Toruń, 17 June 2010

The roots of quantum information – 90th anniversary of a doyen

In 1975, Professor Roman S. Ingarden, a Polish physicist from the Institute of Physics of Nicolaus Copernicus University in Toruń, published a paper, "Quantum Information Theory", which collected ideas and research results that had been emerging in physical literature over a period of a few preceding years. The publication was probably the first one where the notion of quantum information theory had ever been used. Today one of the most popular branches of theoretical physics, Quantum Information Theory celebrates a double anniversary: the 40 years of its existence and the 90th birthday of its doyen.

Quantum Information Theory (QIT) is certainly in fashion today. Although it is impossible to trace back its origin to the work of a single author, yet it is the 1975 paper by professor Roman S. Ingarden that proposed a systematic way of its construction as a generalization of classical information theory by Shannon. The scientific achievements of Professor Ingarden, who is turning 90 this year, will be honoured during the 42nd Symposium on Mathematical Physics. This internationally acknowledged series of conferences is organized annually by the Institute of Physics of Nicolaus Copernicus University (NCU) in Toruń, Poland, and the forthcoming Symposium will be held on June 19-22.

The intricate connections between information theory and fundamental theories of contemporary physics occupied Professor Ingarden and his collaborators at the Department of Mathematical Physics of Toruń University, already at the turn of the 1960s. Many research papers of this group concerned the general rules of information flow in thermodynamic and quantum processes. "In those years it was quite a novelty in physics, a sort of intellectual adventure, balancing on the edge between physics and philosophy. Such an approach had but a few adherents among physicists worldwide, many of whom visited our Institute in Toruń to collaborate with the group of Professor Ingarden" – remembers Prof. Andrzej Jamiołkowski of the Institute of Physics, NCU. It was just in the early 1970s that the notions of Lindblad-Kossakowski evolution generator or the Jamiołkowski isomorphism were introduced into the language of today's theoretical physics.

Yet, Professor Ingarden's intuitions concerning the fundamental meaning of information for physics turned out to be correct. It was only at the beginning of 1990s that the rapid progress in experimental techniques of quantum physics made it possible to conduct the first successful attempts to transmit and store information by means of individual quantum objects, such as, e.g., photons. Those experiments opened new, promising prospects for extremely efficient quantum communication and information technologies and created a continuously growing interest among both scientific and technological communities. Quantum Information Theory has become an important branch of contemporary physics on its own.

Today, QIT research is conducted in numerous leading scientific centres around the world, and it is among the fastest developing and most dynamic branches of science. "The construction and

operation of contemporary computers is based on the laws and principles of classical physics. However, the mere miniaturization of electronic circuits progresses so fast that soon genuinely quantum effects may start affecting their operation, and we'll be forced to change the rules of the game from classical to quantum" – explains Dr. Miłosz Michalski from the Department of Mathematical Physics of Toruń Institute.

Professor Ingarden's scientific achievement in establishing the foundations of QIT will be acclaimed during a special dedicated session of the forthcoming Symposium on Mathematical Physics, to be held in Toruń, Poland, on June 19-22. This annual conference was first organized in the Institute of Physics of Nicolaus Copernicus University in 1968, also on the initiative of Professor Ingarden, in connection with the first editorial meeting of the newly established international scientific journal "Reports on Mathematical Physics". Over the years Toruń Symposia have gained a respectable position among scientific events worldwide. This year, the organizers expect over a hundred physicists and mathematicians from leading scientific centres around the world to attend the meeting. Apart from the main subject of the forthcoming Symposium, "Quantum Channels, Quantum Information — Theory and Applications", other topics of mathematical physics, traditionally represented in the programme of Toruń meetings, will be discussed, e.g., geometric methods in classical and quantum physics, classical and quantum gravity, relativity theory, etc. The Symposium is partially financed by the National Laboratory for Quantum Technologies, whose facility in Toruń is just being erected.

The bimonthly "Reports on Mathematical Physics", in which the pioneering paper by Professor Ingarden was published in 1976, is one of the two international scientific journals edited by the Department of Mathematical Physics in Toruń, the other being "Open Systems & Information Dynamics". Both journals are listed by the Thomson Scientific Master Journal List, the popular "Philadelphia list", that collects the most influential scientific periodicals. Moreover, as of 2009, OSID belongs to the group of four highest ranked Polish journals in the list comprising a total of 60 titles, compiled by the Polish Ministry of Science and Higher Education.

