# Thermal Neuron: Computation via Heat Flows

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Computers need energy to function, and as a result, they are subject to the laws of thermodynamics. A thorough understanding of these limitations is essential for developing more efficient computing devices. In this work, we propose a physical model of computation based on quantum thermal machines (QTMs), which we call the *thermal neuron*. It departs from conventional models by exploiting heat (rather than electronic) currents to perform computation. The thermal neuron model explicitly accounts for all the resources necessary for computation, while remaining simple enough to illustrate the influence of thermodynamic laws on the computing process. The model can execute any binary function, showcasing its versatility. Moreover, to demonstrate its universality, we give examples of the thermal neuron simulating several logic functions: NOT, NOR, majority and XOR. Additionally, we examine the performance of the thermal neuron as a logical device, delving into the relationship between heat dissipated during its operation and its accuracy as a computing device. Finally, we argue that the model can also be seen as an autonomous physical model of an artificial neuron (perceptron), enabling us to model neural networks as autonomous thermodynamic machines.

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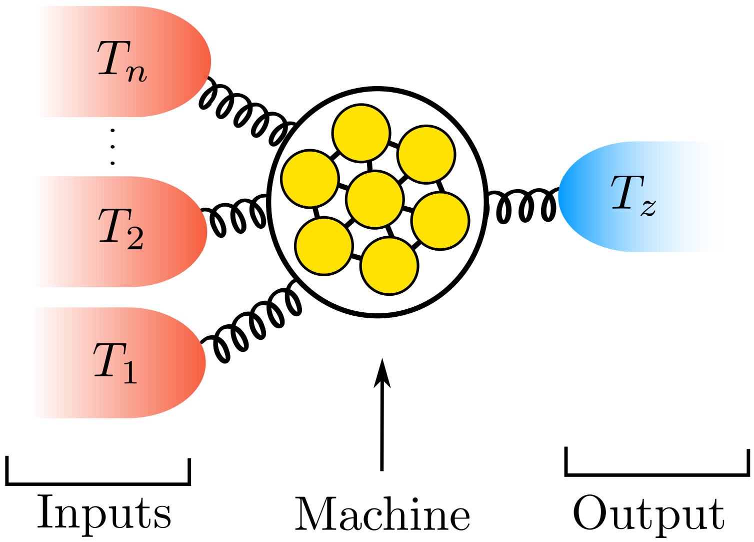


FIG. 1. **Thermal machine for computation.** The device consists of a small number of quantum systems known as qubits, which interact with thermal environments. The temperatures of these environments (depicted in red) function as inputs to the machine. By connecting the machine to another environment (shown in blue), the machine can alter its temperature based on the inputs received. As a result, the machine can be seen as a simple computing device.