Quantum Entanglement, Photosynthesis and Better Solar Cells

Quantum details of plants' food-making ability could improve photovoltaic technology

As nature's own solar cells, plants convert sunlight into energy via photosynthesis. New details are emerging about how the process is able to exploit the strange behavior of quantum systems, which could lead to entirely novel approaches to capturing usable light from the sun.

All photosynthetic organisms use protein-based “antennas” in their cells to capture incoming light, convert it to energy and direct that energy to reaction centers—critical trigger molecules that release electrons and get the chemical conversion rolling. These antennas must strike a difficult balance: they must be broad enough to absorb as much sunlight as possible yet not grow so large that they impair their own ability to shuttle the energy on to the reaction centers.

This is where quantum mechanics becomes useful. Quantum systems can exist in a superposition, or mixture, of many different states at once. What’s more, these states can interfere with one another—adding constructively at some points, subtracting at others. If the energy going into the antennas could be broken into an elaborate superposition and made to interfere constructively with itself, it could be transported to the reaction center with nearly 100 percent efficiency.
A new study by Mohan Sarovar, a chemist at the University of California, Berkeley, shows that some antennas—namely, those found on a certain type of green photosynthetic bacteria—do just that. Moreover, nearby antennas split incoming energy between them, which leads not just to mixed states but to states that are entangled over a broad (in quantum terms) distance. Gregory Scholes, a chemist at the University of Toronto, shows in a soon to be published study that a species of marine algae utilizes a similar trick. Interestingly, the fuzzy quantum states in these systems are relatively long-lived, even though they exist at room temperature and in complicated biological systems. In quantum experiments in the physics lab, the slightest intrusion will destroy a quantum superposition (or state).

These studies mark the first evidence of biological organisms that exploit strange quantum behaviors. A better understanding of this intersection of microbiology and quantum information, researchers say, could lead to “bioquantum” solar cells that are more efficient than today’s photovoltaics.

*Note: This article was originally printed with the title, "Chlorophyll Power."*