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## Quantum-statistical phenomenon of sustainability and its manifestations in dissipative photonic systems

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It is shown that sustainability is a universal quantum-statistical phenomenon, which emerges during propagation of photons inside different dissipative media, such as waveguides, metamaterials or biological tissues. These quantum effects occur due to the interaction of electromagnetic (EM) waves or photons with their environment, which can be described by means of the reduced density operator and effective non-Hermitian Hamiltonian (NH) approach. We illustrate them using two seemingly entirely different kinds of photonic systems: (1) We start by considering EM wave propagation in dielectric linear media, for which we derive the effective Hamiltonian operator, which describes such propagation. This operator turns out to be essentially non-Hermitian. Using the density operator approach for general non-Hermitian Hamiltonians, we derive a master equation that takes into account statistical ensembles of EM wave modes. The method describes dissipative processes which happen during the wave's propagation, and, among other things, it reveals the conditions that are necessary to control the energy and information loss inside the above-mentioned materials. (2) In case of photobiological complexes (PBCs), such as photosynthetic reaction centers and centers of melanogenesis inside living organisms or organelles, we derive a simple effective model of excitonic energy transfer. We demonstrate that photobiological systems must be both quantum and sustainable for them to simultaneously endure continuous energy transfer and keep their internal structure from destruction or critical instability. We show that in sustainable PBCs, quantum effects survive on a much larger time scale than the energy relaxation of an exciton. Besides, sustainable evolution significantly lowers the entropy of PBCs and improves the speed and capacity of energy transfer therein.

**Apply to be considered for a student award (Yes / No)?**

No

**Level for award (Hons, MSc, PhD, N/A)?**

N/A

**Would you like to submit a short paper for the Conference Proceedings (Yes / No)?**

Yes

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