Ultrafast tryptophan-to-tryptophan energy transfer and superradiance in tubulin polymers

Dr. Philip Kurian (Howard University, Washington DC, USA)

Abstract:

Oxidative stress from aerobic processes is a pathological hallmark of degenerative disorders such as Alzheimer's disease and cancer. The precise role of reactive oxygen species (ROS) in the disease process, however, is poorly understood. It is known that the production of ROS by mitochondria can result in ultraweak photon emission (UPE) within cells, and UPEs in the UV and visible ranges have been observed with modern equipment during different stages of the mitotic cycle. Surrounding biomolecules can absorb these photons via aromatic amino acids (e.g., tryptophan and tyrosine), nucleobases (e.g., adenine, cytosine, guanine, thymine), and other chromophoric constituents, forming excited singlet or triplet transition states. One likely absorber is the microtubule cytoskeleton, as it forms a vast network spanning neurons, is highly co-localized with mitochondria, and shows a high density of aromatics, but DNA and the photoactive receptors in the mitochondrial membrane are also potential candidates. These networks may traffic ROS-generated endogenous photon energy for cellular signaling, or they may serve as dissipaters of such energy to protect the cell from potentially harmful effects. Recent modelling efforts based on ambient temperature experiment are presented, showing that such biopolymers can feasibly absorb and channel these photoexcitations via resonance energy transfer, on mesoscopic length scales of physiological significance. Additional simulations using a non-Hermitian Mukamel Hamiltonian demonstrate the possible existence of superradiant states in microtubules corresponding to similar observed phenomena in cylindrical chlorophyll complexes.