Computers Faster Only for 75 More Years? Physicists determine nature's limit to making faster processors

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With the speed of computers so regularly seeing dramatic increases in their processing speed, it seems that it shouldn't be too long before the machines become infinitely fast -- except they can't.

A pair of physicists has shown that computers have a speed limit as unbreakable as the speed of light. If processors continue to accelerate as they have in the past, we'll hit the wall of faster processing in less than a century.

Intel co-founder Gordon Moore predicted 40 years ago that manufacturers could double computing speed every two years or so by cramming ever-tinier transistors on a chip. His prediction became known

as Moore's Law, and it has held true throughout the evolution of computers -- the fastest processor today beats out a ten-year-old competitor by a factor of about 30.

If components are to continue shrinking, physicists must eventually code bits of information onto ever smaller particles. Smaller means faster in the microelectronic world, but physicists Lev Levitin and Tommaso Toffoli at Boston University in Massachusetts, have slapped a speed limit on computing, no matter how small the components get.

"If we believe in Moore's laW ... then it would take about 75 to 80 years to achieve this quantum limit," Levitin said.

"No system can overcome that limit. It doesn't depend on the physical nature of the system or how it's implemented, what algorithm you use for computation … any choice of hardware and software," Levitin said. "This bound poses an absolute law of nature, just like the speed of light."

Scott Aaronson, an assistant professor of electrical engineering and computer science at the Massachusetts Institute of Technology in Cambridge, thought Levitin's estimate of 75 years extremely optimistic.

Moore's Law, he said, probably won't hold for more than 20 years.

In the early 1980s, Levitin singled out a quantum elementary operation, the most basic task a quantum computer could carry out. In a paper published today in the journal *Physical Review Letters*, Levitin and Toffoli present an equation for the minimum sliver of time it takes for this elementary operation to occur. This establishes the speed limit for all possible computers.

Using their equation, Levitin and Toffoli calculated that, for every unit of energy, a perfect quantum computer spits out ten quadrillion more

operations each second than today's fastest processors.

"It's very important to try to establish a fundamental limit -- how far we can go using these resources," Levitin explained.

The physicists pointed out that technological barriers might slow down Moore's law as we approach this limit. Quantum computers, unlike electrical ones, can't handle "noise" -- a kink in a wire or a change in temperature can cause havoc. Overcoming this weakness to make quantum computing a reality will take time and more research.

As computer components are packed tighter and tighter together, companies are finding that the newer processors are getting hotter sooner than they are getting faster. Hence the recent trend in duo and quad-core processing; rather than build faster processors, manufacturers place them in tandem to keep the heat levels tolerable while computing speeds shoot up. Scientists who need to churn through vast numbers of calculations might one day turn to superconducting computers cooled to drastically frigid temperatures. But even with these clever tactics, Levitin and Toffoli said, there's no getting past the fundamental speed limit.

Aaronson called it beautiful that such a limit exists.

"From a theorist's perspective, it's good to know that fundamental limits are there, sort of an absolute ceiling," he said. "You may say it's disappointing that we can't build infinitely fast computers, but as a picture of the world, if you have a theory of physics allows for infinitely fast computation, there could be a problem with that theory."