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Beyond the second law.

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According to the second law, the work needed to bring a system from one state to another one, when in contact with a heat bath, is at least equal to the difference in free energies of these states. By a refinement of the work theorem, we derive an exact microscopic expression for the extra dissipation. It is expressed in terms of the relative entropy of the phase space density. Furthermore, lower bounds for the extra dissipation are obtained when only limited information is available. The result is illustrated on various Hamiltonian and stochastic models. The connection to the thermodynamics of computation is briefly discussed. Ref R. Kawai, JMR. Parrondo and C. Van den Broeck, Phys Rev Lett 98, 080602 (2007)