Abstract Submitted
for the MAR16 Meeting of
The American Physical Society

Extending Landauer's Bound from Bit Erasure to Arbitrary Computation DAVID WOLPERT, Santa Fe Institute — Recent analyses have calculated the minimal thermodynamic work required to perform any computation π whose output is independent of its input, e.g., bit erasure. First I extend these analyses to calculate the work required even if the output of π depends on its input. Next I show that if a physical computer $\mathcal{C}$ implementing a computation π will be re-used, then the work required depends only on the dynamics of the logical variables under π, independent of the physical details of $\mathcal{C}$. This establishes a formal identity between the thermodynamics of (re-usable) computers and theoretical computer science. To illustrate this identity, I prove that the minimal work required to compute a bit string σ on a (physical) Turing machine M is $k_B T \ln(2)$[Kolmogorov complexity(σ) + log (Bernoulli measure of the set of strings that compute σ) + log(halting probability of M)]. I also prove that uncertainty about the distribution over inputs to the computer increases the minimal work required to run the computer. I end by using these results to relate the free energy flux incident on an organism / robot / biosphere to the maximal amount of computation that the organism / robot / biosphere can do per unit time.

David Wolpert
Santa Fe Institute

Date submitted: 02 Nov 2015 Electronic form version 1.4