



### Bit Quântico 3: RAFAEL CHAVES AND QUANTUM TRAJECTORIES

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**Leo** - Hello everyone, I'm Leonardo Guerini and we are starting another Bit Quântico. In today's mini-episode, we start by asking you to imagine a scientist. Did you imagine? Maybe you pictured someone wearing a white coat, with glasses... among other clichés. Or maybe that classic image of Einstein, disheveled and showing his tongue, came to your mind. We have this habit of creating stereotypes, assuming that people should dress or behave in a certain way depending, for example, on their profession. Well, it's no different with a scientist. We often have this vision of the genius predestined for a successful trajectory: excellent student at school, exceptional at college and so on. However, reality is often far from this stereotypical view... It involves many doubts and difficulties that do not appear in that short LinkedIn-type description. And in this Bit Quântico, in order to illustrate the trajectory of a real scientist, we will tell the story of how one of our interviewees, Rafael Chaves, dove into quantum physics. In addition to showing some low points of the academic life, this episode also provides a little insight into the emergence of research in Quantum Information in Brazil.

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**Rafael Chaves:** My history with quantum is quite old, actually.

**Leo** - Here we are already listening to Rafael, who is a professor at the Federal University of Rio Grande do Norte and a researcher at the International Institute of Physics, which is also in Natal.

**Rafael Chaves:** I did technical studies, right? In IT, at the time it was CEFET, nowadays it is called IF, and in industrial IT. So I always liked the hardware part more. From messing around with the parts, programming in assembly, right there at the machine level, right?

**Leo** - In other words, if we were to be guided by this statement, we would expect to see Rafael today as an engineer rather than as a physicist. But don't worry, we're still at the beginning of the story. And anyway, it's cool to see the role that federal institutes, the IFs, play in training future scientists.

**Rafael Chaves:** And then I remember a microelectronics class where I was reading a book and they were talking about semiconductors, right? Which are materials, devices, that are essential for the construction of any modern computer.

**Leo** - We even talk a little about semiconductors in our episode 2, you can check it out there.

**Rafael Chaves:** And then the author of the book says, look, in order to understand this, only using quantum physics. So it was the first time that quantum physics appeared, right?

**Leo** - Well, we are there in our daily routine, and suddenly we stumble upon quantum physics in unexpected places. Like, for example, in a microelectronics book. And this affected Rafael, because he already had an idea of the career he wanted to follow.

**Rafael Chaves:** I always wanted to be a hacker, you know, I watched the movies, read the books about hackers, I said well, so for me to really understand what a computer is, I have to know what quantum physics is.

**Leo -** Well, at this point we might already get a glimpse of the scientist appearing. Rafael didn't want to be just any hacker. When he saw that the fundamental theory behind the components of computers is quantum physics, he decided that this was what he had to learn to be a top-notch hacker. But the expression 'quantum physics' was a bit discouraging. And not because of 'quantum', but because of 'physics'.

**Rafael Chaves:** Anyway, physics for me was that kind of boring thing, right? From the classes there, those carts going down an inclined plane. But I became interested, so I bought some popular science books, and I started to like the topic.

**Leo -** And reading popular science books, his interest grew... and then, when the technical course came to an end and he had to choose which course to study at university, Rafael already had more or less one option in mind.

**Rafael Chaves:** And then this idea of doing physics came up, because of this word that appeared in the computer science book, quantum physics.

**Leo -** So Rafael took the entrance exam, passed, started his degree in physics... and hated it.

**Rafael Chaves:** It was calculus, it was differential equations, algebra, it's that same old, boring high school physics, cart going down an inclined plane but now using more complex equations, right? But it was basically the same thing. So I almost dropped out of the physics course, I found it very boring. I failed in several subjects, I had no interest at all.

**Leo** - Well, in my opinion, calculus, differential equations and algebra are really cool things. But for Rafael at that time, at least, they weren't. In other words, the beginning of his university life was not promising at all. Anyone who looked at Rafael's grades wasn't very optimistic, but more important than that: he himself wasn't motivated by what he found in the courses. Until finally that changed.

**Rafael Chaves:** But anyway, what happened was that in the fourth semester, if I'm not mistaken, quantum finally came, right? And then I finally found it, right? That thing that I was looking for, which was, well, quantum tunneling, the uncertainty principle, superposition, all those exotic things and so on, that I've read, listened to, right?

**Leo** - After years of putting up with courses that, according to him, were boring, Rafael finally opened the door to that quantum world that he had seen from afar in the microelectronics book.

**Rafael Chaves:** Quantum was my goal, right, but I got lost at the beginning of the university studies.

**Leo** - But still, what he discovered is that this world was very big, and you could start to explore it in many different ways. And, at least for Rafael, not all of them were that interesting.

