI (principal investigator) who's got a young PhD or a postdoc in his team that becomes the CEO of the startup, and the PI becomes its chief scientist, kind of working back door, but not taking the bigger risk. He/she stays in the academic world. So you didn't do that.

Sabrina Maniscalco: I didn't do that, and I didn't want to do this, because I wanted to change. You need to have the humility to adapt, and to admit that you must learn a new job. Because it's different and you have to understand that sometimes, your background as a scientist really can be bad because you're not a scientist anymore. The advantage is that I know very well what my team is doing. So I'm really connected to product, to R&D. I know it. I understand it. There is no disconnection, and I think that for quantum at this stage, this is really good.

Fanny Bouton: and how do you learn how to be a CEO?

Sabrina Maniscalco : I can talk only about my experience. I can say first thing is that Algorithmiq is not a spinoff of a university. We didn't have like the university, like innovation or centers or however they are called behind us to guide us. It was born because of me and my three co-founders that are part of my scientific team. He's an initial investor and business co-founder who did this job. He really helped companies like DeepMind initially. He has been helping to create many startups. He had a very, very strong network. And so I learned through the people, our early investors first, but also, for example, my then chief of staff that was hired immediately. She comes from a background of startups. She worked in TechNation and so on. You should think, I need help. You should be ready to read books, listen to talks, imitate what others are doing, learn the language. It's a completely different language. I'm still trying to learn this. So, it's interesting, but it's been a wonderful journey and I'm so glad I did it and I'm very happy at the moment.

Olivier Ezratty: considering the domain of Algorithmiq, which is focused on life science, when did you decide that? Did you work in research in life science before creating the company or was it a conjecture?

Sabrina Maniscalco: what happened is that, of course, initially the core team, so the co-founders were all quantum information people. We had some core IP that was related really, because we still have a product that is more at a low level in the software stacks, how to really use software to extract reliable information from quantum computers. This is really more quantum information and software engineering type of stuff. It's closer to my background as well. Including noise mitigation, for example, all these things are related to open quantum system. We had this initial IP and then we were thinking since the very beginning, in what vertical can we have some strong impact? We realized immediately that we would not be able to actually gain some expertise on all the possible applications of quantum computing. This was a choice. We do all the optimization and all the, all the pieces needed to work at a quantum advantage level. It's hard because part of it is also about identifying the use cases. We decided to focus on chemistry, general chemistry and materials initially. We started hiring one of the leading quantum chemists who worked already with quantum computing, Stefan Knecht. It was our first. And then you see when you have the best one, that has always been our the way in which we hired is have the top leading expert that places. And then they bring in their people.

Olivier Ezratty: there's some coalescence of skills around the one given their knowledge of skills, the masters, the students and everything.

Sabrina Maniscalco: that is how it started. Then we started to cooperate with Cleveland Clinic and other companies more in their life sciences and hire more in this space. We have two products. One is. across verticals, the digital quantum interface between quantum computers and HPC and all this machine learning and

so on. This is a bit across verticals. The other one, Aurora, is really an end-to-end pipeline for quantum chemistry and discovery in life sciences.

Olivier Ezratty: there's a kind of dual journey, one on middleware and the other one on the applications. Which one is the safer revenue-wise in the software company right now?

Sabrina Maniscalco: we are firmly convinced of the fact that you can't have applications in healthcare and life sciences or in chemistry and so on without some sort of co-design, or co-optimization of the two layers. quantum interface and Aurora, the quantum chemistry. This is necessary because if you imagine to have a very complex pipeline, which contains the measurement or the pre-processing measurement and so on. If you optimize only one of these pieces, then you may transfer overhead to another part. So the whole pipeline has to be optimized at the same time, because sometimes maybe not the most efficient measurement scheme is needed in order to have the whole pieces optimized to reach the maximum capacity or the maximum number of qubits and maximum depth. So this co-design and this co-optimization is key. However, what we see in terms of commercial aspects is that the modules, so the algorithms more related to noise mitigation, to pre-processing, initializing quantum interface and so on. This co-optimization is key. We see more requests from hardware providers or via the IBM Qiskit function catalog also from users of quantum computers for these modules, which are across verticals. It will take longer to have really commercial applications in drug discovery. Because there has been already an initial wave of interest from some of the pharma companies in quantum computing, where they've already done their proof of concept. They want to see really something real. For these, it takes longer. We're going to have to wait and see. Probably until 2027. So many more short-term clients are for the digital quantum interface and the other longer terms are more in healthcare and life science.

