PL-03-01

Quantum physics in the macroscopic domain

Vlatko Vedral

Oxford U

Biography

Vlatko Vedral (PhD and BSc at Imperial College) is a Professor of Quantum Information at the University of Oxford. He has published over 400 research papers on various topics in quantum physics and quantum computing and is one of the Clarivate Highly Cited Researchers. He has given numerous invited plenary and public talks during his career. These include a specialised talk at a Solvay meeting (2010) and a popular one at the International Safe Scientifique (2007). He was awarded the Royal Society Wolfson Research Merit Award in 2007, the World Scientific Medal and Prize in 2009, the Marko Jaric Award in 2010 and was elected a Fellow of the Institute of Physics in 2017 and a member of the European Academy of Sciences in 2020. He has held many visiting professorships, among which are those held at the Universities of Vienna and Belo Horizonte, the Perimeter Institute in Canada and the ISI in Turin. He is consulting the World Economic Forum on the Future of Computation. Vlatko is the author of 4 textbooks and 2 popular books ("Decoding Reality" and "From Micro to Macro").

Abstract

Many macroscopic phenomena rely on the laws of quantum physics. The solid-state physics, for instance, started with the realization that both electrons and vibrations have to be treated quantum mechanically to even begin to be able to understand the thermodynamical behaviour of many-body systems. A growing body of evidence now suggests that living systems too could be utilising quantum coherence, superpositions, and even, in some cases, quantum entanglement to perform specific tasks with higher efficiency. However, it is an exciting open question to what degree quantum effects can be maintained and controlled at the macroscopic

level. This is interesting not just for our quest to realise scalable quantum computers, but also for engineering special-purpose programmable nano-machines.
I will explain the basics of witnessing entanglement and I will put this into the context of our present understanding of macroscopic quantum phenomena. I will then present the single molecule spectroscopy experiments we are currently undertaking in our laboratory to obtain a better understanding of quantum effects in complex (bio)molecules. This will include our recent observation of the vacuum Rabi splitting in a living bacterium strongly coupled with the electromagnetic field as well as living tardigrades coupled to a superconducting qubit. I will also discuss how these experiments can be scaled-up, as well as how we can design artificial and hybrid biomimetic structures that capture the underlying fundamental quantum behavior of complex systems. Gravity may well be the only remaining frontier as far as quantisation is concerned. The fundamental question underpinning all this is: will quantum physics ultimately be superseded in the macro domain, or will it prove to be a universal description of all the known phenomena?