

Laudation by Professor Doctor D. Miguel Ángel Martín-Delgado Alcántara on granting the Hon. Mr. Rainer Blatt the title Doctor “Honoris Causa”

January 31st, 2020

Most Excellent and Grand Rector, Honorary Rectors, Most Excellent Counselor of Science, Universities and Innovation, Most Excellent Ambassador of Austria, academic and non-academic authorities, university faculty, esteemed Rainer, ladies and gentlemen,

I thank the Faculty Board of the School of Physical Sciences of the UCM and its Dean for the opportunity to present this commendation. For me, it is a great honor to speak of Professor Rainer Blatt, whom I have known since my first visit to the University of Innsbruck in 2007, and for whom I have a deep admiration and great affection.

The School of Physical Sciences, at the request of the Department of Theoretical Physics, and with the unanimous support of the Faculty Board, brought to the Governing Council of the University the request for awarding the title “doctor honoris causa” by the Complutense University of Madrid to Otto Rainer Blatt, Professor of Physics at the University of Innsbruck; Director of the Institute for Experimental Physics of the aforementioned university and member of its academic senate; Scientific Director of the Institute for Quantum Optics and Quantum Information or IQOQI; full member of the Austrian Academy of Sciences, and foreign member of the Royal Academy of Sciences of Spain.

One of the most important identities of Rainer Blatt is as an experimental physicist. I know that he feels very proud of it. This part of him makes him live and feel physics in a very special way.

The work of the experimental physicist is twofold:

- a) On the one hand, with their experiments, they forge new paths where theory has not yet gone;

b) On the other hand, they verify the models proposed by theorists to consolidate them and, eventually, elevate them to the Laws-of-Physics category.

In both tasks, Rainer has excelled spectacularly with his advances, discoveries, and milestones that have earned him worldwide recognition and fame as an experimental physicist in quantum optics, atomic physics, and quantum computing.

The Department of Theoretical Physics has nominated Rainer Blatt, and this is very interesting. There are very good reasons to endorse this proposal: one must be a physicist before a theorist. One of his virtues as a physicist has been knowing how to develop excellent collaborations with theoretical physicists to perform experimental tests of models that had been conjectured but not verified.

"The sleep of reason produces monsters," says Goya. This happens when theorists over theorize, and we forget to test our ideas against nature, through experiments. "Nature is beautiful" ... by definition. If we accept this maxim as a definition of scientific beauty, we will have little to fear from the torments of which Goya warns us with his famous Plate 43 of his series *Los Caprichos*. Rainer Blatt is a discoverer and creator of beauty through his experiments and in accordance with the twofold duty mentioned above. This continuous dialogue between theory and experiment is the foundation of the scientific method: the fundamental tool of the natural sciences with which humanity has made so many achievements.

The Complutense University has a long tradition in quantum physics that began in the mid-twentieth century. The arrival of Professor Alberto Galindo in 1968 to the College of Sciences (Physics Department) of this university as a Professor of Theoretical Physics helped modernize scientific teaching and research in Spain, with the incorporation of novel curricula for Quantum Mechanics. His arrival also contributed to the creation of a Quantum Mechanics 'school' internationally recognized for the excellence, rigor, and highly skilled undergraduates, graduates, doctors, professors, researchers, etc. who have flourished under the program of quantum physics that was designed at that time and is still taught today.

Years ago, the European Commission chose the year 2020 in its famous challenge for the Horizon 2020 program of promoting European research and innovation. Well, the 'horizon' is already here. Much earlier, back in early 2000, there were

predictions about when quantum technologies would become a reality, and in particular about when the quantum computer would be feasible. It was estimated that by the 2020s, the effects of quantum computing would inevitably be felt since the atomic scale would be reaching the size of the bits. The atomic scale is precisely the scale at which the laws of quantum mechanics govern the movement of particles.

