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Hamiltonian mechanics limits microscopic engines JAMES ANGLIN, LUKAS GILZ, EIKE THESING, TU Kaiserslautern — We propose a definition of fully microscopic engines (micro-engines) in terms of pure mechanics, without reference to thermodynamics, equilibrium, or cycles imposed by external control, and without invoking ergodic theory. This definition is pragmatically based on the observation that what makes engines useful is energy transport across a large ratio of dynamical time scales. We then prove that classical and quantum mechanics set non-trivial limits–of different kinds–on how much of the energy that a micro-engine extracts from its fuel can be converted into work. Our results are not merely formal; they imply manageable design constraints on micro-engines. They also suggest the novel possibility that thermodynamics does not emerge from mechanics in macroscopic regimes, but rather represents the macroscopic limit of a generalized theory, valid on all scales, which governs the important phenomenon of energy transport across large time scale ratios. We propose experimental realizations of the dynamical mechanisms we identify, with trapped ions and in Bose-Einstein condensates ("motorized bright solitons").

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