

Sulfur Bacteria Offers Luminous Clues for Quantum Computing

By [REDACTED]

In the depths of the ocean, there's a teeny sulfur bacteria that can harvest light with exquisite efficiency. It does so in a quantum way, by trapping an elusive light photon and sending it simultaneously on all paths to its reaction center for photosynthesis. Its success has baffled scientists, who grapple with cryogenic fortresses to maintain the most basic quantum activity in a computer. But recently, a team of engineers from Massachusetts Institute of Technology and other universities has isolated the enigma that makes the bacteria a quantum master.

Quantum computing is built on particles called qubits. Unlike the electrons used in classical computers which have one voltage or another and follow instructions sequentially (if 0, then 1), qubits have an excited spin that give them the weird property of occupying all voltages at once, enabling them to follow multiple instructions concurrently and exponentially as qubits are added. The ability offers a tantalizing glance into a world where computers can instantaneously test millions of data variations to crack a code, target a cell's pathway, scope the universe for life or any data set to apply to a model.

To date however, scientists can only manipulate about 10 qubits, limiting them to a very narrow task capacity. To avoid particle chaos, scientists have to freeze equipment to near absolute zero, which is colder than interstellar space — not something you could manage in your living room. The famous D-Wave Computer, sold to NASA, Google and Lockheed Martin, requires elaborate pulse fridges and Helium-3 to keep it cold and the Army Research Office and the National Science Foundation use charged barium chloride molecules in a super cloud of calcium atoms. Particle chaos can also creep in from atmospheric electro-magnetic waves and the equipment's nuclear spin, requiring sophisticated magnetic vacuums.

To peel back the mystery of how the itty green sulfur bacteria zaps quantum photons around for use in photosynthesis in the messy, warm ocean, Seth Lloyd, a professor of quantum mechanical engineering at M.I.T., and the innovator behind the first quantum computer, worked with a team of scientists to recreate the bacteria's light absorbing molecules called chromophores. They did this by creating a scaffolding of soft cyanine-dye molecules that, like in the bacteria, naturally assemble into a bundle of hexagon shaped cylinders.

Using optical spectroscopy and other devices, what they saw was compelling: the hexagon shape of the cylinders, similar to honeycombs, insect eyes, epithelial cells and so many forms in nature, provide maximum energy flow in their tubes while providing stable, insulated space. (If the cylinders were spherical, the ultimate shape for energy transport, they wouldn't be able to stack onto each other without gaps between them).

Indeed, the air-tight, compressed cylinders enhanced a phenomenon called photon coupling—the joining of waves between two particles—which helped propel other photons through the cylinders. The bundled cylinders also increased light absorption by creating overlapping absorption bands on their surfaces.

Lloyd and his group also saw that a precise amount of photon chaos in the modelled cylinders actually boosted other photons forward. If chaos duration was too short, the travelling photons got diffused over time. If slightly too long, photons became disorderly.

Other variables that needed to be 'just right', (dubbed by Lloyd's group as the 'quantum Goldilocks effect'), included photon coupling. If too few photons coupled, the travelling photons lost momentum. If too many coupled, travelling photons got stuck. Similarly, the amount of photon chaos and the density of cylinder bundling had to be just right to maintain the balance between photon coupling and splitting.

And as Lloyd and his colleagues continue to unveil the sulfur bacteria's secrets, what emerges is a picture of a greatly challenged species that survives from a highly evolved architecture versus an arsenal of fancy equipment. A creature that has to rely on the precise interaction of basic elements. The discovery is already generating a paradigm shift in quantum computing: to not approach it so defensively with frozen barricades and brawn, but to step back and learn from nature's most tenacious design.