The 1920s are known as the “roaring 20s” and are synonymous with joy and happiness. For Quantum Physics, it was also a golden age when the principles of the new mechanics, quantum mechanics, were formulated, of which Schrödinger’s equation and Heisenberg’s uncertainty principle are fundamental ingredients. The former, Austrian, and the latter, German, two citizenships that Rainer holds. Thus culminated the work begun by Planck, Einstein, and Bohr at the beginning of the last century, and let us not forget Dirac with his later electron equation. Let us hope that the twenties of this century, which are about to begin next year, are the “quantum golden 20s” in which many of the expectations we have for them are realized. Rainer Blatt is one of the experimental physicists whose discoveries have put us at the dawn of a new era of quantum technologies, the so-called “second quantum revolution”.

Rainer’s career began with a degree in physics and mathematics at the University of Mainz. Between 1984 and 1994, he worked at the Joint Institute Laboratory of Astrophysics (JILA) in Boulder, Colorado, in Berlin, and at the University of Hamburg. After 1994, he moved to the University of Göttingen, and a year later, he accepted a professorship at the Institute for Experimental Physics of the University of Innsbruck, which he has directed since 2000. He was a founding member in 2003 of the IQOQI, which is one of the few quantum computing flagship centers in the world. The Advanced Quantum Computing with Trapped Ions, or AQTION, project of the European Quantum Flagship is headquartered in his laboratory, with the goal of developing the European trapped-ion quantum computer.

There are many achievements that mark his extensive scientific career. I will mention only some of them.

One of the first was his participation in the direct experimental observation of the quantum jumps that electrons make between the energy levels of a single atom isolated in a Paul trap (1986) and then later a renewed and fundamental role in the

Cirac-Zoller scheme for the first physical formulation of a trapped-ion quantum computer. He was the first to succeed in experimentally realizing the Cirac-Zoller quantum logic gate, another example of the theory–experiment dialogue mentioned above, published in Nature in 2004.

Among his milestones are the experimental demonstration of the basic building blocks of a quantum computer and quantum algorithms, the first teleportation of quantum states of matter, the first realization of quantum bytes, and the digital simulation of quantum systems, making into reality Richard Feynman’s dream of studying quantum systems without resorting to classical computers, which are inefficient for this general purpose.

One of these achievements deserves special attention: the first complete quantum error correction using trapped ions was done in Rainer’s laboratory, with the collaboration of my theoretical quantum computing group (GICC) in the School of Physical Sciences of the UCM. We were overjoyed at seeing it published in the journal Science in 2014. During the March meeting of the APS (American Physical Society) in 2016, David DiVincenzo named it as a milestone in the celebration of 20 years of quantum error correction. And his list goes on and will go on...

For all this, Rainer Blatt has received highly prestigious awards and prizes, such as the Schrödinger Prize (2006), the Karl Innitzer Award (2008), the Carl Zeiss Research Award (2009, with Ignacio Cirac), the German Physical Society’s Stern-Gerlach Medal (2012), the Alexander von Humboldt Award (2013), the John Stewart Bell Prize (2015), and the Quantum Communication Award (2016, together with Artur Ekert), and I have no doubt that more are yet to come.

His unparalleled ability to manage unprecedented achievements, which no other laboratory would have been capable of, is legendary, as I can attest to. He is also relentless in his search for precision and accuracy to reduce errors and uncertainties to unimaginable limits. This pursuit has led to his awards for his contributions to metrology.

His works transcend his natural scope of quantum optics, metrology, and quantum computing and have influenced other areas, such as ultracold atoms, condensed matter, and theoretical physics.

One of the most laudable and satisfying aspects of Rainer's work is his training of young researchers in his group and his laboratory and through his international collaborations. It has a long trajectory. His mentees have gone on to lead groups and research laboratories in the best centers in the world.

There are many ties that bind Rainer to the Spanish and Latin American scientific community, and we welcome this. We are very pleased to recall the support we received from Rainer in 2009 to launch the QUITEMAD consortium (QUantum Information TEchnologies in MADrid) of the Community of Madrid, coordinated by the GICC group of the UCM at a time when discussing quantum technologies was science fiction.

