ION HOLE, EVELINA DOMNITCH & DMITRY GELFAND

1/ THE RESEARCH GOAL OF THE RYSQ CONSORTIUM

The goal of the research of RySQ explained by the scientist Robert Spreeuw, University of Amsterdam

https://www.youtube.com/watch?v=VMJ8R_6V5mE

2/ RYSQ, RYDBERG QUANTUM SIMULATORS : A QUANTUM PHYSICS FET OPEN PROJECT

From the RySQ documents
http://cordis.europa.eu/project/rcn/193719_en.html

QUANTUM SIMULATION

In modern times, quantum technologies, that translate unique properties of quantum mechanics into practical applications, play a crucial role in pushing forward the development of our society. The key aspect in realizing new quantum technologies is to understand the underlying fundamental physics of quantum mechanics through various models. This task becomes difficult at the current study of interacting many-body systems due to the lack of methods: analytical models are very rare at this level and all numerical methods running on conventional computers have their own drawbacks. The essential reason is that the resource needed for a classical method to simulate a quantum system/process increases exponentially with the number of the components.

It is possible to overcome this difficulty using quantum simulation, i.e. applying some controllable quantum systems to mimic the dynamics of the to-be-studied models.
This process is called quantum simulation and the controllable quantum systems are called quantum simulators (QS).

[...]
The main objective of the RYSQ project is to use Rydberg atoms for quantum simulations because their outstanding versatility will allow to perform a great variety of useful quantum simulations, by exploiting different aspects of the same experimental and theoretical tools. By implementing not only one but a whole family of Rydberg Quantum Simulators, the project will address both the coherent and incoherent dissipative dynamics of many-body quantum systems.
[...]
The long-term technological vision of QS is twofold: on the one hand, to create computational

devices that can be used for the exploration of otherwise unsolvable scientific questions, some of which possibly yet to be asked; and on the other hand to exploit the answers thus obtained in order to build technologies, beyond information and communication technologies (ICT), that can address societal challenges of global significance like energy production and transport.

Ultra-cold atoms and trapped ions are two appealing candidates for the physical realization of QS owing to their controllability over large number of interacting particles and strong interactions, respectively. RySQ offer the stimulating possibility of combining both advantages, by manipulating large numbers of strongly interacting particles (ultra-cold atoms excited to Rydberg levels), such that the thermal fluctuations originating from the non-zero temperature of atoms can be effectively neglected.

3/ PAUL TRAP

A Paul trap is an electrodynamic ion trap – named after Wolfgang Paul, the Nobel Prize winning scientist who invented it – that allowed scientists for the first time to observe isolated atoms – a new stage in the understanding of quantum physics, which until the invention of such tools could only be theorised or understood.

Among the ongoing philosophical problems in theoretical physics is the inability to describe a quantum system in terms of classical physics. The only way to precisely understand and manipulate quantum phenomena is on their own terms: by means of a quantum simulator - a rapidly evolving methodology initially proposed by Richard Feynman in 1981. Nearly a decade later, in 1989, Wolfgang Paul was awarded the Nobel Prize for having invented the electrodynamic quadrupole ion trap, which enabled physicists to observe for the first time the quantum nature of an individual atom. Finally, instead of measurements comprising averaged statistical values of large ensembles of atoms, an isolated singular atom could be directly probed.

The former approach was based on the classical assumption that all atoms behave in exactly the same way as an average of their statistical behavior. The Paul trap proceeded to become an ideal environment for quantum simulation. Furthermore, the trap's ability to address individual atoms opened a tangible route towards quantum computation: designing logic gates not with bulk matter but rather with discrete properties, such as a single atom's spin, to perform logic operations at unfathomable speeds. The Paul trap has also become a valuable tool in numerous domains besides experimental physics, including chemical analysis, atmospheric science, and aerobiology.

CREDITS

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