Awarding of an honorary degree of University of Gdansk.
Laudation for Professor Ch. H. Bennett
given by Prof. Dr. hab. Ryszard Horodecki (12.10.2006)

Today's ceremony of awarding honorary degree for Professor Charles H. Bennett from IBM Watson Research Center has at least tree dimensions. Certainly – a natural dimension, as the quantum information, of which Professor Bennett was one of the founding fathers, known today as quantum informatics, is a part of physics, or even wider –a part of natural philosophy.

There is no doubt, that the ceremony has as well a cultural dimension. A scientific work belongs to cultural sphere, which is like a measurement of condition of any civilization.

The third dimension, which we all are witnesses of, shows inseparable elements of human recognition –theory and experiment.

The context of the ceremony refers to 20's of the past centaury, when quantum description of the world was discovered. Whole previous physicists experience seems to say: Everything that the quantum mathematics description forecasts should happen in laboratory. This description is very abstract. It can be expressed in a language, which –like John Bell showed – cannot be translated into a common language. Without knowing this language, it is just impossible to get to "quantum land". However, in 70's it seemed that the Rosetta Stone had been already deciphered, and in that language the Nature had no more anything interesting to offer.

In science, there is a lot of ways, which lead to knowing the truth. On one of them I had luck to meet Bennett – researcher with incredible and very seldom perspicacity. It can be that these virtues helped him to discover, that the quantum language forecast new fascinating effects, which surprised our imagination. At the end of past century Bennett became a co-author of a new discipline, based on concept of quantum information, spreading by quantum particles.

Quantum information has some non intuitive features. In particular – quantum information can not be copied. This feature distinguishes quantum information from classical information, which has been always copied, and it is copied now. We are doing it every day using the Internet. Usually a ban on copying evokes negative emotions. Bennett - a pragmatic romantic, converted the ban on copying, placed by nature, to a commercial success. Based on Wiesner's idea he and Prof. Brassard introduced the famous system of quantum cryptography.

This protocol is based on sending single randomly polarized photons. The eavesdropper cannot copy the state of photons without disturbing them. Any of such an attempt can be detected.

Romanticism of the explorer was due to the fact that sources of single photons at that time were object of dreams. We can only admire this determination, which Bennett had – despite skepticism of other cryptographers. He and Dr Smolin (who is also present today) built first quantum key distribution channel. Although the prototype was not perfect, this event had a spectacular implication. It not only broke through cryptographers' pessimism, but also focused attention of experimental physics on quantum cryptography.

Soon we had witnessed a rapid development of quantum cryptography with use of fibers as well as in free space. First commercial sets appeared in Hannover Fair 2000. Two years later, Gisin's group co-created secure key between Genève and Lausanne, the cities placed at a distance of 67 km. The quantum cryptography era has begun.

At the beginning on 90's Bennett focused his attention on incredible correlation discovered in 30's by Einstein, Rosen, Podolski and Schrödinger called quantum entanglement. Through decades these correlations were more like a curiosity, and just as the ban on copying were useful. Bennett considered quantum entanglement not as a subject of

philosophical debate, but he treated it like a fascinating resource of Nature. In 1992 they Bennett and Wiesner published a work, which was a radical change. Namely, thanks to pair of entangled particles, by means of a single quantum bit (e.g. polarization of photon) not one, but two bits of information can be reliably transmitted. Hence the name of the discovery: dense coding.

Quantum teleportation is probably the most amazing discovery of the past century. Some people still remember a very spontaneous reaction of mass media, and a semantic problem, with the term "teleportation", which was understood as a science fiction process. There were a lot of comical moments. Once a press reporter asked Asher Peres -one of the discoverers –"Is it possible to teleport the soul as well as the body?", "Only the soul" – answered Peres.

Peres wrote a very interesting article, which was dedicated to Bennett on his 60-birthday. In Montreal 1992, after the Wootter's seminar a very important discussion took place among Bennett, Brassard, Crepeau and Jozsa about optimal transfer of quantum state between two distant laboratories. Then Bennett with his specific operational way of thinking asked: "What if the labs share a pair?".

That famous question opened the secret door to discover the effect of teleportation. This is the process, in which one transfers a special feature of a particle – quantum information in such a way, that it is destroyed on one particle, and recreated in the other particle, sitting in distant laboratory. One can do this having at a disposal pair of entangled particles and possibility of communication of two classical bits (e.g. using telephone). Several years later, both shocking effects: dense coding and teleportation have been implemented in pioneering experiments performed by Anton's Zeilinger group. Since that time, many experimental realizations of teleportation have been performed, including experiments with objects of different kind e.g. photons and cesium atoms. Teleportation has become a basic brick in quantum information. Soon, entanglement has entered the laboratories as a resource as real as energy.

However entanglement in pure form, like pure metal is hard to encounter in Nature. It is usually noisy, and is not directly useful to such tasks as teleportation or dense coding. Therefore a problem has arisen: how to extract pure entanglement from the noisy one? In 1996 Bennett with coworkers discovers protocol of distillation of noisy entanglement, which allows to extract pure entanglement, read y for quantum tasks. This is the point, where our „entangled" paths have met. We have shown in Gdansk group, that in Nature there exists noisy entanglement, from which no pure entanglement can be distilled. This peculiar entanglement, called bound entanglement, has been subject of intensive research carried over both by Bennett's group as well as Gdansk group, and has initiated collaboration, whose result was in particular the discovery of the effect of locking of information.

Bennett's creative courage has been proved as well by another work "*Logical Reversibility of Computation*" published in the early 70-ties. Bennett indicated – despite of Landauer's pessimism, that computation can be performed in reversible way. It was like a prophetic vision, because reversibility of computation has been a basis for the concept of quantum computer introduced later by Feynmann and Deutsch.

This is just a short presentation of Bennett's achievements, which is only a part in wide spectrum of his attainments. All referees emphasize the fundamental meaning of his findings, not only for quantum informatics, but also for understanding the base of quantum description of Nature. Professor M. Kuś from Center for Theoretical Physics of the Polish Academy of Sciences in Warsaw states: "Charles Bennett belongs to a group of world's most prominent researchers. He is a creator of quantum informatics and one of the greatest researchers in this rapidly growing discipline." Professor R. Alicki from University of Gdansk sums up: "Charles Bennett belongs to a tight circle of researchers, who in a consequent way

was creating a discipline, known today as quantum informatics." Professor K. Życzkowski from Jagiellonian University emphasizes: "Bennett's impressive attainment makes, that I support with pleasure all efforts leading to awarding honorary degree to him."

Bennett's charming personality is just irresistible – he is not only a discerning researcher, but also a photographer, excellent organizer of numerous conferences, research programs, and winner of prestigious prizes. Similarly to ancient masters, he is looking for the truth about Nature, and he is finding Beauty, which is like an award for him.