People behind PASQuanS

"It has been amazing to see how industry and research have come together to address some of the most outstanding challenges in quantum simulations."

Immanuel Bloch
Max Planck Institute of Quantum Optics, Germany
Coordinator & PI, Experimentalist

Could you briefly describe your institutional and personal role within the PASQuanS project: Which specific project activities are you involved in?

I am one of the coordinators of the PASQuanS project and one of the scientific directors at the Max Planck Institute for Quantum Optics in Garching, Germany. In addition, I hold a chair for Experimental Quantum Optics at the Ludwig-Maximilians-Universität in Munich. My team is working on quantum simulations using ultracold neutral atoms in optical lattices. We are trying to advance this platform to emulate the behaviour of complex condensed matter systems using highly controllable model systems.

Which results have already been achieved on your end and what will be the next milestones?

Our team realised "Quantum Gas Microscopes", which allow to observe individual atoms trapped in artificial crystals of light (so called optical lattices). The atoms in the light crystal mimic the behaviour of electrons in real solid. One amazing aspect is that we can control and detect each individual atom in the system with a resolution down to single lattice sites. This enables us to explore the phases and dynamical properties of such artificial materials in completely new ways and learn about their working principles. The idea here is that this knowledge can, via theory, be transferred to real materials and help develop better classical numerical methods for which our systems can serve as benchmarks.

For you personally, what has been most fascinating about the project so far and how do you think PASQuanS will impact future research and developments in this field?

It has been amazing to see how industry and research have come together to address some of the most outstanding challenges in quantum simulations. As the field very much depends on technological developments in supporting systems, such as lasers, control electronic etc., the joint effort enabled by PASQuanS has significantly contributed to the advancement of the field. Plus, the three platforms pursued in PASQuanS also very nicely complement each other.

PASQuanS was launched in 2018 as one of 20 projects funded in the ramp-up phase of the EU Quantum Flagship initiative. Who came up with the very first ideas for the proposal and how did they evolve?

Together with my colleagues Antoine Browaeys, Peter Zoller and Andrew Daley, we discussed first ideas to form a joint European effort to advance quantum simulations and find new application areas relevant to end users. We then rapidly brought together complementary team members from theory, experiment, and industry to bring this effort to life.

The number "five" seems to have a special meaning in the organisational structure of PASQuanS: Could you explain why?

What a coincidence... I think it nicely symbolizes the balance between experiment, theory and industry across Europe!

Quantum simulation has the potential to solve crucial issues in multiple industrial fields. What are the current shortcomings and how do the programmable platforms developed in PASQuanS address these?

In order to make our simulations even more relevant to material science, we have to be able to enhance their programmability, i.e. we have to be able to realise more complex lattice structures akin to the ones we find in real materials. And all this is supposed to happen in a highly flexible way at the push of a button. In addition, we would like to enhance the initial state preparation, i.e. cool the system down to lower temperatures, such that we can access lower temperature phases and potentially discover new ones. This will also be one of the major development lines for the major development lines for the envisaged follow-up project.

In January 2020, you have initiated the first European end user workshop on "Applications of Quantum Simulation", and associated end users of PASQuanS include large industry players such as Airbus, Bayer, Siemens or Bosch. What have been the main outcomes of the workshop and what are you doing to bring the PASQuanS project results closer to industrial application?

This exchange between industry and science has been very important to identify possible applications for industry and inform our industrial partners in an objective way about the novel capabilities afforded by quantum simulators. All this has been done through intense, fact-based information and discussion without some of the unfortunate 'hype' one often finds around quantum technologies.