LAUDATIO for professor S.L. Woronowicz
recipient of the Wigner Medal 2025

Let me begin by expressing how honored I feel to be asked to write a laudation for professor Stanisław Lech Woronowicz my mentor for over thirty years.

Professor Woronowicz was born in Wiłkomierz in modern-day Lithuania and grew up in Giżycko. His outstanding talents in mathematics and the sciences became apparent early as he emerged as the winner of both the National Mathematics and Physics Olympiads in secondary school. In future he was to receive many other accolades including giving two lectures at the International Congress of Mathematicians (in 1983 and 1990), the Prize of the Foundation for Polish Science (1993), the Humboldt Research Award (2008), the Banach Medal (2009) and the Sierpiński Medal (2010).

He began studies at the Faculty of Mathematics and Physics of the University of Warsaw in 1958 and obtained PhD in 1968 with a dissertation about causal spaces in which he proved that the causal structure of spacetime implies that spacetime is a topological manifold.

Professor Woronowicz's first scientific papers were devoted to mathematics of broadly viewed axiomatic quantum field theory with the first publication "On a theorem of Mackey, Stone and von Neumann" (*Studia Mathematica* **24**) coming in 1964. However he also published on Riemannian geometry, twistor theory, and potential theory showing great breadth of mathematical erudition.

While on a scientific visit in Princeton he was introduced to the then recent advances in the theory of von Neumann algebras, namely the Tomita-Takesaki theory. This resulted in his life-long involvement in the theory starting with "On the purification of factor states" (*Communication in Mathematical Physics* **28**) and a number of subsequent papers leading to the paper "Operator systems and their applications to the Tomita-Takesaki theory" (*Journal of Operator Theory* **2**). His approach to the fundamental theorems of this theory, along that of Alfons Van Daele, is by now the standard one presented in many textbooks including the famous "Operator algebras and quantum Statistical Mechanics" by O. Bratteli and D.W. Robinson.

The next crucial development was the research S.L Woronowicz conducted with his long-time collaborator Wiesław Pusz on functional calculus for sesquilinear forms. The paper "Functional calculus for sesquilinear forms and the purification map" (*Reports on Mathematical Physics* **8**) from 1975 lead to many applications in fields as diverse as mathematical physics (including proofs of various matrix inequalities appearing in physics by Pusz and Woronowicz) and theoretical computer science.

In 1976 Woronowicz published "Positive maps of low-dimensional matrix algebras" (*Reports on Mathematical Physics* **10**). This highly influential paper contains the mathematical core of the famous PPT (positive partial transposition) criterion for entanglement/separability of states in quantum information theory — the so called Peres-Horodecki criterion.

Finding his way back to the interplay between quantum statistical physics and the Tomita-Takesaki theory, in 1978 Woronowicz co-authored with W. Pusz the paper "Passive states and KMS states for general quantum systems" (*Communications in Mathematical Physics* **58**). The notion of passivity of states and its relation to the famous KMS condition has by now become a standard element of the theory known to all experts in quantum statistical physics.

After serving as dean of the Faculty of Physics in the years 1981-1984 professor Woronowicz redirected his research towards the newly emerging field of non-commutative geometry and became one of the founders of the theory of quantum groups. While his first works on this subject appeared earlier (e.g. "Pseudospaces, pseudogroups and Pontryagin Duality" from 1978), the most influential papers came in 1987 with "Twisted SU(2) group. An example of a non-commutative differential

calculus" (*Publications of RIMS, Kyoto University* **23**) and "Compact matrix pseudogroups" (*Communications in Mathematical Physics* **111**). These two papers which, as of today, have been cited almost 900 times, laid the foundations of the theory of compact quantum groups starting with the definition, through the proof of existence of Haar measure to representation theory and differential calculi. Following these developments Woronowicz extended the Tannaka-Krein duality for compact groups to what is now know as Tannaka-Krein-Woronowicz duality for compact quantum groups.

After establishing the groundwork of compact quantum groups professor Woronowicz turned to examples of non-compact quantum groups such as the quantum Lorentz group (with Piotr Podleś and, on the algebraic level, with Stanisław Zakrzewski), the quantum E(2) group and the quantum "$ax + b$" and "$az + b$" groups. Interestingly his work on the contraction of the quantum SU(2) and E(2) groups recalls the original approach of E. Wigner and Erdal İnönü – both recepients of the Wigner Medal in the past. His investigations lead him to introduce the affiliation relation in the context of C*-algebras and to and to study the recently proposed theory of multiplicative unitaries.

In that last theory Woronowicz made enormous strides introducing in 1996 the condition of manageability for multiplicative unitary operators and showing that it is the correct condition to develop a reasonable theory of locally compact quantum groups ("From multiplicative unitaries to quantum groups" *International Journal of Mathematics* **7**). Later he would continue this work with investigations of the existence of Haar measure, an axiomatic approach to quantum groups with Haar measure (with T. Masuda and Y. Nakagami) as well as a thorough treatment of homomorphisms of quantum groups (with R. Meyer and S. Roy) and culminating in the study of categories of C*-algebras endowed with actions of quantum groups leading to the notion of a twisted (or braided) tensor product in the C*-algebra theory.

Apart from his research work and administrative functions professor Woronowicz has always been an amazing teacher. I have had the good luck and enormous pleasure to attend his lectures from the very beginning of my university days all the way through my masters thesis and PhD dissertation both written under his supervision. Although it may seem out of place on this occasion, but I would like to thank him for generous sharing of his knowledge and continuous strong support and help in all my undertakings. I feel privileged to be one of just a handful his pupils and to share this distinction with great mathematicians such as already mentioned Piotr Podleś — the discoverer of the famous Podleś spheres. I cannot witness the ceremony of awarding the Wigner Medal to my mentor in person, but I share his happiness on this memorable occasion

Piotr Mikołaj Sołtan
Warsaw, June 18, 2025