Quantum thermodynamics: Increasing quantum heat engine efficiency via quantum coherence

Gombojav O. Ariunbold[1, 2], Philip Vetter[1, 3], Dmitri V. Voronine[1, 2], and Marlan Scully[1, 2, 3]

[1] *Texas A&M University, College Station, TX 77843-4242, USA*

[2] *Baylor University, Waco, TX 76706, USA*

[3] *Princeton University, Princeton NJ 08544, USA*

Laser and photocell quantum heat engines (QHEs) are powered by thermal light and governed by the laws of quantum thermodynamics. To appreciate the deep connection between quantum mechanics and thermodynamics we need only recall that in 1901 Planck introduced the quantum of action to calculate the entropy of thermal light, and in 1905 Einstein's studies of the entropy of thermal light led him to introduce the photon.

We here show how to use quantum coherence induced by external coherent fields [1] or by quantum noise [2] to improve the efficiency of a laser or photocell QHE. Surprisingly, this coherence can be induced by the same noisy (thermal) emission and absorption processes that drive the QHE. Furthermore, this noise-induced coherence can be robust against environmental decoherence. Applications of these ideas to photosynthesis [3,4] will also be discussed.

[1] M.O. Scully, "Quantum Photocell: Using Quantum Coherence to Reduce Radiative Recombination and Increase Efficiency", Physical Review Letters, 104, 207701 (2010).

[2] M.O. Scully, K.R. Chapin, K.E. Dorfman, M.B. Kim, and A. Svidzinsky, "Quantum heat engine power can be increased by noise-induced coherence", PNAS, 108, 15097 (2011).

[3] G.S. Engel et al., "Evidence for wavelike energy transfer through quantum coherence in photosynthetic systems", Nature, 446, 782-786 (2007).

[4] K.E. Dorfman, D.V. Voronine, S. Mukamel, and M.O. Scully, "Photosynthetic reaction center as a quantum heat engine", PNAS, 110, 2746 (2013).