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## **The ethics of quantum technologies: a problematic formulation**

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### ***Abstract:***

In this conference, we want to propose a first formulation of the problems related to the ethics of quantum technologies, in the framework of a philosophical argument. These technologies are still not very developed. They still fall within the logic of scientific research (and the ethics that go with it). But, if we listen to the media, the revolution of quantum technologies is happening, or will happen soon. What ethics will apply to these technologies when they reach the stage of marketed innovations? Finally, how can we conceive, with the hypothesis formulated by the science and technology studies current of the mutual construction of science and society, an ethics based on the diffusion of these technologies and on the interaction between the stakeholders of their implementation in society?

***Keywords:*** quantum, physics and computer science, technology, ethics, innovation, utilitarianism

The theme I will examine is the ethics of or for quantum technologies. This theme is one of the pillars of the new project obtained by the quantum federation financed by the Initiative of Excellence (Idex) of the Grenoble academic site, Tools for Interdisciplinarity in QuantAlps (TiQua, 2022-2025). This is the task n°1 of the first WP, whose work I will coordinate. During the three years of this new project, we will be able to deepen the reflection in order to define and characterise this ethic, in dialogue with colleagues (physicists, computer scientists and lawyers) who have themselves started to tackle this subject [Grinbaum, 2017; Perrier, 2021; Kop, 2021].

As you have noticed, I do not use the term 'quantum ethics', but 'ethics of (or for) quantum technologies'. You will also note that I have entitled my speech "the problem of quantum technologies". I will explain why.

First of all, I do not use the expression "quantum ethics" because it includes a confusion by implying that ethics can by itself be (or become) quantum, as are physics or computer science, two other academic disciplines. For physics and computer science, we mean those parts of physics and computer science that adopt quantum assumptions with respect to the scientific knowledge of atomic matter. Taken narrowly, quantum physics and quantum computing refer generically to the science of quantas. But understood in a broader sense, physics and computer science have thus become quantum.

Quantum ethics, similarly understood in a restricted way, should be the ethics that concern the quantum. But since, at least for me, ethics is about human persons and their relations with themselves, with other persons and with other living and natural beings in the context of social relations, my subject is not quantum ethics, but the ethics of the quantum or for the quantum, the ethics of the quantum domain through technologies. The reflection is not on quantum in general, but on quantum technologies. Since the subject is the ethics of or for quantum technologies, several points appear in the form of problems.

Secondly, the theme of ethics adapted to quantum technologies does indeed pose several kinds of problems. These problems constitute the challenges that must be faced in constructing an ethics or an ethical position valid for these new technologies. Philosophy (from epistemology and ontology to practical philosophy, the one that concerns ethics and political theory) loves problems: it is typical of the philosophical approach, at least of one of its most important modern rationalist traditions (criticism), that before reaching a result or even hoping to reach a result, one rationally constructs the problem that corresponds to what one is examining. It is in the problematic approach that we recognise philosophy, a rational discipline that considers the limits of what it examines [Kant, 1986]. This examination of limits makes it both analytical (it analyses in detail and wants to define concepts and the relations between them) and reflexive (it undertakes not only to make concepts effective in describing reality, but also to understand their various meanings).

As a rational activity, philosophy constructs problems and, to do so, it must clarify the terms that compose them as well as the links maintained by these terms. Constructing problems and clarifying terms constitute a double task important for the goal it sets itself: "to orient oneself in thought", to use another famous formulation of Kant [Kant, 1990]. However, in the case that interests us today, these terms must be clarified. In order to define the nature of an ethics of quantum technologies, it is necessary to succeed in 'orienting oneself in thought'. To this end, I propose to establish three observations that deserve attention. Indeed, depending on whether or not we recognise these observations (or even depending on our vision of these observations, our reflection on the nature of the ethics of quantum technologies, as well as on the possibility of its emergence) will be oriented in one direction or in another. This is what I will do in the last part of my speech, when I will formulate several versions of the problem of the ethics of quantum technologies.

But before that, in order to be as clear as possible, I need to recall the philosophical meaning of the term "ethics".

### ***What is ethics?***

Ethics, as understood in philosophy, aims to formulate judgements about the value of decisions or actions in terms of their considered desirability or desirability based on rational arguments [Canto-Sperber, 2004; Copp, 2007; Billier, 2010; Spinoza, 2011]. This means formulating rational evaluations according to what is humanly and socially superior. Ethics defined in this way refers to the order of constraint imposed by reasoning based on the criteria of what is good, right and good. To carry out an ethical assessment is therefore to ask three sets of questions.

