

Ethics in the quantum age

Mauritz Kop assesses the ethical principles we must all adopt so that the application of quantum technologies is equitable and safe

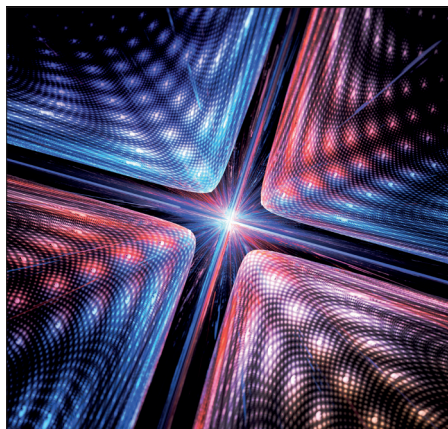
Research into quantum technologies has advanced so much over the past decade that the underlying science is rapidly being translated into real-world applications – be it quantum computers, materials or communications systems. But before these innovations are widely rolled out, I believe we must do more to address their ethical, legal and social implications.

It's easy to think that science has nothing to do with ethics, which is about the creation of universal rules and standards for moral behaviour. But there are ethical questions throughout science, whether it's artificial intelligence, nanotechnology, biotech or nuclear power. In fact, what's known as “quantum ethics” is an emerging field within applied ethics, which focuses on moral behaviour in specific domains.

Each of those domains has its own distinct properties, cases and societal impact, in which ethics applies. For example, the Hippocratic Oath taken by doctors exemplifies the moral responsibility of medical professionals towards their patients in upholding ethical standards such as helping the ill and prescribing only beneficial treatments. Similarly, quantum technology has its own specific ethical challenges and dilemmas.

Theories of ethics that are considered useful regarding the values and motives of human conduct can be converted into practical rules, principles and responsibilities. At one level, universal ethical standards will apply to quantum technologies and, when determining those standards, we can use our “normative” ethical theories. Key principles that emerge from these theories are fairness, benevolence, non-maleficence (avoiding harm), autonomy and sustainability.

In addition, the unique and counterintuitive phenomena that underpin quantum physics – such as superposition, entanglement and tunnelling – will require a tailored approach. Take quantum machine learning. The probabilistic nature of quantum mechanics means that deploying quantum algorithms and quantum data leads to different outcomes in terms of fairness and transparency (obligations and constraints) than drawing on classical methods, which raises ethical questions. In designing



Building bridges The rise of quantum technologies raises a set of ethical questions to consider.

applied quantum ethics, cross-disciplinary research must be conducted into the consequences of the distinct features of applied quantum technology.

To see why we urgently need to address the ethics of quantum technology, consider these questions. How can we create equal access to a socially responsible quantum internet in developing countries? How should we use intellectual property and open-source instruments in an ethical way to prevent certain groups or businesses from monopolizing quantum computation and simulation, while still fostering innovation and ensuring equitable outcomes regarding benefits of the technology?

How, moreover, do we prevent human suffering from nefarious use of cryptographic items in the financial and energy sectors? What are the ethical concerns surrounding manipulating biological processes on the subatomic level and how can we make sure quantum machine-learning processes remain fair, democratic and unbiased? And how should we proceed when the principles of open science and innovation conflict with the desire to keep new information – such as discoveries in quantum materials science and engineering – undisclosed?

Coherent pathways

One possible definition of quantum ethics could be: “Quantum ethics calls for humans to act virtuously, abiding by the standards of ethical practice and conduct set by the quantum community, and to make sure these actions have desirable consequences, with the latter being higher in rank in case it conflicts with the former.” Here we employ the old, familiar ethics that apply to all transformative technologies and to information. Due to the unique

characteristics of quantum technologies, we also develop a new subtype of context-specific practical ethics.

This proposed definition allows different industries or economic sectors in which quantum systems, products and services operate to have their own sector-specific ethical rules. In the case of quantum-driven tools in neuroscientific medical R&D, for example, “neuroethics” generates ethical considerations about professional responsibility, personal identity and informed consent. Thus, a multi-layered, interdisciplinary ethical framework for quantum technology is formed.

The next step is to embed the quantum-specific ethical framework into a more comprehensive concept, dubbed “quantum-ELSPI”, which describes the ethical, legal, social and policy implications of quantum technology. Such an approach would help us to regulate quantum technologies, the benefits and risks of which must be equally distributed across all members of society and across developed and developing countries in equal measure. Regulating quantum technology, therefore, requires a multidisciplinary approach that unifies perspectives from the humanities, natural and social sciences into evidence-based technology governance strategies.

Quantum ethics should not, however, be seen as a trade-off to innovation. Instead, inclusive, values-based, sustainable development will help reduce and remove barriers for translating technology into real-world commercial products. We must therefore develop structured methods that provide a coherent ethical pathway in which physicists can develop their ideas. This methodology should be endorsed by as many interested parties as possible, beginning with the quantum community itself.

We need to build bridges of mutual understanding between disciplines – a move that will involve learning to speak each other's language. This is easier said than done but the physics community must learn to understand the importance of ethics, its role in physics education and the ethical questions facing society. Bringing stakeholders together in a conference to establish a practical code of quantum ethics would be a crucial first step.



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