ATREUS

A HEIDRICK & STRUGGLES COMPANY

WHITEPAPER · QUANTUM COMPUTING

QUANTUM COMPUTING: A GAME CHANGER ON THE HORIZON

Quantum computers promise a technological revolution, but know-how could migrate from Europe from 2026. **Why you should start thinking about this future technology today.**

ATREUS
A HEIDRICK & STRUGGLES COMPANY

"Develop your quantum strategy, learn from experts, and assess the reality and applicability of this fascinating technology."

DEAR CUSTOMERS AND BUSINESS PARTNERS OF ATREUS

We stand on the threshold of a technological revolution: Quantum computers promise unprecedented computing power and unimaginable applications in areas such as measurement technology, imaging, communication security, and highly complex calculations. While quantum technology has won Nobel Prizes and has long been recognized as a game-changer in waiting, its integration into everyday business operations remains a vision for the future. While the very early adopters are already enthusiastic about individual applications, quantum technology, especially quantum computing, remains a future prospect for everyday business. Its industrialization and the development of profitable application fields will take time.

This poses risks: Despite the rapid growth of the quantum technology ecosystem in Germany and Europe, funding through European research grants is only secured until 2026. What happens after that? Will the European industry take on a more prominent role as the seed funder? Is there a risk of the accumulated know-how migrating to the USA and China without adequate refinancing? Will investors from North America or the Middle East acquire German startups at bargain prices? This must be prevented at all costs – which is why the industry should increasingly engage with quantum technology even when immediate business value is not yet apparent.

In this whitepaper, we take a closer look at the current state of quantum technology in science and application. We hear from some of the most renowned experts in the field of quantum computing and explore how you can approach the technology today. Because the question is not whether quantum technology will come, but when – and who will ultimately benefit.

I wish you an inspiring read!

DR. CHRISTIAN FRANK
Partner & Member of the Executive Board

ATREUS
A HEIDRICK & STRUGGLES COMPANY

WHAT'S THE HYPE ABOUT QUANTUM COMPUTING?

Fraunhofer ALUMNI

Quantum technology is currently hailed as a solution to many problems. But how long will it take for quantum computers to become powerful enough to tackle complex scientific, economic, ecological, and societal challenges? Are there already applications that offer real benefits?

During an Innovation Lounge organized by Atreus in collaboration with Fraunhofer in the summer of 2023, experts from applied research and practice delved into how quantum computing works, current research efforts, and the foreseeable applications of the technology. An overview.

1. Quantum computing: Enormous market potential, diverse use cases.

Quantum computing is one of the technologies currently being massively hyped, but is still barely understood. Dr. Hannah Venzl, head of project management for large projects and the business office of the Fraunhofer Competence Network for Quantum Computing, highlights the enormous market potential of quantum computing. The market is expected to grow by more than 20% annually until 2030. The applications are diverse, ranging from the development of medicines and vaccines to real-time detection of credit card fraud and solving complex optimization problems in various industries: What is the optimal route for me as a parcel service provider? When does the airplane need to be refueled and where? How do I optimally load my fleet of ships?

2. Quantum computing: A leap like from abacus to PC.

Dr. Venzl quotes Nobel laureate Bill Philips, who years ago likened the difference between a quantum computer and a classical computer to that between a classical computer and an abacus. Venzl explains this using the Bloch sphere: A classical computer operates with the smallest logical unit, a "bit," which can take on the value of 0 or 1. Quantum computing, on the other hand, uses Qubits, which are capable of more complex superpositions and entanglements. In the Bloch sphere, for example, the top point represents the value 1, while the bottom point assumes the value 0. However, unlike binary bits, the quantum computer can accept any point on the sphere, making quantum computers exponentially more complex than traditional computers.

3. The quantum computer is a diva.

The challenges of quantum computing lie in the high complexity of manufacturing and operation. It requires specialized hardware, new algorithms, and operates on an entirely different logic and computing paradigm, making it extremely expensive. While a typical quantum computer chip is no larger than a thumbnail, the overall system is large due to cooling requirements. Moreover, quantum computing requires an extremely low temperature, often approaching absolute zero at 0° Kelvin (-273.15° C). The error susceptibility is relatively high, and the coherence times, during which quantum states remain stable, are very short. Currently, there are no universal quantum computers, only a few physical ones termed NISQ (Noisy Intermediate Scale Quantum). No quantum advantage has been demonstrated yet over solving real-world problems more efficiently than with conventional computers. Specialized expertise is also a bottleneck.

