The Quantum Carnot Engine

In classical thermodynamics, irreversibility is described by defining the Carnot engine (whose cycle consists of alternate isothermal, or constant temperature, and adiabatic, or constant entropy, phases) as the one that is theoretically most efficient; and one of the many statements of the second law of thermodynamics is that no engine can be more efficient than a Carnot engine.

To ensure the incorporation of thermodynamic with quantum and classical dynamical laws, we propose that the universe is treated as a quantum Carnot engine (QCE), consisting of a single heat bath in which the ensemble of elementary particles retain a small amount of quantum coherence, so as to constitute new states of matter, called by Sully et al. a ‘phaseonium’,** the first of which is the empty ensemble of dark energy.

The explanation of how this initial phaseonium fuels the natural structure of the universe, may be then shown to be in complete accord with Nilpotent Universal Computational Rewrite System (NUCRS) and thus the existence of a 3 + 1 space-time, the known quantizations of the elementary particles, and galactic structure. The NUCRS provides a novel synthesis of critical evidence in relation to cosmology and living systems in favour of such a quantum description of the Universe from its conception to the present day.

This synthesis is proposed because, although the Second Law of Thermodynamics continues to hold since any such quantum coherent system must be quantum mechanically prepared, quantum coherence fundamentally alters Carnot heat engine operation (i.e. the Carnot efficiency \( \eta \) for converting heat into work) from what is thermodynamically possible classically

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\eta = 1 - \frac{T_c}{T_h}
\]

\[
\eta = 1 - \cos \theta
\]

where \( T_c \) and \( T_h \) are the temperatures of the low temperature entropy sink and the high temperature source respectively, and \( \theta \) is the quantum coherent phase, such that by the proper choice of \( \theta \), work is obtained even when \( T_h = T_c \) i.e. even when there is only one thermal bath.