

# Photoassisted chiral transport beyond the Carnot limit

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Classically, the power generated by an ideal thermal machine cannot be larger than the Carnot limit. This profound result is rooted in the second law of thermodynamics. A hot question is whether this bound is still valid for microengines operating far from equilibrium. We will show [1] that a quantum chiral conductor driven by AC voltage can indeed work with efficiencies much larger than the Carnot bound. The system also extracts work from common temperature baths, violating Kelvin-Planck statement. Nonetheless, with the proper definition, entropy production is always positive and the second law is preserved. To this end, we adopt the Floquet scattering matrix approach for electric and heat currents and also a generalized definition of entropy production based on Shannon formula for the incoming and outgoing electron distributions in each terminal. We find that the engine efficiency exceeds the Carnot limit when the entropy production is deviated from the Clausius relation due to the energy uncertainty induced by the AC driving. The role of the AC driving can be interpreted as a nonequilibrium demon as the driving induces additional entropy production by rearranging the distribution of electrons in energy in a more uncertain way, while injecting no energy. Our results are relevant in view of recent developments that use small conductors to test the fundamental limits of thermodynamic engines.

- [1] S. Ryu, R. Lopez, L. Serra, D. Sanchez. Beating Carnot efficiency with periodically driven chiral conductors, *Nature Communications* 13, 2512 (2022).