Olivier Ezratty: there's another typical topic when you do software in this world is either you start with the problem and you look at the resources estimates and sometimes you find out that you need a couple of zillions of logical qubits and physical qubits and it's far off in the future. Or it looks like your case, you try to find use cases that fit in existing NISQ system, using quantum error mitigation and so on. So what was your path? Did you explicitly started with saying, we want to find solutions that fit existing hardware or future hardware in the next 12 months or 24 months, given the roadmap for IBM? Or it was both ways.

Sabrina Maniscalco: it was both ways. At the beginning, we thought very carefully, and we worked for years on what we thought were the very basic roadblocks to scale use cases in general. Some of these roadblocks are very simple. You need a lot of statistics, and you need to do measurements well. And they are generally overlooked. So that is our main point. So we thought very extensively how we can measure and in which way we can, let's say, map or even take a screenshot of the quantum computer. And we had in mind since the very beginning which started from existing NISQ quantum computers but then could be applicable also to fault tolerant quantum computers. And so that was one side. Let's say from the existing issues that are in any case inevitable in simulating chemistry or materials. You always have to measure properties so you always have the issue of the statistics. Then with Cleveland Clinic, there was an interesting application about some photodynamic therapy for cancer treatment where the quantum mechanical nature of the interaction of light with the molecules could lead to create some quantum computer algorithm. It's not us who alone can decide what is a proper use case. You need to have a third party which has some interest and knowledge, and which clearly has a blocker, because in the end, you want to solve a problem which is not solvable classically. In doing so, you learn a lot. You see there are two sides. You go from one side. They come from the other side. And they converge in the middle at some point. The most beautiful thing is that now is the most exciting time because we now manage to put all the pieces together. So, we have really an end-to-end pipeline optimization. It's also interesting from the point of view of the people. We have many different multidisciplinary teams which are now very well coordinated. They know how to work together, and they know how to somehow coordinate and interchange information. It takes a lot of time to do this. This is part of growing a startup. It's

exciting for us because we think that we are here at the right time because now everything is working all together. We are reaching a point in which we can see quantum advantage next year.

Fanny Bouton: did you find a recipe to discuss with the client that they discover the good use cases they identify? Because sometimes they're waiting that we provide an "advantage" use cases and they don't understand what their own use case is. And I think we need to find a journey about that. Did you have how to talk with them and help them to discover what is good for them.

Sabrina Maniscalco: this is still a very difficult point. Our experience was that we were also lucky. For example, in the collaboration with Cleveland Clinic, which is the most advanced, they were eager to challenge themselves and to interact with us. You need to have the right contact point. Once you prove, now this is proof that this works, and not just in this case, it's a transferable pipeline. Only when you scale, obviously, that is not the interaction anymore. It's just that you know how to, but initially, I mean, this is so hard, and it takes so much of so strong efforts that it really important that there is a click between the parties.

Olivier Ezratty: is there a common characteristic between the applications you found out in NISQ for Cleveland Clinic and what people want to do with FTQC (QPE, finding an electronic structure, ...)?

Sabrina Maniscalco: we have two categories. We think the closest advantage is more related to these Floquet systems like kicked Ising models where somehow the quantum computer naturally fits well the systems right now. For these, the systems are extremely interesting and well studied by a large community of scientists, because, for example, there are state of equilibrium state phases. There is a combination of matters that are not understood. And also they can be models that apply to very different forms. Now, of course, the question is really what has been extremely interesting is to push the boundaries of classical simulations. There are many people doing it. But the way in which we are working now is to bring on board the top leader of classical simulators. They obviously don't do experiments unless we know that they are classically non-simulable. That is the main point. You must satisfy a number of requirements. So, the signal does not have to be too low because if it decays too much then it has to fit the specifications of the machine. It must be physically meaningful. Then you need to have some way of benchmarking to say that you can trust the result of the quantum computer, even in a regime inaccessible to classical computing. And as you work with machines, you realize all the boxes that you have. Then there is the other side, which is more related to electronic structure problem simulations. There we have a different approach because what we are working on is the combination of techniques that are classical but boosted by quantum computers. For example, you can prepare a ground state with a VQE to feed a classical DMRG simulation.

