

# Kapteyn lecture 2023 (Royal Natural Society, KNG) by Prof.dr. Anton Zeilinger

Introduction: Prof.dr. Douwe Wiersma, 20<sup>th</sup> April 2023, Aula Academic Building University of Groningen



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It is a great honour and great pleasure for me to introduce to you Anton Zeilinger, winner of the **Nobel Prize in Physics 2022**, professor Emeritus University of Vienna and Senior Scientist at the Institute for Quantum Optics and Quantum Information in Vienna, who will present the 10th Kapteyn lecture entitled 'A Voyage through Quantum Wonderland'.

My name is Douwe Wiersma. I am professor Emeritus **Physical Chemistry** and member of the Board of the Royal Natural Society.

Anton Zeilinger was born in Austria shortly after the end of the second world war in Ried im Innkreis, a small town 60 km north of Salzburg, which became located in the American occupation zone, until in 1955 the allied forces, including the Russians, left the country.

Anton Zeilinger received his academic training in Physics and Mathematics and his Ph.D at the University of Vienna. In a project with his thesis advisor Helmut Rauch –*who had developed a novel neutron interferometer*- he worked out what would happen if the neutron spin were utilized in an interference experiment. This was Anton Zeilinger's first involvement in the foundations of quantum mechanics. The experiment beautifully confirmed that a spinor wave function changes sign upon a  $2\pi$  rotation. Only after a double rotation the original state is recovered. This experiment opened new possibilities for his career, when in 1976 he was invited to participate in a "Thinkshop in Physics", organized by John Bell and Bernard d'Espagnat. It was at **this meeting** that he heard for the first time about EPR correlations, Bell's inequalities and entanglement. He also met the people who later became very famous in the field of **quantum physics**, as, for example, John Clauser and Alain Aspect.

As research assistant with Helmut Rauch, he went to MIT to work as a Fulbright fellow in the group of Clifford Shull, who was an expert in **neutron diffraction experiments**, for the development of which he won the Nobel Prize in Physics in 1994. Shortly after several visits to MIT –*the last one as visiting associate professor*- his career took off in Vienna, starting with an appointment as associate professor at the Vienna University of Technology in 1983. In a 1986-Physics-Letters paper he pointed at a loophole in the famous Bell inequalities-testing experiments from the Aspect group, showing his deep interest and insight in the entanglement-problem. In 1990 Zeilinger moved to Innsbruck as professor in Experimental Physics and became increasingly involved in debates and experiments concerning

Entanglement. In 1999 he moved to the University of Vienna and it was here and at the Institute for Quantum Optics and Quantum Information in Vienna, that he published most of his work –**in total more than 500 papers**- on the foundation of quantum mechanics and on quantum information science, for which he became world famous.

The most important research achievements of prof. Zeilinger are:

- **Matter**-wave interferometry experiments with neutrons, atoms and buckyball molecules.
- **Long-distance** realization of quantum-communication and of loophole-free tests of Bell's Inequality.
- **Discovery** of three-particle entanglement as an extreme demonstration of quantum nonlocality. *The so-called Greenberger-Horne-Zeilinger states have become a cornerstone in the development of quantum information science.*
- **First** experimental realization of single-photon quantum teleportation and of entanglement-based quantum cryptography.

According to Zeilinger, one of his biggest surprises in his life was an invitation to participate in dOCUMENTA (13), one of the biggest exhibitions in the world of contemporary art. It takes place every five years in Kassel. For this purpose the group designed 5 experiments which are important for understanding the nature of light and in particular its quantum features. The most spectacular of these experiments at dOCUMENTA (13) were:

- **The double-slit experiment, pioneered by Thomas Young in 1801**
- **Quantum entanglement and Bell's inequality with photons**
- **The change of state by a polarizer**

During the exhibition, which drew more than 850.000 visitors, there were always two members of the group present at all times to make sure that everything was running smoothly, to talk to visitors, to give explanations, answer questions etc.

Professor Zeilinger received many prizes and awards for his scientific work: more than 40 invitations for distinguished lectures, 6 honorary degrees and 3 honorary professorships, 15 Austrian Prizes including several Grand Decorations from the city of Vienna and the Republic of Austria, more than 30 international prizes including the Wolf Prize in 2005, the John Stewart Bell prize in 2017, the Heisenberg medal in 2022 and, last but not least, **the Nobel Prize in Physics 2022**, which he shared with Alain Aspect and John Clauser “**for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science**”.

I now invite prof. Zeilinger to the floor for the presentation of his Kapteyn lecture entitled:

**A Voyage Through Quantum Wonderland.**