Firstly, questions concerning the identification of values: which values can serve as criteria for defining what is good, right and good? How do they hierarchise into coherent and satisfactory value systems for individuals and social collectives (organisations and institutions)?

Secondly, what form of reasoning should be adopted? In fact, judging ethically means being able to call on four possible forms of reasoning. Firstly, utilitarian or consequentialist reasoning, which formulates what appears to be good, just and right according to the relationship between the means used and the ends pursued. Secondly, deontological reasoning, which is based on the experience of duty that people have in their moral life (for my part, I prefer to use the adjective deontic to distinguish this type of ethical reasoning from the social dimension of deontology, which is quite different). Thirdly, reasoning from values considered superior to others, or axiological ethics, which is based on supreme values (be they religious, social, political or metaphysical values). Finally, fourthly, virtue ethics or aretaeism, which consists in evaluating what is good, right and just in relation to the qualities and defects of the characters/temperaments of the one who is to judge ethically. In the words of the founder of this family of ethics, it is a question of the person who adopts ethical behaviour aiming at an optimum of possible excellence [Aristotle, 2004], or, in other words, according to one of its contemporary designations, of indulging in "moral perfectionism" [Laugier, 2010].

Finally, making an ethical judgement always means reinterpreting or reinventing good and evil in a rationally argued judgement and according to specific circumstances. Thus, if some technologies are to be designated as 'good', 'just' or consistent with the value of good (and others as 'bad', 'unjust' or affiliated with evil), then it will necessarily be necessary in turn to specify which social uses are good/bad, just/unjust, good/evil. In other words, to ethically qualify technology is also to establish the trial of society. This is a very noble and important task, but also a very ambitious and difficult one! All this, already from the point of view of utilitarian ethics (largely dominant in ethical approaches to science, technology and innovation), but even

more so from the point of view of the other forms of ethical reasoning known to moral theory and which I have just identified.

To complete this analysis, it is necessary to formulate the questions concerning the specifically ethical constraint: at what level should this constraint apply? In the everyday practices of ordinary life through the intermediary of people's individual judgement (what we call in French the "for intérieur"), which makes it possible to say that ethics is a private matter? Or in social life as defined by the legal rules and regulations of organisations (for there is, indeed, a part of legal science or Law that also deals with ethics)? Or finally at the level of public debate in democratic societies, which are societies that through their institutions (where elected representatives sit) impose publicly debated choices on what appears collectively good, right and good? Of course, all people can have an opinion on these issues. But at the stage we are at for the topic I am examining, these questions must be left open in order to better understand the problem of the ethics of quantum technologies, as we will see later.

Now that I have done this reminder on ethics, I will make the three preparatory observations for the formulation of the problem of quantum technologies.

### ***The three observations***

First observation: at the present stage, and apparently with rare exceptions, quantum technologies are not yet completely out of the research laboratories. Their current state even corresponds to a stage that is difficult to qualify: if quantum science does indeed give hope for a technological expression of its own results, announcements are regularly made by large companies to the effect that they have already achieved the major breakthrough that allows the industrial 'scaling up' of quantum technologies. Indeed, some start-ups are beginning to emerge, with significant funding and closely linked to major industrial economic and financial interests, and even to strategic national interests. In other words, there is the expectation, and already the announcement, of a new industrial 'revolution' (this word is regularly used in the specialist media). In any case, both industry players and nations are already in a competitive situation. One of the points that appears characteristic in this situation is that the qualification of quantum technologies on the TRL (Technology Readiness Level) scale of technological maturity shows them to be advanced between levels 3 (which characterises the "first stage of analytical or experimental demonstration of critical functions and/or certain characteristics") and 5 (which concerns the "validation in a representative environment of elementary bricks and/or sub-systems") [ANR 2014].

Second observation: when they leave the laboratory to be produced by industry, quantum technologies will no longer be considered as scientific discoveries, but as innovations. This is not the same thing at all, and this change in status is very important, as I have personally endeavoured to emphasise in my work [Ménissier 2021 & 2022]. According to the logic first described by the economist Joseph Aloïs Schumpeter, an innovation is an invention that is marketed, inscribed in the capitalist valorisation dynamic, i.e. carried by entrepreneurs who invest in its marketing and aim for its social acceptability [Schumpeter, 1934 & 1994].