At this stage, we don't do VQE at all on quantum computers, but we have a very efficient method to do VQE in preprocessing completely. So and then. we generate the answer. This is a very recent paper we put out. We are extremely excited about it. It's an approximate method, but it was extremely well with up to more than 50 qubits, actually.

You can use a simulator of fermionic system. We call it a Majorana simulator, majoranic creation method. But you can also efficiently generate answers for VQE, but without doing the VQE on the quantum computer, if it makes sense. So it's a way in which we avoid actually doing VQE on quantum computers because it's very problematic to do VQE on NISQ, but still have an initial answer which has a sufficiently large overlap with whatever ground or excited states, because what we do involves also not only ground, but also excited states, and so therefore can then be, created on the quantum computer and then considered as an input for whatever, let's say, the DMRG or other method we use in post-processing.

Simulation of Fermionic circuits using Majorana Propagation by Aaron Miller, Zoë Holmes, Özlem Salehi, Rahul Chakraborty, Anton Nykänen, Zoltán Zimborás, Adam Glos, and Guillermo García-Pérez, Algorithmiq,

arXiv, March 2025 (18 pages).

Olivier Ezratty: we mentioned Jay Gambetta already, but could you elaborate a little bit on your partnership with IBM since it's a key partner for you. I see you everywhere, all over the place when IBM is organizing events.

Sabrina Maniscalco: we don't collaborate only with IBM, but that collaboration has been very long-standing because, and that's the reason why clearly we work a lot with them. And the reason is that when IBM deployed the very first quantum computer, it was called the IBM Quantum Experience, back then.

Olivier Ezratty: at the beginning of 2016.

Sabrina Maniscalco: 2016, 2017. I was still a professor and my students, started to use it just for fun. Many of my colleagues, were asking "what are you doing?". This is useless and so on. I said, well, actually, I think it's fun. And there was the very first, they call it Qiskit Camps in Vermont at that time, organized by IBM. And I went there with my students. I was the only professor. There were all young people. I went with three members of my team, then the co-founders of Algorithmiq. We started to go to all the Qiskit Camps and to really play with these devices. And then a number of papers came out. We had a paper, for example, in Nature Quantum Information with the first digital simulator of open quantum systems with an IBM quantum device. You start establishing a relationship and then the relationship continued also when we had Algorithmiq and both with the Zurich and the Yorktown teams. This has been growing and we have been working very well with them and through them obviously we also met Cleveland Clinic.

?ADAPT-VQE: Toward Accurate Calculation of Excitation Energies on Quantum Computers for BODIPY Molecules With Application in Photodynamic Therapy by Anton Nykänen et al, Algorithmiq and Cleveland Clinic, arXiv, April 2024 (21 pages).

Practical techniques for high precision measurements on near-term quantum hardware: a Case Study in Molecular Energy Estimation by Keijo Korhonen, Daniel Cavalcanti et al, Algorithmiq and University of Helsinki, arXiv, September 2024 (15 pages).

Olivier Ezratty: which is one of their key customers where they deployed a system on QPU.

Sabrina Maniscalco: and then more recently we had a very very exciting partnership with QCI for example.

Olivier Ezratty: you mean the QCI from Yale with dual-rail superconducting qubits?

Sabrina Maniscalco: yes. Our partnership works very well with them. We have been using their new device (which has 8 qubits) and a very interesting architecture.

We work first on small use cases and are combining our tensor network error mitigation with error detection. The interface between error mitigation and error correction is really a very hot topic. To be able to do this on this type of hardware is exciting.