**Rafael Chaves:** I tried to go to this more experimental part, it didn't work out at all. I tried, let's say, to study quantum in a broader context, right? Which is the combination of quantum theory with the theory of special relativity, which is what we call quantum field theory. And again, it didn't go well.

**Leo** - So it wasn't enough just to be in the quantum domain... nothing guarantees that we will fit into a scientific area, not even when we have been looking for this area for some time. But Rafael didn't give up.

**Rafael Chaves:** I went through different parts of physics, right? I started there with experimental physics, where I discovered that I didn't even know how to tighten a screw properly, so it became clear that my gift, or let's say, where I had any chance of succeeding, would be in theory.

**Leo -** In other words, that engineer profile became a thing of the past.

**Rafael Chaves:** So I started studying quantum information already a long time ago, in two thousand and two there was a professor there at UFMG, right? I was starting to study this topic, it was still something very new, so I started there with error correction codes and things like that.

**Leo -** Here, Rafael is referring to Reinaldo Oliveira Vianna, who is a Professor in the Department of Physics at UFMG and a researcher in quantum information theory. The area of quantum information theory and quantum computing are actually quite new. Despite the fact that quantum theory itself was developed there from the 1920s onwards, the focus of these ideas on communication and computing tasks emerged and gained strength only many decades later.

**Rafael Chaves:** So, the field of research, let's say its beginnings, was there in the eighties with articles by Feynmann and Deutsch, but it really took off in the nineties, right? At least from a more conceptual point of view.

**Leo -** Just to be clear: the eighties and nineties of the last century, thirty, forty years ago. On the time scale of science, that's basically yesterday! But when new fields of study emerge, they don't appear everywhere at once. So it took a little more time for these ideas to start being developed here in Brazil.

**Rafael Chaves:** The history of quantum information in Brazil is very interesting, right? Several Brazilian researchers were involved in these movements from the 90s onwards, right? People who were mainly in Europe, some in the United States and as these people started to return to Brazil, right? They started to open this line of research here, so we're talking about

the beginning of the 2000s, right? Which was still an area that wasn't as hot as it is nowadays, right? It's not as big, well-known and well-funded as it is today.

**Leo** - And Rafael, who experienced this, draws our attention to a very interesting point:

**Rafael Chaves:** That was something really cool at that time, where students and Professors were learning together, right? Everyone starting from scratch.

**Leo** - In other words, in such a new area and with so many relatively simple ideas to be explored, even the Professors were still becoming familiar with the concepts and problems. But let's go back to the particular path that Rafael followed.

**Rafael Chaves:** In my master's degree I decided to go into particle physics. Again, only to discover that I had no aptitude at all. So I mean, it was a bit of trial and error, right? And so I always went back and forth and always ended up going back to quantum theory, the fundamentals, quantum information.

**Leo** - This work of exploration and, as Rafael himself said, trial and error, ends up being quite common in academic life. We don't always fit into a research area right away, and having doubts and the desire to look for something better is completely natural. Now, one thing is to be admired: even though he tried several different things and several of them failed, Rafael did not give up on academic life. He managed to do something that is easier said than done, which is to use these experiences as learning.

**Rafael Chaves:** What I realized is that for me a difficult problem is not interesting. It's interesting if it's conceptually relevant, if it brings something new, if it allows me to discover something, think about something outside the box without necessarily doing thirty-five pages of calculations, right?

**Leo** - I agree with Rafael that, although quantum has this reputation for being incomprehensible, especially in quantum information theory and quantum computing, you don't need to spend that much time studying it until you find open questions that are conceptually challenging.

**Rafael Chaves:** So in quantum I found myself. Not that quantum is easy or that we don't need to be rigorous or have an arsenal of mathematical techniques, but it allows, let's say, to explore the terrain without necessarily knowing these mathematical techniques beforehand. I felt like I was there, exploring the terrain, and as I entered, mathematical techniques were being learned along the way, right? So I think this image, this analogy, sums up why I like quantum information and computing.

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**Leo** - Well, we heard four or five times throughout Rafael's story that he had no talent at all for a lot of things. I'm not sure if this is completely true or if there is a certain modesty involved here, but it's nice to mention that today, without a doubt, he is one of the most successful Brazilian researchers in the area of quantum information theory. Of course, each case is different, but one lesson that remains is that just because you found a subject boring in high school, or because you, at this moment, don't really like your research topic, doesn't necessarily mean you won't be a successful scientist... Oftentimes, going through trouble is part of the path to success.

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**Leo** - In this Bit Quântico we told a little about Rafael Chaves' trajectory, but on our website you will find the profiles of all our interviewees. Check it out so you can find out a little about the trajectory of these incredible researchers. We'll be back in the next episode, see you then!

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