

“We have to make the right moves!”



“The benefit of quantum information today? Modest. The potential? Huge!”

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ETH professor Renato Renner is one of the world’s leading theoreticians in quantum information science.

He talks to Uplift about the latest developments.

*You studied at ETH in the 1990s – how did quantum information science stand back then?*

**RENATO RENNER** – Just as at most universities, the field did not yet exist at ETH. Nevertheless, Klaus Hepp, now emeritus professor for theoretical physics, with his forward-thinking approach, offered a seminar on the subject. I asked what I should do if I wanted to look into the field more closely. Hepp advised me to contact the computer science professor Ueli Maurer, who, he said, was very open to new subjects. He was indeed – open enough to take me on as a doctoral student. He said he knew little about quantum information, but was happy to learn. (Laughs.)

*You are a father of four; how do you explain to your children what you do for a living?*

When it comes to the two younger ones, I simply say that I do research – theoretical research. This means going places in your thoughts where no one’s ever been. Then I explain that if you keep on zooming in on Google Maps, something fascinating happens – new laws suddenly apply. Laws that are so different to everything we know that you almost believe we’re in a different world. Even the concept that everything can only be in one place at a time doesn’t work in this “new” world.

*Which leads us to the question: why does the world as we know it from our everyday life not obey these different laws?*

There are two outlooks on this: one assumption is that the laws of quantum physics no longer apply to large objects such as a coffee cup, where many particles come together. The alternative hypothesis is that even a coffee cup is subject to these laws. As we do not have the appropriate measuring instruments, we cannot perform the experiments to find out. What we can perform, however, are thought experiments: what would be the result if we did have these devices? Like most physicists of my generation, I believe that the laws of quantum physics apply on a large scale with all the consequences this implies, such as that I could theoretically be in two places at once. In principle, my entire research is based on turning this question of “belief” into one that can be resolved by science. For me, the scope within which quantum mechanics can be applied is the central issue.

*And what are the specific social benefits of quantum science?*

If we're honest, we have to say that the current applications are modest. The potential, however, is huge! But we do not yet know what the “killer application” will be. The situation is comparable with that 80 years ago, when the first primitive computers were developed. If we had asked about their benefits back then, no one would have thought that one day we would all have a mobile phone in our pockets and use them to do all manner of things. It's important to understand that at the moment, not only the hardware but also the software is lacking. This means that we not only need quantum computers, but also an army of quantum software engineers. We have now started training these people at ETH.

*Huge sums of money are being invested in this research worldwide. How is ETH positioned in this race?*

Ten years ago, ETH was one of the few universities that had a broad range of expertise in quantum science. We continue to play a leading role, but the field of competition has become huge, from Canada to China. We are currently at a critical point, and have to make the right moves if we want to maintain our position! We can only achieve this in collaboration with industrial partners. Students also benefit from these partnerships; for example, an internship at IBM Research gives them the opportunity to program on a quantum computer, which ETH alone would be unable to offer.

*Why does quantum science deserve to attract attention within society in the form of philanthropy?*

Support in this area promotes basic research that has the potential to enable progress in a wide range of applications. The development of new drugs, for example, is hugely data-intensive, and supercomputers could be a game-changer in this regard. Anyone who supports quantum science is thus helping to solve problems in many socially relevant areas simultaneously by making these innovative and potentially hugely powerful tools available.

#### **Accelerate progress in quantum science**

### Quantum information theory at ETH Zurich

Renato Renner's group focuses on the question of how the processing and transmission of information relates to physical laws. The group studies the opportunities created by quantum physics for information processing, and how these may be exploited. The researchers also hope to gain a deeper understanding of physical relationships through information theory.

