A VOYAGER BETWEEN THE WORLDS OF PHYSICS

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Florian Mintert knew from an early age that that he would become a natural scientist. "This already became clear when I was still a child," remembers the Junior Fellow from the FRIAS School of Soft Matter Research. But nobody could ever have dreamed back then that he would one day receive such prestigious accolades such as the ERC grant, which was awarded to him last autumn by the European Research Council.

Like all secondary school students, Florian Mintert's first contact with physics was shaped by classical mechanics, which allows the human imagination to get a clear grasp of matter as small ball-like particles that move around the room. "That said, this model can no longer be used to accurately describes matter at very small scales," explains the Junior Fellow. In order to arrive at coherent physics descriptions in the field of atomic and subatomic physics, we need quantum mechanics, which is fundamentally different from classical mechanics in its mathematical structure. It reveals effects which simply do not exist in the world of classical physics.

While in classical mechanics a particle's state is defined clearly through its position and velocity, in quantum mechanics it is generally not possible to predict where and at what speed a particle can be measured. "The objects' properties are often only defined once measurements have been taken," explains the physicist, "Restoring the particles to their initial state and repeating the experiment several times usually leads to different values." Florian Mintert is fascinated by the fact that quantum mechanics goes beyond the realms of the human imagination and that the brain can only develop an understanding of it using mathematical descriptions. He says, "I find it immensely exciting that quantum mechanical objects behave fundamentally different to objects that can be observed with our own eyes." He and his two colleagues now aim to explore the boundary between classical and quantum mechanics. They want to identify situations where the quantum mechanical properties of an object remain stable, and to discover the point of transition from quantum mechanical to classical behaviour of particles. "We want to find large objects, in which quantum mechanical properties are preserved – such large objects are nevertheless still very small," says the Junior Fellow. Instead of comprising only one atom, these objects consist of four, five or ten particles.

To the surprise of many scientists, more detailed study of photosynthesis revealed that quantum mechanical properties can also be observed in larger objects. "It is unclear why these light-harvesting complexes, which consist of well over ten particles, exhibit quantum mechanical properties. Nevertheless, this encourages us in wanting to characterise quantum mechanical properties in larger objects, too," explains Florian Mintert. In any case, the physicists must first devise measures to be able to characterise these properties. Choosing these measures so that they can be calculated without excessive effort is just one of the challenges confronting the scientists. "Devising a new measure is a very lengthy process. Normally, this involves us making many attempts, which subsequently fail. We move on and try other approaches until one leads to the right idea," admits the physicist. Once this has been achieved, Florian Mintert and his team want to use these measures to produce states with predefined, desired properties in a controlled manner. Once again, photosynthesis provides a good example of such states. The plant directs sunlight energy via 'chromophores' through light-harvesting complexes to the reaction centre, where it is used to produce carbohydrates. "It is assumed that excitation energy simultaneously spreads across many different pathways and is never restricted to just one chromophore. These chromophores are, as quantum physicist put it, entangled," the Junior Fellow describes what happens. This parallel relationship explains why plants can use light energy so very efficiently without any heat loss.

The original motivation behind Florian Mintert's project stemmed from quantum communication. This field aims at using quantum properties such as entanglement to transfer information across large distances in such a way that it cannot be intercepted by a third party. "This could offer a way to keep credit card numbers secure when shopping over the internet, for example," explains the Junior Fellow. The scientists also have their sights on developing solar cells that are significantly more efficient than those currently available. "We dream of a form of artificial photosynthesis that boasts a level of energy efficiency close to that found in a plant system," says Florian Mintert, whose project will be financed for the next five years with the ERC grant. Thanks to this grant, he still has a little more time to conceptualise things that fly in the face of human intuition. *(kb)*