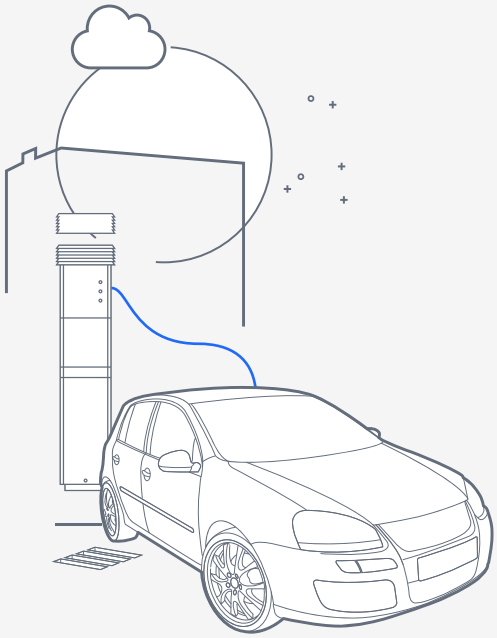
DR. HANNAH VENZL,
Head of the Quantum Computing Competence Network Office, Fraunhofer-Gesellschaft

"An incredible amount has happened in quantum computing in recent years – especially in Europe."

4.

From 1982 to today: Development in leaps.

The concept of a quantum computer was first formulated by physicist Richard Feynman in 1982, explains Dr. Florian Knäble, a quantum software engineer researching at the Fraunhofer IAO. Feynman recognized that nature essentially functions as a giant quantum computer. In the 40 years or so since Feynman's thesis, quantum computing has made significant progress, but widespread practical application is still a long way off. In June 2023, IBM released the paper "Quantum Utility," addressing a real-world problem that happened to align perfectly with the capabilities of the selected quantum computer. However, this marked progress compared to the "Quantum Supremacy" moment claimed by Google in 2019. Using a quantum computer with 53 qubits, Google was able to create a quantum circuit back then, but the problem it aimed to solve was theoretical and highly contrived.



5.

Charging stations for electric cars – just one application of quantum computing.

Knäble outlines the potential applications of quantum computing currently under research. Hopes for the coming years include real-time solutions, tackling previously unsolvable complex problems, advancements in Green Computing, and more accurate results in simulations. In the energy sector, for example, quantum computing could optimize the arrangement and operation of electric vehicle charging stations based on factors such as the number of vehicles, dwell times, and required energy. In finance, portfolio analyses and risk models could be optimized through quantum computing, while logistics could benefit from improved route planning and production could see streamlined processes. Cybersecurity is another area that could profit from this technology.

> *"In the roughly 40 years since Feynman's thesis, quantum computing has made significant progress, but we are still far from mass-scale deployment."*

DR. FLORIAN KNÄBLE,
Quantum Software Engineer, Fraunhofer IAO

6.

Quantum computers are still in their infancy.

Dr. Michael Förtsch is the founder and CEO of the start-up Q.ANT, which produces innovative sensors and photonic computer chips using photonic quantum technology. Light therefore plays a central role in Q.ANT's business model. According to Förtsch, we are still a long way from the widespread use of quantum technology, with only an elite circle showing high interest and willingness to pay for the technology. "I have little hope that we will be able to address the early majority in the next ten years." From today's perspective, it will take a considerable amount of time before quantum computers can be developed for the general public.

7.

Artificial intelligence and quantum computing – a dream combination?

According to Förtsch, there are analogies between quantum computing and neural networks, especially in algorithms. This is interesting in scenarios like the "Airport Gate Assigning Problem" at airports, where the challenge is efficiently directing passengers to various airport locations. While quantum computers can solve this problem, there's often a debate about whether an information theorist could handle it even faster with a classical computer. The greatest potential often lies in a hybrid architecture combining classical and quantum computers. In essence, as Hannah Venzl adds, traffic control questions are always intriguing optimization problems that can be well-addressed through the combination of AI and QC.

8.

Europe has an international opportunity in quantum computing.

Just four years ago, IBM possessed the world's only true quantum computer, says Hannah Venzl. Since then, however, "an incredible amount has happened", not only in the USA or (presumably) in China, but also in Europe. Quantum computing is currently well-funded in Germany. Nevertheless, the USA is significantly ahead of Europe due to more readily available venture capital. When public funding expires in 2026, as unanimously expressed by Venzl and Förtsch, there is indeed a risk of a sell-off to U.S. companies – despite Germany's scientific leadership on the international stage. Förtsch therefore urges support for the technology: "Support quantum computing in your communication if you see an opportunity in it!"

