### **Which modality do you think would be the first to support a functional quantum computer?**

**Respond to questions 1 and 2 (300 words each)**

1. **Why do you think your chosen modality will be the first one in supporting a functional quantum computer? Compare at least three modalities.**
2. **Think about the second modality that might be also a good candidate and answer the same as above.**

Qubits are the heart and the engine of quantum computers. They are what makes the quantum computer to be what expect it to be; fast, efficient and, most importantly, a game-changer. As we already know, the power of a quantum computer depends on the number of qubits it has and even working with only one qubit is a very challenging task. Certain modalities try to tackle the problem of creating and manipulating qubits and some of them are showing promising results.

Among all the modalities that exist as of today, superconducting qubits and trapped ions are the most famous approaches used to create quantum computers. As the name suggests, superconducting electronic circuits are used in this modality, which consists of inductors and capacitors. Qubits in this way are represented as LC circuits. They are used in different fields of science and engineering, and through time a huge experience has accumulated, so this technology is a mature one. That is why one of the advantages of superconducting qubits is that they could be easily mass-produced. Another benefit of superconducting qubits is that gates are applied much faster than, for example, compared to trapped ions. Trapped ions are another type of existing modalities which are not less famous. They are charged atomic particles that are “trapped” using electromagnetic fields. Although it is a new approach, it has shown pretty good results and is considered by a lot of leading companies. What can also be noticed is that the lifetime of ion qubits is longer than compared with other modalities. However, the drawbacks of both approaches are that in the case of superconducting qubits near absolute zero temperature is needed and in the case of trapped ions, a vacuum chamber is used. Both modalities are very hard to maintain, especially when the number of qubits is increasing through time. Another type of a qubit modality is called linear optics quantum computing, where qubits are described as a presence or absence of a photon.

When comparing classical computers, we don’t look only at how powerful the computer or laptop is, but we are also interested in the compatibility of the device. This is one of the reasons I think that out of the mentioned modalities above photonic qubits would be one of those modalities that will support a functional quantum computer. Photonic qubits are free of costly and difficult equipment in the case of superconducting qubits and trapped ions. In addition, photons interaction with the environment is relatively weak, which allows transmitting information over long distances and quantum commination can benefit from it a lot. As in the case of superconducting qubits, we have a long history with photons and we know pretty much everything about them and how to use them. Thus, it would be much easier for scientists and engineers to work with photons.

Although for the reasons mentioned above, I believe that future quantum computers will be based on photonic qubits, I don’t think this modality will be used in the first quantum computers. In my opinion, either superconducting qubits or trapped ions would dominate the market at the beginning. It is even possible that some hybrid approach could be created using these two modalities. However, what I am sure of is that in the future, quantum technology would slowly migrate to the linear optics quantum computing.

**When do you think the first functional quantum computer will be created?**

**Respond to questions 3 and 4**

1. **Why do you think it will take the time that you chose to create the first functional quantum computer? Argue at least two reasons.**
2. **Think about the time frame of the second modality that might also be a good candidate. Argue at least two reasons.**

As it is already stated in the previous 2 questions, we know that there are some types of quantum modalities which are good candidates for building our future, however, we choose two of them, which we think are closer to becoming the supporting model for functional quantum computers.

So, the first modality we choose is superconducting qubits. To understand how much time we need to build superconducting quantum computers, let’s go inside the problems of the making process of it.

We know that we need thousands of qubits, not 50, 100 and not even 1000, and this will take more than 100 years. However, we need to remember that not always quantity defines quality. By increasing the number of bits, can have a crucial effect on the quality of those bits. High coherence superconducting qubits are established in 200 mm wafers, while to make the number of qubits larger, we need to maintain qubit coherence and increase it. As the number of qubits increases the number of qubit spans gets worse at quality, as that much number of qubits will, of course, include more improbable variations. Nowadays, we achieve some results, however, there is not so much difference and the exploration process of making is larger, and decreasing the time will demand 100s of years. Another reason, to support my guess is that actually, we need 12 GHz for controlling nowadays qubits, however, we need higher frequencies for being able to minimize decoherence, which starts being difficult to solve as we physically increase the size. Thus, we need time to understand how to make sizes bigger but do not change the rate of decoherence. And last reason: I started to count based on real numbers--

On 2017 IBM reveals a working 50-qubit quantum computer

On 2019 IBM reveals its biggest yet quantum computer, consisting of 53 qubits

So, for 2 years, they increase the number of qubits by 3. To achieve, for example, 10000 qubits, we need about 6000 years, continuing with these steps. This number is, of course, a result of the very rough calculation.

The next candidate is linear photon quantum computers, which actually has not less success than superconducting quantum computers, but still, we have some problems. And the first one in size. We know, that photons have a wavelength, and which is micron, and the photons have a speed of light, and the directions of those in chips are limited by one direction, increasing the number of photons, to increase the number of qubits inside the same size of the chip is very difficult from the viewpoint of technology. To calculate, in 2014 they started working on the process, and in 2017 we had 1056 qubits in one chip. These numbers are very motivating, compared with superconducting quantum computers’ numbers, however, if we will need the same 10000 qubits, we will need not less than 30 years. Another problem is their own sizes. They are very very small, and besides that it has some advantages, the small sizes create some problems for making them a million. And, another trouble that scientists face is that as they have the speed of light, it is a very complicated task to take control over them. They are always in motion and nowadays, there is no type of technology that can solve this problem.