Olivier Ezratty: you are the co-author of a famous paper, on the potential of NISQ a couple of months ago. I think it was earlier this year. The myth around quantum computation. And you were a co-author with many folks, including from IBM. Can you elaborate on this paper? And I've got a side question related to that paper. You mentioned early on that you think that in maybe one or two years, we're going to reach a quantum advantage. So, what do you think is going to be the milestone? Is it one of the new systems from IBM that is in their roadmap, or is it something else?

Myths around quantum computation before full fault tolerance: What no-go theorems rule out and what

they don't by Zoltán Zimborás, Fernando G. S. L. Brandão, Elica Kyoseva, Ivano Tavernelli, Sabrina Maniscalco et al, arXiv, January 2025 (11 pages).

Sabrina Maniscalco: first I'll tell you about the paper. Yes, the mystifying. It's an interesting story. The background starts with the fact that one of my passions is organizing events, like quantum events, like quantum hiking workshops, quantum sailing workshops, conferences of all time. I've organized conferences, small workshop in castles in Edinburgh in Scotland, like all type of, because I believe very strongly, not necessarily in big events, but small events where you bring people together and really work like hackathon style, really, like intense work, workshops in the original meaning of the term. So what we did is that in, I think it was last year in April, we organized an Algorithmiq conference, we called them, called Quantum Now in Lapland. In a very beautiful place in Lapland with all these fantastic Northern lights. It was incredible. And we invited the people who became the authors of this paper to discuss about quantum now, actually. So what can we do now with quantum computers? And eventually, the topics of this paper is precisely related to what we discussed. We wanted to convey that across many different companies, they have also very different points of view.

Some of the authors are really much more FTQC than NISC. There wasn't really necessarily an agreement on quantum now, was not necessarily NISQ. We wanted to understand really what we could consider a myth and what not, and how to estimate the resources in order to somehow do this and that. I believe a lot in these collective voices, it's important and I think that this was indeed immediately very popular like the debunking meter.

The message was it wasn't just necessarily to go in depth of the scientific calculation. It is all based on science obviously. The authors are all scientists so there was a lot of scientific discussions behind but what we wanted to do is a message from the scientists to the larger community so the language has to be such that the larger community understand it. It is based on science because the science was discussed obviously by all of these scientists clearly. I liked very much how it went. You can't imagine how difficult it was to coordinate all these people. It's been a nightmare, but eventually we made it.

Fanny Bouton: you made the talk at the QEI workshop last January in Grenoble. Can you give your thoughts about the energetic of quantum computing? How should we address it?

Sabrina Maniscalco: this is something I'm super interested. I think it's one of the most important topics when thinking about quantum computing. At the same time, it's a topic in which I don't know a lot. Olivier has been doing fantastic work in teaching us and explaining in a very comprehensive, but also simple way. What is quantum computing and what are the directions? So that is for sure something that I really appreciate, because I think that when also when we talk in terms of quantum advantage, we cannot forget the energetic aspect is one of the variables, obviously, that defines advantage. Advantage is also energetic advantage, clearly. So my opinion is that while I don't think there is yet a conclusive argument, there cannot be. This consideration changes from platform to platform. But the importance of really properly studying and keeping to study and finding benchmarks, finding ways of quantifying these things, this is undoubtable.

Olivier Ezratty: when we think in terms of some of the things we do, of course, we do use also supercomputer, HPC and so on. We use it in post-processing. We can use it also in pre-processing generally. And we use it in both the quantum computer and the HPC. So what we observe is that the balance between the amount of usage somehow of the HPC and the usage of the quantum computer, changes or will change with time.

Sabrina Maniscalco: this we can actually even prove. So as the quantum computers become better and better because the hardware is better, error rates go down and so on and so forth, the amount of HPC resources that you will need, they will decrease. I mean, we can prove it even mathematically.

Olivier Ezratty: even in quantum chemistry?

Sabrina Maniscalco: even in chemistry, yes. We have very strong proofs that this is the case in chemistry. We do know that generally chemistry calculations are very, very intensive in terms of HPC usage and therefore in terms of energetic resources. So clearly, we believe that if the overall energy consumption of a quantum computer remains something that does not exceed these huge supercomputers, then obviously there should be a reduction. But I'm just telling you things that are very hand-wavy still at this point. Luckily, there are people and groups and organizations, the Quantum Energy Initiative and so on and so forth, that are very rigorously pushing forward this agenda. And I'm happy to keep following.