The third observation is more general in that it concerns the status of the ethics of technology. Although research in this field exists in the humanities and social sciences, the ethics of technology is not really an important academic theme. Its academic importance appears, for example, to be much lower than the huge output of bioethics or ethics of life and health. This is despite the fact that technology is massively used in the social world and by the economy. Nor is it dominant in the industrial world where, however, many technologies are deployed for production activities, services and ultimately users. The ethics of technology is, however, both legitimate and feasible. It even already exists in relation to existing or emerging technologies, in particular thanks to the so-called participatory technology assessment (eTA) experiments [Palm & Hansson, 2006].

The last point I want to make in this regard is that these approaches are based on a specific and well-known option in the theory of deliberative democracy, the so-called 'reflective equilibrium' [Rawls 1971; Daniels 1996 & 2020]. This option consists of a back-and-forth between four distinct levels: (1) consideration of the 'dominant' ethical judgements on concrete cases, inspired (on the part of those making them) by their culture and intuition; (2) scrupulous observation of the cases, amplified by their careful description; (3) identification of the general ethical principles that govern the judgements; (4) identification/reflection of the factors of acceptance of these principles (e.g. expectation of the ethical benefits of quantum technologies) In relation to an ethics of use, the theory of "reflective equilibrium" has the merit of being dynamic: because of its iterative character, it provides a canon that allows, if not to forge, at least to reinforce the ethical judgement, never totally considered as definitive, during each of the evaluation attempts. And not only does this approach place the question of ethical assessment on deliberative democracy, but it involves the participation of stakeholders who do not necessarily agree (and may never agree) in the process of establishing what is ethically and democratically desirable: In Grin and De Graaf's beautiful phrase, 'technology assessment as learning', this way of proceeding makes society evolve, it represents for the various actors in

the process (scientists, engineers, social scientists, entrepreneurs, financiers, prescribers, users) a new way of learning from each other [Grin & van de Graaf, 1996].

I will complete this first moment by underlining the fact that there is also an emerging field, called science & technology studies (STS), for which this kind of approach is all the more important as one of its hypotheses is that technologies and societies have very deep, inseparable links. One could say that for STS, technologies and societies are mutually constitutive [Oudshoorn & Pinch, 2003; Van House, 2004]. It is even possible to speak of the 'social shaping of technology' [Williams & Edge, 1996; Williams 1997]. Of course, science is value-neutral, or at least, according to the constant effort of scientific research ethics, it always tends to be value-neutral. But for the STS approach, technology can never be certain of being neutral in the social values that underlie it.

***The scientific challenges of ethics for quantum technologies allow for a first problematic formulation of this type of ethics***

We have clarified some terms of the problem of ethics for quantum technologies. We can now better formulate the current state of the problem. I propose three formulations of the problem that correspond to the three observations made above. These three problem formulations seem to me to be important in order to "orientate our thinking" in order to better discern the ethics of quantum technologies.

First formulation: at present, while the ethics of quantum technologies is not defined either in its nature or in its limits, the quantum field is not without an ethical approach. Indeed, it is concerned by research ethics. Today, given the low degree of maturity of technologies that are still in the laboratories, quantum scientists find themselves in the situation of determining whether research ethics are adapted and sufficient for this emergence. It seems to me that this point deserves particular attention.

In order to understand it better, it is possible to mobilise historical knowledge, in order to deepen by referring to some great examples of the same kind. What happens when a type of scientific knowledge or a major field of discovery has been transferred to the technological field and industry? What happens to research ethics is the perception of major risks, which ethically translate into moral dilemmas (to use the logic of deontic ethics). For example, this is what happened with the development of electricity or fossil carbon resources as energy sources, or with the rise of nuclear physics. In the case of the latter, one recalls the kind of moral dilemmas faced by atomic scientists in the middle of the last century.

Of course, the quantum field does not seem to have the same potential for concern as nuclear physics, through its major ambiguity, a major object of ethical questioning, yesterday with regard to the emergence of the Bomb, today with regard to the production of radioactive waste and, more generally, the impact on the environment [Simondon, 2014; Friederich & Boudry, 2022]. I will simply ask this question: do the moral vicissitudes experienced by the actors of the Manhattan Project constitute an example or a counter-example of what will happen to ethics adapted to quantum technologies? Can the emergence of an ethics of quantum technologies create a new Russell-Einstein Manifesto [Russell & Einstein 1954]? Who will be the Joseph Rotblat (named after the only physicist who left the Manhattan Project with the Hiroshima bomb explosion) of the quantum, if any [Veys, 2013]? These abrupt questions are philosophical formulations of moral theory. They may appear quite brutal: they reflect the nature of the ethical constraint and express the kind of pressure that can weigh on scientists at their level. But they should not be excessively frightening, since the scientific community has the tools and means to ask itself this kind of question [see, for example, Audouze, 1997, on the subject of energy].

