

**Opening welcome for the conference “Conceptual Foundations  
and Foils for Quantum Information Processing”**

Giulio Chiribella

*Perimeter Institute for Theoretical Physics,*

*31 Caroline Street North, Ontario, Ontario N2L 2Y5, Canada.\**

---

\* <http://www.perimeterinstitute.ca>

## I. GREETINGS

Good morning everybody. My name is Giulio Chiribella; I am from Perimeter Institute and I am one of the Organizers of this conference. Today it is my great pleasure to welcome you to the Perimeter Institute on behalf of the Conference Organizers. The enormous response that this event has received is for us extremely pleasing, exciting, ...and also a little bit thrilling! First of all, we would like to thank you very much for your interest and for enriching this event with your participation.

## II. CONCEPT OF THE CONFERENCE

I will now give an brief overview of the concept that inspired the conference.

### A. Scientific

The focus of the conference lies at the interface between Quantum Foundations and Quantum Information. Precisely, the main theme is the interplay between information-theoretic protocols and fundamental principles.

#### 1. *The contribution of QI to QF*

Quantum Information provided many deep insights into the foundations of Quantum Theory: it showed that Quantum Mechanics is not only a theory of precision limits, but also a theory of new exciting protocols that were impossible in the old classical world of Newton and Laplace. Quantum Information unearthed a huge number of concrete operational consequences of Quantum Theory, thus suggesting that Quantum Theory is, in its backbone, a theory of information.

#### 2. *The contribution of QF to QI, conceptual foundations*

On the other side, also Quantum Foundations can offer a contribution to Quantum Information. This brings me to the title of this conference: “Conceptual Foundations and Foils for QIP”.

You may ask: Does Quantum Information need a conceptual foundation at all? Why?

Well, Quantum Information is extremely powerful. However, if we are asked what are the roots of its power, then we are in trouble: the only answer we have is “well... quantum systems are associated to Hilbert spaces... states are vectors etc etc ” . In other words: our ability to understand Quantum Information relies on the particular mathematical formalism of Hilbert spaces. This is inconvenient for three reasons:

1. the connections between different quantum protocols are often hidden in the mathematics
2. the validity of the protocols is tied to the validity of Hilbert space formalism. Should Quantum Theory theory be surpassed one day in the future, we would have to start again re-deriving all the protocols
3. the potential of Quantum Information to produce a new world view that crosses the borders of the community of specialists and reaches the general public is now blocked by its technicalities. Quantum Physics is fascinating, but nobody is able to say what it is without using the abstract language of Hilbert spaces.

To address these problems we need a “conceptual” foundation, as opposed to the “purely mathematical” foundation provided by Hilbert spaces. The recent research is moving, more or less consciously, toward the achievement of this goal, and is gradually providing a unified view of Quantum Information, where many different protocols are reduced to a small number of basic principles.

### *3. Quantum Foils*

To proceed toward a conceptual foundation we need to take a step back from the familiar framework of Hilbert spaces. It is only by considering a more general framework—where Quantum Theory is just one of many possible alternatives—that we can hope to capture the fundamental principles of Quantum Information.

This brings us to the notion of “quantum foils”: a “quantum foil” is an alternative theory that shares some given feature with quantum theory but differs from it some other feature. For example, a theory that satisfies the no-signalling principle (like quantum theory) but exhibits super-quantum non-locality.

Many of you are probably wondering now about the meaning of the name “foil”. Actually, this is a FAQ concerning our conference. The best answer to this question comes from the dictionary itself: at [thefreedictionary.com](http://thefreedictionary.com) we find

- *Foil: One that by contrast underscores or enhances the distinctive characteristics of another.*

The dictionary also provides a colourful example, taken from *Jane Eyre* by Charlotte Brontë: “I am resolved my husband shall not be a rival, but a foil to me” . This is pretty much the spirit in our case too: Quantum Foils are not meant to be rival theories to Quantum Theory (not yet, at least!). They are rather meant to be alternative models that by contrast underscore its distinctive features.

#### 4. *Synthesis of the scientific motivation*

Summarizing the scientific vision behind this conference: the idea is that Quantum Information is not only a technological endeavour, but also contains an indispensable chapter of fundamentals physics that still needs to be learned. Understanding the principles of Quantum Information, also by contrast with its foil theories, means understanding something new about the fundamental laws of nature.

## B. Social

### 1. *The new community of Quantum Foundations-Information.*

In addition to the scientific motivation of this conference, there is also a more “social” one. The field of quantum foundations is rapidly growing, with a flourishing of new results and an increasing number of researchers joining the community. The idea of this conference is to capture the excitement pervading the field, to celebrate the achievements of the last years and to boost the future progress of our community toward an informational understanding of nature.

## *2. Position of this conference in the series of previous workshops*

The conference represents the continuation of a series of workshops organized at Cambridge and ETH Zürich during the past four years. It was easy to predict that, due to the increasing interest gained by the topic and to the enlargement of the community, this event would have had a much broader audience. We took this fact into account and tried to provide an overview of the main recent trends, combining classical topics with the latest results in foundations, and also offering stimulating contributions from the Quantum Information side. Defining the scientific program has been very exciting, but also required us to make choices, which are always difficult. We hope anyway that the final result will meet your scientific taste.

### **III. CLOSING WISHES**

Our wish is that this conference will be a feast celebrating the achievements of a new community and will lead to new collaborations and new discoveries. We wish to all of you to enjoy a nice atmosphere during this week and to benefit from a stimulating exchange of ideas in a relaxed and respectful environment.