Olivier Ezratty: do you think we could improve the interplay between academics and industry vendors in that space? It's not easy. I mean, initially, the QEI was mostly about research, fundamental research in quantum thermodynamics and stuff like that. And now we need to expand that. So do you have any ideas?

Sabrina Maniscalco: I agree that this should be done. Of course, there is an aspect which is obviously related to money when it comes to industry and skills and skills. This is always something which is in the agenda of any industry and commercial entity. But if you ask me which practical steps I could recommend for this to happen, I think that most likely, the very first steps would be bringing together, maybe via this type of events, more "unconference" formats, trying to bring together these people. This is probably already happening. You know, some the right people, because, for example, when we organize, I stress again, the part of the right people. When you organize events like the Quantum Unconference, it's very important to select people. They are by invitation only because we need to select the people who come there, not just because other people are bad and these are good. But it's just because you want to create the right synergy. Is about engineering synchronicity. You are engineering something that then emerges like it happened in this NISQ paper. Probably a selection of a few key players and giving them space and a nice environment where to discuss this could be the first step.

Olivier Ezratty: it has to be done. What I found out in this energetic discussion is the probably under-assessed role of software. It's about the same in classical computing. We know that classical computing makes progress both with hardware and software. You don't just make progress because of GPUs from NVIDIA. You also make progress because you have tensor networks. We have a lot of new mathematical methods. So I suspect that in the quantum world, it's going to be the same thing to mitigate the resource consumption. Whether it's energy or just the hardware cost. So software is going to be probably a more important asset, including compilers, optimizers and stuff like that.

Sabrina Maniscalco: this will happen at some point in the future. From the perspective of scalability, one can never be certain. But if it follows a similar path than what it happened in the classical computing paradigm, this is likely to happen. Yes, I agree.

Olivier Ezratty: we were also planning to discuss something that's important for you, that is education. Part of your team is engaged in that thing and you yourself also with the EU at the European Quantum Flagship level. Can you talk about what your team is doing in the QplayLearn initiative? I saw the team when I visited you in Helsinki last year. They are really passionate about this. So communicate us and our audience this passion about learning.

Sabrina Maniscalco: qplaylearn.com is the address for everyone who wants to learn quantum computing. We also have a great mix of great things. This initiative started really almost at the same time as when Algorithmiq started. It didn't start only within Algorithmiq. It is also involving universities, in this case, the University of Helsinki and Aalto University. Eventually, it really started because of the fact that, let's say, the second wave of love for quantum physics came from public outreach and from science and art. At the quantum hacking

workshop that I organized in the Dolomites, I met Caterina Foti, who was a PhD student in Florence, and then after her PhD, she wanted to start doing only outreach, and at that time I said, okay, I think it would be great if we could hire you at Algorithmiq, and you can lead our effort for outreach. QPlayLearn is a platform that is aimed at many audiences, the general public, but of course it also has a specific content for schools and young people, we say 099 is our, or 199, because nowadays we live longer, is our audience. There are even, we also realized some kits for the schools, that contain didactical activities, a booklet with a story that was created by an Italian writer. It contains a guide for the teacher for quantum physics. So these are more educational for schools. There is also a part that is related to retraining and informing, for example, CEO of companies. So in order to understand, for example, or distinguish hype from reality.

So we have some courses like Inspiration Quantum and then there's Quantum Software. So there are a number of simple training courses. And then, of course, there is the part on science and art that is also something we love. So there are, for example, video games that are engaging without teaching necessarily quantum physics, but they can be what you can develop some quantum intuition, obviously. Then there is a deeper level. Which is when you start learning about, for example, experiment. So if you want to dive deeper, you have the possibility of going into the experiments. And then there is another level yet that is the mathematical formulation.