Second formulation: since quantum technologies are destined to become innovations, they will fall under the ethics of innovation. But there is no such thing, at least not yet or not really. By innovation we mean not only the emergence of novelty from a technical and organisational point of view, but also a coherent economic system aimed at bringing the novelty to market [Ménissier 2021 & 2022]. In this system, users play a fundamental role (users who are often customers, even if sometimes in a hidden way, which makes their willingness to pay almost invisible). And it is at the level of the user that there is something similar to ethics, which values the form of utilitarian reasoning and which is played out in the dimension of the acceptability of novelties. Technological and organisational novelties, when accepted (sometimes at the end of a preference calculation based on the consequentialist reasoning of utilitarianism), are considered to be good; their adoption is considered to be an ethical validation; a purely utilitarian approach to ethics could even validate this point. However, in all rigour (and especially if we include other forms of ethical reasoning in the discussion), we can easily find this questionable, even criticizable, for two sets of reasons.

On the one hand, the acceptance of novelties does not apply to an ethical approach. Acceptability is not an ethical criterion. This is because the innovation system plays on the seductions of novelty, on material interests and the desire fostered by marketing. Acceptability reproduces the world in which innovations emerge, and this world is strictly a capitalist economy. On the other hand, utilitarianism is not the only form of ethical reasoning, and it has



even been severely criticised insofar as it sometimes leads to an amoral if not immoral attitude (this is the criticism of its 'sacrificial' aspect [Rawls, 1971; Smart & Williams, 1973]). The very form of reasoning on which it is based, 'consequentialism', has also been criticised on the grounds that, by reducing the vigour of ethical questioning, it would empty the utilitarian approach of its meaning [Anscombe, 1958]. This is the second problematic characterisation of the ethics of quantum technologies, of which I will give these two complementary formulations: while these technologies, when start-ups are created that come out of the laboratories, do fall into the category of innovations, can the ethics of quantum technologies escape the (ethically impoverished) category of acceptability? And how will the quantum field, in search of the ethics of the technologies it will help to produce, organise the "conflict of ethical reasoning" that is bound to arise between the ethics of duty that corresponds to the dilemmas potentially experienced by scientists and the utilitarian ethics typical of the world of innovation?

Third formulation. As I said earlier, the so-called STS approach offers the most comprehensive view of the relationship between technologies and societies to date. And for it, technologies and societies are in a relationship of co-dependence, or co-implication. This interpretation takes so seriously the importance of technologies for societies that it believes they are mutually reinforcing. The dominant technology of a society is the one that it has (more or less clearly and explicitly) chosen for itself, according to its technical history, but also to its major social values. Thus, for the STS approach, the choice of thermal energy through its scientific and industrial developments is representative of the modern era, since the publication of Carnot's *Réflexions sur "la puissance motrice du feu"* (1824), the technical development of the thermodynamic paradigm and the industrial revolution. For several sociologists of technology, since then, within the framework of the same socio-technical paradigm, electricity has developed the day before yesterday, computer science yesterday and artificial intelligence today [Gras, 2007; Dubey & Gras, 2021].

This last point appears to be very important for the subject we are examining. Indeed, it questions what is expected from an ethics of/for technologies. What is the purpose of an ethics of/for technologies in these conditions?

Should it only serve to ethically evaluate existing technologies? If so, how? According to whether they appear to be good/bad in terms of a ratio between the expected costs and benefits, i.e. according to a "utility calculation", as proposed by utilitarian reasoning? Or should it evaluate these technologies in terms of the duties of those involved in their design, development, prescription and use (duty or deontological ethics)? Or with values (axiological ethics) and in terms of the virtues or vices they stimulate (aretic ethics)?

Or should it ethically evaluate technologies with regard to the possible, which any ethical approach must also necessarily open up? As I mentioned earlier, in the STS approach, the technique or technology is always a mirror that is held up to society. Socially accepted techniques point to social values, so that to accept the development of this or that technology in this or that particular way is to implicitly accept the values of the social system that generated it. If we now formulate an ethical ambition in terms of the STS approach, we will have to question the desirable values for quantum technologies. The best problematic formulation for the ethics of quantum technologies could then be the following (and this is the last one I submit for our collective reflection): "what ethical choices should be made for quantum technologies in relation to what choice of society, or for what type of society?"

This question seems to me to be formidable because of its questioning power, or its depth. It is this question that constitutes for us the most ambitious challenge of the ethical part of the TiQua project, and I hope that we will be able to take it up with the forces of the Grenoble quantum federation.

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