ADDITIONAL INFORMATION:

A short biography of Professor Roman S. Ingarden:

Roman Stanisław Ingarden is a mathematical physicist specializing in geometric, statistical and quantum optics, thermodynamics and information thermodynamics, quantum dynamics and information, as well as application of Finsler geometry in physics. He is a member of numerous Polish and international scientific societies and an author or co-author of about 100 original papers in mathematical physics together with several textbooks and monographs in this field.

He was born on October 1, 1920, in Zakopane, Poland; his father, Roman Witold Ingarden, was an acclaimed professor of philosophy of Lvov and Cracow Universities. In the period of 1921-26 he lived in Toruń, then in Lvov, where in 1938 he begun his studies in physics, interrupted by the war of 1939 and the subsequent German occupation of Poland. He graduated in 1946 from the Jagiellonian University. Working at the University of Wrocław, he became a full professor in 1964. He was also a member of the Mathematical Institute of Polish Academy of Sciences (PAS) where he headed the geometric optics group, as well as of the Institute of Physics of PAS heading its Department of Physics of Low Temperatures. His research concerned information-theoretic approach in thermodynamics, in particular the formulation of information theory without probability. In 1966 Professor Ingarden moved to Toruń where at Nicolaus Copernicus University (NCU) he became head of the newly created Institute of Physics, holding this post until 1978. In 1968 he was the initiator and later the first editor-in-chief of the international journal "Reports on Mathematical Physics" printed and distributed since 1970. He also worked as a visiting professor in numerous scientific institutions abroad, e.g., in the USA, Japan, Germany and France.

Professor Ingarden retired in 1991. Continuing his scientific activities, in the 1990s he published two monographs in mathematical physics as well as two historical and philosophical essays. In 1996 he received the doctorate Honoris Causa of the Nicolaus Copernicus University. Fascinated by Japan and its traditions, he was one of the creators of the Department of Japanese Culture and Language at NCU, where he continues to work as a lecturer.

The Institute of Physics of Nicolaus Copernicus University:

The Institute of Physics has been a scientific unit of Nicolaus Copernicus University since 1968. Its research concentrates on atomic and molecular physics, spectroscopy, laser optics, mathematical physics, and in recent years optoelectronics, photonics and bioinformatics. Today the Institute consists of 9 departments and several didactic laboratories. The Institute, as part of the Faculty of Physics, Astronomy and Applied Computer Science, belongs to the top category of Polish scientific units conducting research in the field of physics.

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LINKS:

http://www.fizyka.umk.pl/zfmis/smp42/
42 Symposium on Mathematical Physics.

http://www.fizyka.umk.pl/zfmis/romp/
„Reports on Mathematical Physics".

http://www.osid.org.pl
„Open Systems & Information Dynamics".

http://www.fizyka.umk.pl/
Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University in Torun, Poland.

http://www.umk.pl/
Nicolaus Copernicus University in Torun, Poland.

IMAGES:

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Professor Roman Stanislaw Ingarden in his office at the Institute of Physics of Nicolaus Copernicus University in Torun, Poland. July 2010. (Source: Institute of Physics NCU/Andrzej Romański)

HR (4783×3211; 8,8 MB): http://www.fizyka.umk.pl/wfaiis/files/IFUMK100617c_fot01.jpg
MR (2000×1343; 1,6 MB): http://www.fizyka.umk.pl/wfaiis/files/IFUMK100617c_fot01m.jpg

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The cover of "Reports on Mathematical Physics", a journal published by Institute of Physics of Nicolaus Copernicus University in Torun, Poland, with the first page of the article about the quantum theory of information (1976). The article was written by prof. Roman S. Ingarden in December 1975. (Source: Institute of Physics NCU)

HR (2000×1453; 2,7 MB): http://www.fizyka.umk.pl/wfaiis/files/IFUMK100617c_fot02.jpg

SCIENTIFIC PAPERS:

1. R. S. Ingarden, Quantum Information Theory, Rep. Math. Phys. 10, 43-72 (1976).
2. A. Jamiołkowski, Linear transformations which preserve trace and positive semidefiniteness of operators, Rep.Math. Phys. 3, 275-178 (1972).
3. Gorini, V., A. Kossakowski, and E. C. G. Sudarshan, Completely Positive Dynamical Semigroups of N Level Systems, J. Math. Phys. 17, 821 (1976) http://dx.doi.org/10.1063/1.522979