We always like to have this multi-content and multi-layered type of material that allows to discover new meaning as you progress. So you decide where to stay in the exposure. But the passion comes from the fact that we believe that quantum physics is beautiful. We think that to some degrees. And in different ways, many different people can enjoy the beauty of quantum physics, but from the perspective also of a new technology, new exponential disruptive technology is also important for society somehow to have an idea of what this technology is because it makes easier the adoption and acceptance. You don't see it as far and as distant. And additionally, there is something unique to quantum physics, which is the fact that it pushes you to think outside the box. It's like a puzzle. It can have an additional somehow push to creativity.

Olivier Ezratty: do you think that bringing young people on quantum science is a way to attract younger generations in science overall, not just quantum science? It's like a good hook, I would say, like astrophysics in your case. Because of the mystery part, because of maybe of the complexity, the understanding of nature, there's many, many things, and even the philosophical aspect.

Sabrina Maniscalco: absolutely. There's also the fact that young generations are also used to different types of media, like video games. It is absolutely fine and normal to use this type of media to attract them. And we have been doing it since a long time. I organized the very first Quantum Game Jam. Then we started to organize it. The very first one was organized by myself and the Finnish Game Jam Association. At some point, of course, other people that came from my group continued and we developed very many games along the way. Some of them are in the QPlayLearn. Nowadays, everyone organizes Quantum Game Jams, which is nice and fun.

Fanny Bouton: you are involved in the Finland Quantum Strategy, to design this strategy, this is a that can't be summarized by BlueFors and IQM, I presume. You're working on this strategy, can you tell us a bit about that?

Sabrina Maniscalco: I'm strictly speaking not directly involved in that.

Olivier Ezratty: you're a contributor?

Sabrina Maniscalco: I contributed in the past, and I've been representing Finland in many of the meetings like this, of the like-minded countries that initiated in the, actually the White House was the first meeting, this multilateral dialogue on quantum. And so I've been following a lot the development and how the strategies are aligned, really, or there was an attempt to align strategies and to discuss different use cases. So that has been happening. I've been consulted, of course, and I've been following the development of the Finnish strategic

agenda. The current working group includes some representatives from Algorithmiq as well as from IQM and others.

Olivier Ezratty: you're a real European, a bit like Tommaso Calacco, you're Italian, based in another country. How could we be European in quantum? How can we be the real European industry, which is the key stake, if we want to compete with the USA. We can't reason only at the country level. So how can you do that more efficiently than what we do today?

Sabrina Maniscalco: this is a very big question. There are many aspects related to geopolitics and sovereignty. We want to have our own independence when it comes to quantum technology, and there is a reason why this should be. On the other hand, it's also true that it is, to a certain extent, collaboration and dialogue is absolutely needed still, because this is the way in which we will advance for the whole global quantum ecosystem. This can be done more easily with like-minded countries. That's why certain groups have been already formed and they're progressing. I think that there is a risk if we are too protective and nationalistic. Certainly Europe has to be Europe, okay, and we have to as much as possible think. And this is also something that, in a way, there is a lot of willingness to act more, let's say, collaborative within Europe, despite the fragmentation and all these issues that we know are still there. There is additionally the fact that we are the first generation of the Erasmus project. I was the first of my university to go to an Erasmus project. So obviously we were born going beyond the borders of our countries. This is reflected in the way in which we think as Europeans. Clearly there are many still difficulties that there need to be, and there are many problems that need to be solved for doing this. But at least in terms of identity, I think that this is something which we have more and more and is growing more and more. And I'm optimistic obviously. Again, we know that in order, to be competitive, we need more capital. We need more procurement rather than grants from the state. I see some actions in this direction. It's not yet enough, but I think that there is goodwill to progress and I'm optimistic.

Fanny Bouton: thank you, Sabrina!

*PS: Fanny Bouton and I have been hosting the **Decode Quantum** podcast series since 2020. We do this pro-bono, without an economic model. This is not our main activity. Fanny Bouton and I are active in the ecosystem in several ways: she is the "quantum lead" at OVHcloud and cofounder of the France Quantum event, and I am an author, teacher (EPITA, CentraleSupélec, ENS Paris Saclay, etc.), trainer, independent researcher, technical expert with various organizations (Bpifrance, the ANR, the French Academy of Technologies, etc.) and also a cofounder of the Quantum Energy Initiative.*

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