Efficiency of photosynthesis depends on quantum coherence

Photosynthesis is an amazingly efficient process, capturing 95% or more of the light energy that hits a leaf. Now a study led by researchers at the Lawrence Berkeley National Laboratory and the University of California at Berkeley reveals at least part of how this is done. The trick, revealed by beat patterns in two-dimensional Fourier transform spectroscopy of a bacteriochlorophyll, seems to be that incoming light causes coherent excitation of many different states simultaneously in superposition. This then allows a very efficient search of the various possible reaction complexes into which the energy could be delivered.

The discovery hinged on the two-dimensional electronic-spectroscopy technique developed by the group, which is led by Graham Fleming at Berkeley. This enables the researchers to follow the light-induced excitation energy at it passes through molecular complexes, with a time resolution of femtoseconds. It involves flashing a sample sequentially with femtosecond pulses of light from three laser beams, with a fourth beam to amplify and detect the resulting spectroscopic signals.

The finding contradicts the classical description of the photosynthetic energy transfer process as one in which excitation energy moves step-by-step down the molecular energy ladder from pigment molecules to reaction centres. Instead, the process seems to depend on quantum coherence, which is also what underlies quantum computing. Further research into this effect could lead to a better understanding of how life uses quantum mechanics, and perhaps could also lead to new ways of making solar cells.