Qu ntum Computing in the NISQ er nd beyond

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Noisy Intermediate-Scale Quantum (NISQ) technology will be available in the near future. Quantum computers with 50-100 qubits may be able to perform tasks which surpass the capabilities of today's classical digital computers, but noise in quantum gates will limit the size of quantum circuits that can be executed reliably. NISQ devices will be useful tools for exploring many-body quantum physics, and may have other useful applications, but the 100-qubit quantum computer will not change the world right away — we should regard it as a significant step toward the more powerful quantum technologies of the future. Quantum technologists should continue to strive for more accurate quantum gates and, eventually, fully fault-tolerant quantum computing.

1 Introduction

Now is an opportune time for a fruitful discussion among researchers, entrepreneurs, managers, and investors who share an interest in quantum computing. There has been a recent surge of investment by both large public companies and startup companies, a trend that has surprised many quantumists working in academia. While we have long recognized the commercial potential of quantum technology, this ramping up of industrial activity has happened sooner and more suddenly than most of us expected.

In this article I assess the current status and future potential of quantum computing. Because quantum computing technology is so different from the information technology we use now, we have only a very limited ability to glimpse its future applications, or to project when these applications will come to fruition. While this uncertainty fuels optimism, our optimism should be tempered with caution. We may feel confident that quantum technology will have a substantial impact on society in the decades ahead, but we cannot be nearly so confident about the commercial potential of quantum technology in the near term, say the next five to ten years. That is the main message I hope to convey. With that said, I'm sure that vigorous discussion among all the interested parties can help light the way toward future progress.

2 Opportunities at the entanglement frontier

I am a theoretical physicist with a background in particle physics and cosmology, but for more than 20 years much of my research effort has been directed toward quantum information science. I'm drawn to this field because I feel we are now in the early stages

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