Another example is the collaboration that his laboratory is carrying out with the Spanish Metrology Center (or Centro Español de Metrología - CEM) to launch a Quantum Metrology unit in its facilities, in which the UCM and QUITEMAD participate.

Rainer likes Spain and has visited it several times. He likes its climate, its people, its diverse places, its wines, its food... Here, too, he has made notable discoveries, such as when you designate something as excellent you can say it's "pata negra"... and he does! and laughs at the thought of the culinary qualities evoked by the description. He knows how to enjoy the moment and celebrate the successes he has seen with his working group and collaborators. He is a great cook and connoisseur who knows how to entertain his guests on such occasions as I have had the pleasure of enjoying. On these occasions, we can once again see his bonhomie, his love of other people, and his affection for his colleagues. The culmination of these celebrations is when Rainer grabs his accordion and gives us the joy of his songs.

The study of quantum mechanics has occupied much of the time and work of Rainer, from its most advanced technological developments to the deepest part of it. Quantum mechanics is in very good health, and even more so with its fusion with information theory, giving rise to fruitful disciplines such as quantum computing and simulation, quantum metrology and cryptography. However, we should not be self-indulgent. We still do not know what to do with the two central theories of physics: quantum mechanics and general relativity. We cope with the situation

thanks to the fact that its scales of action are very different and hardly 'talk to one another': the atomic and the nano-world for quantum mechanics; the macroscopic and cosmological world for general relativity. But even so, the situation is not satisfactory: there are quantum effects that have macroscopic consequences, such as the fact that we are standing here and not collapsing to the ground, thanks to the Pauli exclusion principle; we still haven't found direct quantum effects in gravitation, but presumably they occur in the formation of black holes or in the origin of the universe itself. The situation is disconcerting, sometimes paradoxical. We have been able to make Heisenberg's uncertainty principle compatible with Einstein's principle of relativity, but not with his principle of equivalence. The most popular trend is to try to "quantize" gravity ... or will we have to "gravitize" the quantum as the ingenious Penrose proposes? ... or neither of the two? I have no doubt that the solution to the greatest problem in physics today will come again by some groundbreaking experiment that manages to observe quantum effects in gravitation. For this, it is not necessary to have a complete theory. We need experiments of this nature to be able to construct a theory of something quantum in gravitation, of at least something ... although we do not have the whole picture yet. Again it is laboratories such as those of Rainer Blatt that are of vital importance for solving fundamental problems of physics, not only technological ones. The high-precision and increasingly precise measures of frequency and time that he achieves with his experiments are a window to possible new physics, such as the temporal and spatial stability of the fundamental constants of physics that now play an essential role in the new International System of Units put into effect in 2019 and in which quantum physics played a central role, for example, in the definition of the "quantum kilo".

We see Einstein everywhere, in the classical, in the quantum, ... and also in the Complutense, where on March 8, 1923 he was granted a doctor honoris causa, and also at eleven o' clock in the morning (but solar time). It is appropriate to recall some of his words referring to the types of physicists:

"Perhaps on this occasion it would be better for us to contemplate about which are the inner forces that drive us to scientific research and lead us to positive results and how we appreciate them" He continued: "This bias of interest, which arises

from a deep, almost religious faith, in the unity and simplicity of the principles of the structure of the Universe, has guided all my scientific work. This faith has given me the strength to dedicate all my activity to the study of problems that seemed almost unresolvable despite long years of frustrated attempts. The solution lies in the harmonious mingling of spirits oriented in different ways. I hope that coming out of your University there will be active researchers of both kinds who will increase and deepen human knowledge". These last words of Albert Einstein may well be valid for the new generation of doctors who today collect their diplomas.

Today, it is with great honor and great joy that we receive such an illustrious and distinguished physicist as Professor Rainer Blatt as the new doctor honoris causa at Complutense University. Rainer, welcome.

Thank you very much.