First question
Some of your work involves reversible computing, which I previously discussed with Mike Frank. Mike's view seemed to be that there were promising signs that reversible computing would be possible eventually, but progress is not moving quickly due to lack of funding and interested researchers. Is that your view as well? And based on my interview with him, do you seem to have a *substantially* different impression that Mike does about anything he and I discussed?

Answer
I agree with Mike, but his discussion of minimum energy in computing due to irreversibility is just part of a larger topic of minimum energy in computing that starts with “Moore’s Law Ending.”

For any reader who has not read Mike Frank’s interview, I’d like to give a quick summary of the relevant points. Mike was interviewed about reversible logic, which is sometimes called reversible computing. If you were a brilliant engineer and could figure out how to make a computer logic gate like AND or OR that dissipated kT joules per logic operation (the meaning of kT is in the next paragraph), you would discover that there is an additional heat production on the order of kT due to the interaction between information and thermodynamics. If you were determined to make even lower power computer gates anyway, you would have to use reversible logic principles. You could use a different universal gate set like TOFFOLI, FREDKIN, and CNOT or you could engineer the system to reverse the computation after you outputted the answer (which is the source of the name “reversible”).

For reference on kT: k = 1.38 x 10^-23 is Boltzmann’s constant and T is the absolute temperature with T = 300 Kelvin at room temperature. kT is about 4 zeptojoules = 4 x 10^-21 joules. Comparing this number to today’s computers is imprecise because dissipation in today’s computers is primarily attributable to the interconnect wire, which varies in length. An AND or OR gate in a modern computer may dissipate a million times this value.

A great many respected scientists believe that reversible computing is feasible, but challenging. If their views are correct, computation should be possible at “arbitrarily low energy levels” and all theories proposing unavoidable limits are incorrect. There are a handful of contrary theories proposing minimum energy dissipation levels. Several key ones are Landauer’s Limit of “on the order of kT” per logic operation, a thermal limit of 40-100 kT (depending on your definition of reliable), and the concept in the popular press today that “Moore’s Law is Ending” and the minimum energy per computation is whatever is in the rightmost column of the International Technology Roadmap for Semiconductors (ITRS). That value is about 50,000 kT with typical lengths of interconnect wire.

Scientific situations with multiple competing theories can be settled by a scientific experiment. For example, there is a researcher in New York that has a superconducting circuit running in the sub-kT range and looks like it could demonstrate a logic circuit in another couple “spins” of his chip. Demonstrating and rigorously measuring a sub-kT circuit would invalidate all current theories claiming unavoidable limits – provided the measurement was rigorous and the result could be reproduced.

Whether anybody will fund such an experiment should depend on whether anybody cares about the result, and I’d like to present two society-level questions that the experiment would resolve:

The computer industry started its upward trend during WW II, growing industry revenue and computer throughput in a fairly clean exponential lasting 70 years. The revenue from semiconductors and downstream industries is around $7 trillion per year right now. If there is a limit to computing, the shift in growth rate will cause a glitch in the world’s economy. My argument is that proving or disproving theories of computing limits could be accomplished for a very small fraction of $7 trillion per year.

The second has to do with profoundly important computational problems, such as the simulation of the global environment to assess climate change issues. Existing climate models running on Petaflops supercomputers give varying projections for the future climate, with these projections diverging from observations over the last decade. Regardless of politics, the remedy would be a more sophisticated climate model running on a bigger supercomputer. We don’t know how much bigger. If any of the minimum energy dissipation theories are correct, the energy dissipation of the required supercomputer could turn out to be too large and climate modeling may be infeasible; if the theory that computing is possible at “arbitrarily low levels” is true, accurate climate modeling will just require a highly-advanced computer.

I’ve tried to expand on Mike’s point: Research on reversible computing could shed light on the future of the economy and the planet’s climate, but I do not know of a single person funded for reversible computing research (in the USA). Furthermore, a conclusive demonstration of reversible computing would show the statement “Moore’s Law is Ending” to be a matter of choice not technology.