DR. MICHAEL FÖRTSCH,
Founder and CEO, Q.ANT

> *"From today's perspective, it will take a considerable amount of time before quantum computers can be developed for the general public."*

ATREUS
A HEIDRICK & STRUGGLES COMPANY

HEIDRICK & STRUGGLES

INTERVIEW

QUANTUM COMPUTERS COULD COME INTO WIDESPREAD USE IN TEN YEARS

Dr. Roman Wecker, Partner at Heidrick & Struggles in Germany, in conversation with Jan Götz, Founder and CEO of the German-Finnish startup IQM, specializing in quantum computer development. IQM is considered one of the major European hopefuls in the global race for the first industrially usable quantum computer.*

DR. ROMAN WECKER: Mr. Götz, you are building the first quantum computers in Finland and at the Leibniz Supercomputing Center in Munich-Garching. What can the technology already do?

JAN GÖTZ: A large data center is still faster than today's quantum computers. In Garching, we primarily work on proof-of-concepts. To use quantum computers on a large scale, we need to establish the basics – what I like to call quantum readiness. This involves developing industry competencies, training talents and establishing value chains. Garching is a beacon project for us. In Munich, there will be a quantum computer, and we are building the ecosystem around it, from education and supply chains to utilization and use cases. This is exciting because it's not just a group of researchers in the lab; we have concrete contracts with specifications and delivery milestones. This allows us to build a certain structure as a company and prepare for the time when quantum computers are used on a large scale.

DR. ROMAN WECKER,
Partner Heidrick & Struggles

DR. JAN GÖTZ
Founder and CEO of the German-Finnish start-up IQM

DR. ROMAN WECKER: The goal of your research group is early collaboration with users. How should we envision cooperation with the industry in detail?

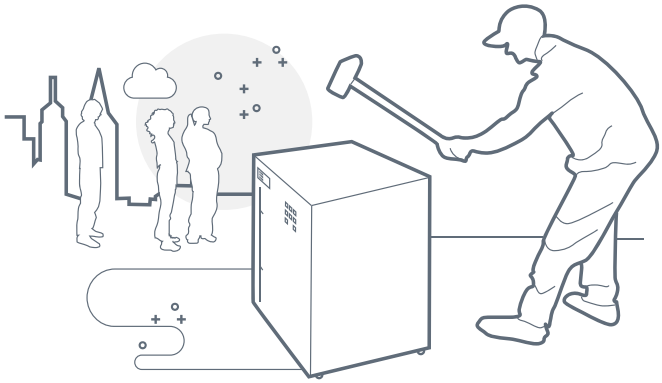
JAN GÖTZ: Most of our employees have a PhD in quantum physics but little industry experience. This means we have to learn to speak the language of the industry. And conversely, the industry needs to understand quantum physics at least conceptually. Currently, we are working on various research projects, some of which are third-party funded. Together with the industry, we are developing concepts for using quantum computers once they provide a real business advantage – when they are large enough, for example, to develop better fertilizers or solar cells or reduce CO_2 emissions.

DR. ROMAN WECKER: When could quantum computers be widely deployable? What can we realistically expect from them in, let's say, ten years?

JAN GÖTZ: The promise of quantum computers is that they can solve problems that classical computers cannot. Take drug development, for example. It is physically impossible to simulate the penicillin molecule on a conventional computer. Quantum computers, on the other hand, could solve many problems to which we would otherwise never get an answer. Of course, this doesn't happen overnight. We essentially see three strategic phases: in the current Foundation Phase, we are laying the foundations, getting the industry off the ground, developing the supply chains, and building the first systems. At some point, we will reach the Advantage Phase, in which a quantum computer will provide a real business advantage for the first time. And in perhaps ten years' time, the Disruption Phase will follow, in which quantum computers will really come into widespread use. Then we are faced with questions that we see today in the traditional semiconductor industry: How can we reduce prices, how can we miniaturize?

DR. ROMAN WECKER: There is often talk publicly about a global race for technological leadership in quantum computing. What are the major players doing, and where do the USA and China stand?

JAN GÖTZ: Of course, we aren't the only ones who have realized that quantum computing can do amazing things. However, in Europe, we are facing a dilemma: many companies are interested in the application of quantum computers, but hardly any established company is involved in development. Because quantum computers are an extremely strategic technology, there is now a lot of political support. The Leibniz Supercomputing Center is heavily funded by the Federal Ministry of Research. Without start-ups, not much will happen in terms of industrialization. For them to grow and become global players, they need support. Just as an example, the first major contracts for SpaceX essentially all came from the government, through NASA. This is exactly the concept we are pursuing here. Contracts must be supported by the government in the early risk phase. Only then can we build large technology companies in Europe that can compete with IBM, Google, or Huawei.



