Computers as physical systems

Contemporary computing is based on the concept of states and state transformations by fixed sets of rules.

states → are mathematical abstractions of physical states
(states of physical systems | phenomena)

basic level of abstraction → binary states | (0 | 1)
⇝ current on | off
⇝ voltage high | low
⇝ electrical charges present | absent
⇝ magnetization left | right (up | down)

further levels of abstraction
→ n-tuples of binary digits
⇝ codes for atomic objects (numbers | characters | operators | addresses)
→ representation of complex objects as compositions of elementary objects (compound operators | operands)
→ representation of algorithms | programs as (partially) ordered structures composed of operators and operands
→ ...

The physics of the underlying system has little | no influence on the higher levels of abstraction → on the model of computation other than on
⇝ space and time requirements of computations
→ the tractability problem
⇝ energy consumption

Otherwise → all systems are fully Turing compatible → may realize all intuitively computable functions

However →
miniaturization of computer components by a factor of 1/2 per 18 month leads to sizes approaching individual atoms by year 2020
⇝ the classical Turing model becomes invalid
⇝ quantum effects take over → leading to a new model of computation based on an algebra | a calculus that describes quantum mechanical processes | phenomena

Quantum computers
⇝ are inherently reversible → computations may run forward | backward
⇝ perform certain computations exponentially faster than classical computers → quantum concurrency
⇝ may generate truly random numbers
⇝ teleport messages by entanglement of quantum states | betray eavesdropping
⇝ break supposedly unbreakable code
⇝ are fully Turing compatible otherwise