Quantum physics provides startling insights into biological processes

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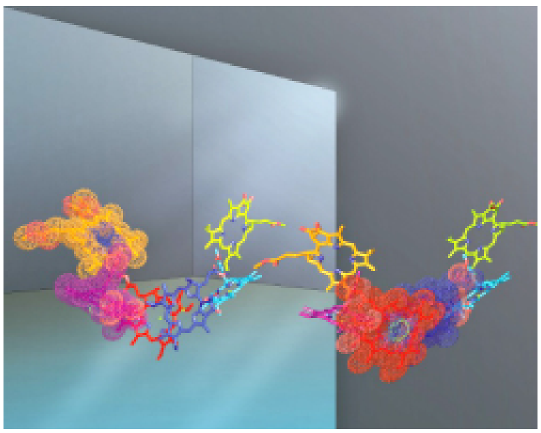

Can something be for instance in two different places at the same time? According to quantum physics, it can. More precisely, in line with the principle of 'superposition', a particle can be described as being in two different states simultaneously.

While it may sound like voodoo to the non-expert, superposition is based on solid science. Researchers in the PAPETS project are exploring this and other phenomena on the frontier between biology and quantum physics. Their goal is to determine the role of vibrational dynamics in photosynthesis and olfaction.

Quantum 'superposition' makes photosynthesis more efficient

Quantum effects in a biological system, namely in a photosynthetic complex, were first observed by Greg Engel and collaborators in 2007, in the USA. These effects were reproduced in different laboratories at a temperature of around -193 degrees Celsius and subsequently at ambient temperature.

'What's surprising and exciting is that these quantum effects have been observed in biological complexes, which are large, wet and noisy systems,' says PAPETS project coordinator, Dr. Yasser Omar, researcher at Instituto de Telecomunicações and professor at Universidade de Lisboa. 'Superposition is fragile and we would expect it to be destroyed by the environment.'

Superposition contributes to more efficient energy transport. An exciton, a quantum quasi-particle carrying energy, can travel faster along the photosynthetic complex due to the fact that it can exist in two states simultaneously. When it comes to a bifurcation it need not choose left or right. It can proceed down both paths simultaneously.

'It's like a maze,' says Dr. Omar. 'Only one door leads to the exit but the exciton can probe both left and right at the same time. It's more efficient.'

Dr. Omar and his colleagues believe that a confluence of factors help superposition to be effected and maintained, namely the dynamics of the vibrating environment, whose role is precisely what the PAPETS project aims to understand and exploit.

Theory and experimentation meet

The theories being explored by PAPETS are also tested in experiments to validate them and gain further insights. To study quantum transport in photosynthesis, for example, researchers shoot fast laser pulses into biological systems. They then observe interference along the transport network, a signature of wavelike phenomena.

'It's like dropping stones into a lake,' explains Dr. Omar. 'You can then see whether the waves that are generated grow bigger or cancel each other when they meet.'

Applications: more efficient solar cells and odour detection

While PAPETS is essentially an exploratory project, it is generating insights that could have practical applications. PAPETS' researchers are getting a more fundamental understanding of how photosynthesis works and this could result in the design of much more efficient solar cells.

Olfaction, the capacity to recognise and distinguish different odours, is another promising area. Experiments focus on the behaviour of Drosophila flies. So far, researchers suspect that the tunnelling of electrons associated to the internal vibrations of a molecule may be a signature of odour. Dr. Omar likens this tunnelling to a ping-pong ball resting in a bowl that goes through the side of the bowl to appear outside it.

This work could have applications in the food, water, cosmetics or drugs industries. Better artificial odour sensing could be used to detect impurities or pollution, for example.

'Unlike seeing, hearing or touching, the sense of smell is difficult to reproduce artificially with high efficacy,' says Dr. Omar.

More information: For more information, see www.papets.eu/

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