



Vienna Symposium on the Foundations of Modern Physics

Author: Günther Greindl

From the 7th to the 10th of June, Vienna was – if such is still possible in the internet age – the center of the physics world. The "Vienna Symposium on the Foundations of Modern Physics" was organized by the working group of Quantum Optics and Quantum Information of the Faculty of Physics of the University of Vienna. Caslav Brukner, Markus Arndt, Markus Aspelmeyer and Anton Zeilinger were among the local organizers.

Approximately 165 people from over 25 countries attended the conference, among them well-known physicists as Claude Cohen-Tannoudji, William Unruh, Charles Bennett and too many others to list them all here.

Four days of intense talks and discussions

Each of the four days of the conference that was largely held in the Main Lecture Hall at Strudlhofgasse 4 was devoted to a certain topic. The material was dense, in large parts mathematical, and not easily compressible without irresponsible abbreviation. I can only give here a highly idiosyncratic view of the conference, through the lense of a philosopher of science. A physicist may have taken note of very different things.

The idea of the conference was to explicitly discuss the foundational questions - not only to "shut up and calculate", as the great Richard Feynman would have put it, but to discuss the very philosophical and metaphysical underpinnings of the world as we know it. Indeed, I think that this is of utmost importance: the goal of science is not only to measure and predict, but to *explain*. To this end it is vital to think deeply about results of experiments and their philosophical implications. It is very beneficial that a conference was held with such a process in mind.

Fundamental Tests and Experiments

The first day was firmly in the hand of experimentalists – which reported impressive progress on the manipulation of matter on the ultra-small level. Whereas quantum weirdness stood at the beginning of quantum mechanics in the 1930s and has confounded philosophers and physicists ever since, the possible effects which can be reaped from the quantum world are only gradually being explored. The increased precision and imaginativeness of these experiments promise not only further experimental data but also new insights to support further theoretical and philosophical excursions.

Foundations of Cosmology, Relativity and Quantum Gravity

The second day witnessed the discussion of quantum gravity and cosmological problems. This is the area which probably raises the most expectations for the future, but also reveals the deep trouble physics is in at the moment. The two most successful theories of contemporary physics – Einstein's general relativity theory and quantum mechanics (or quantum field theory, which includes relativistic effects) are in contradiction when one assumes large gravitational effects at the quantum scale – as would occur in a black hole or at the Big Bang.

This reveals that something is not yet right with the fundamental way we theorize about our universe, and I suspect that a successful unification of the two theories will change our view

of the nature of our universe in a way similar to the changes witnessed at the beginning of the last century. While a solution is not yet in sight, the talks showed that thoughtful work is being done on this subject which will form the cornerstone of any future solutions. The approaches in this field are very diverse.

Public Lecture about Time Travel

The day ended with a public lecture by Paul Davies in the "Festsaal" of the Austrian Academy of Sciences on the possibility of time travel. Whereas time travel into the future is a trivial effect of special relativity, the problem is getting *back* again. Here things get very speculative, and it seems to me that a lot of assumptions have to be made to somehow save the concept of time travel into the past. As it stands, you better not count on it right now.

Foundations of Quantum Physics and Quantum Information

On the third day, quantum information was at the center of attention which I suspect will provide the most important contribution to the future of the field. Quantum Mechanics will grow on our intuitions when we use it at a technological versus only at a research level. We should expect a lot of innovation in this field in the next couple of years.

Recommendations for Young Researchers

After the talks there was a plenum discussion about recommendations the accomplished physicists would give to young people venturing into this field. The recommendations were quite diverse: they ranged from "be willing to take risks" and "do what you believe in" to "stay away from the hard problems in physics so you won't ruin your thesis". The general consensus view was that the "low-hanging fruit" have been taken – astonishing results will necessarily have to be preceded by hard work - but the knowledge of physics in twenty years will be very different from that of today – logically entailing that there is much to be discovered and a lot to be gained from original work.

Decoherence and Collapse Models

On the last day Anton Zeilinger talked about the current research being done at the University of Vienna concerning decoherence – the phenomenon that all the possibilities of the wave function "collapse" into a definite measurement in a seemingly random way. A very intriguing notion, which was also presented at the poster session and which is done under the auspices of Zeilinger's colleague Caslav Brukner is the attempt to unite quantum randomness with concepts from mathematical logic – especially Gödel's famous incompleteness theorems. The basic idea is that quantum states embody a finite amount of information, and when queried in such a way as to force an answer about information not contained in the quantum state, the result is necessarily random – because, in fact, no sensible answer can be given. This is somewhat analogous to an undecidable statement in mathematics.

"Physical Realism"

Another topic raised by Zeilinger is that of giving up physical realism. Does this mean that the last safe haven from post-modernistic and relativistic fuzziness, physics, has fallen? Fortunately not: "physical realism" is a technical term meaning that certain physical attributes are properties of physical systems independent of measurement. Giving up this kind of realism would only mean that certain properties emerge during the measurement process (or, more neutrally: "interaction process" – to make clear that no human being is needed to measure, as some mystical interpretations of quantum mechanics would have it). The existence of an external world per se is, however, not at stake. I would certainly suggest naming this differently – maybe "Einsteinian realism" or "attribute-realism". Using the term "physical realism" and then proclaiming to give it up incurs the wrong connotations rather quickly as soon as one moves out of the domain of physics and may add to the confusion rather than ease it.

"Heurigen" Visit

The atmosphere at the conference was very amicable, and the well-spaced breaks led to interesting discussions and an informal exchange of ideas. The amenable atmosphere was

reflected by the well attended social event Saturday evening at a "Heuriger" in Döbling, which saw further physical discussions.

Conclusions

All in all, the state of physics seems vigorous and full of cautious optimism. I was very impressed with the amount of self-reflection, self-criticism, methodological criticism and cooperative interest shown at this conference – from a philosophy of science point of view I couldn't be happier. I think the next ten to twenty years will see breakthrough discoveries and increased efficacy at the handling of quantum phenomena. Quantum Computation and Cryptography will certainly be the driving forces and much can be gained - indeed, will and must be gained - by the mastery of the ultra-small, the very fabric of the universe. The conference was, so much can be said, a definite success – Anton Zeilinger proclaimed at the end of the conference that it should be renamed into the "First Symposium of Foundations of Modern Physics" – the *second* being envisaged in two or three years. I am looking forward very much to attending again and observing the progress which will have been made till then.

Further Reading

A list of all the speakers who attended and contact information can be found at <http://www.quantum.at/talksevents/vienna-symposium.html>.

Many papers concerning current or past research work of the speakers can be found at <http://arxiv.org/>.

Günther Greindl is currently writing his PhD thesis in the philosophy of science at the Department of Philosophy of Science at the University of Vienna. He holds degrees in Law and Computer Science.

Website: www.complexitystudies.org