DR. ROMAN WECKER: What else would you need to successfully promote the topic?

JAN GÖTZ: If quantum computers become a truly significant industry, the entire ecosystem is needed. So, we need support to grow as an initially small player and also to develop negotiating power on a political level. When decisions are made today in Berlin or Brussels, start-ups often aren't at the table. We need every helping hand we can get.

DR. ROMAN WECKER: As a member of the European Innovation Council, you outlined your plans to Emmanuel Macron at the Élysée Palace to ensure that we are not left behind by other economic blocs when it comes to deep tech. What is currently happening at EU level to play a leading role in quantum computing and other key technologies in the future?

JAN GÖTZ: If we want to have prosperity in Europe in the future, we must be at the forefront of technology development. A rethink is currently taking place not to repeat the mistakes made, for example, in AI. In my view, extremely good strategies are emerging here: through the European Innovation Council, we currently support technology start-ups with about two billion euros per year. For example, a scale-up initiative is currently running a call for tenders to equip another four to five data centers in Europe with quantum computers, including start-ups. The European Chips Act also involves pilot lines and start-ups so that we can build supply chains and infrastructure. In the past, there has been a tendency to pit Location A against Location B, both within EU states and Germany itself. However, it is only when we all work together that we can be internationally competitive with a European project.

DR. ROMAN WECKER: Mr. Götz, thank you very much for the interview.

* This interview first appeared on the Heidrick Talks podcast.

ATREUS
A HEIDRICK & STRUGGLES COMPANY

ATREUS' QUANTUM COMPUTING PORTFOLIO

Quantum technology is one of the most promising technologies of the future. In this whitepaper, we have presented some of its diverse applications. We are still at the beginning. Nevertheless, we need entrepreneurial courage today to advance this technology – investors, development partners, and industrial partners who have a long-term vision and won't lose interest after a few years.

HOW ATREUS SUPPORTS YOU IN THE FIELD OF QUANTUM COMPUTING

01 STRATEGIC ORIENTATION

Development of strategies for the implementation of projects in the field of quantum technology, for example

- Searching for market or customer applications
- Market potential assessment
- Developing value propositions and customer promises
- Building bridges between technology and users (market) by mediating between developers/research and the commercial side

02 PROJECT MANAGEMENT

for example

- Initiating (development) projects
- Establishing and orchestrating teams
- Monitoring progress and milestones

03 DEVELOPMENT/IMPLEMENTATION OF USE CASES

for example

- Selection of use cases
- Methodical support in prioritizing suitable use cases
- Development of financial plans and business plans

04 PARTNERSHIPS

for example

- Searching for suitable industrial partners
- Identifying partnership opportunities
- Approaching industry and development partners
- Applying for funding (private and public)

ATREUS
A HEIDRICK & STRUGGLES COMPANY

WE CREATE SUCCESS

DR. CHRISTIAN FRANK,
Partner & Member
of the Executive Board
christian.frank@atreus.de
Tel.: +49 89 45 22 49-180

DR. CHRISTIAN FRANK, MEMBER OF THE EXECUTIVE BOARD, ATREUS
His focus is on projects and programs in restructuring and organizational realignment, change and performance management, M&A, post-merger integration, and the interim placement of top management positions. He focuses primarily on the capital goods/high-tech industry, professional services and the construction, construction supply and tool industries. Dr. Frank has more than 20 years of experience in general and change management, restructuring, transformation and performance management. Prior to joining Atreus, he held several senior management positions at leading global consulting and high-tech companies.

ATREUS AWARDED BEST CONSULTANT ON THE MARKET FOR THE NINTH TIME IN A ROW

"We are very pleased with our top position once again and the extremely positive feedback, especially from our customers. This shows that our consulting and implementation expertise is clearly recognized in the market. It also confirms our commitment to meeting the increased demand for interim mandates at the transformation and restructuring levels in all industries with our consistently high quality and precision in the future."

ATREUS HAS RECEIVED MULTIPLE AWARDS

Automotive, Change Management, Chemicals & Pharmaceuticals, Digitalization, Trade incl. E-Commerce, Life Science, Mechanical & Plant Engineering, Operations Management, Performance Improvement, Human Resources Consulting, Restructuring

Atreus GmbH
Landshuter Allee 8
80637 Munich
Germany
Phone.: +49 89 452249-0
contact@atreus.de

atreus.com