

Norman Margolus*

Curriculum Vitae

Education

Ph.D. in Physics, Massachusetts Institute of Technology (1987).
Thesis Title: Physics and Computation (Edward Fredkin supervisor).

Employment

2006–2022 Independent academic researcher (currently affiliated with MIT).

2000–2005 Co-founder (with Tom Knight) and Chief Scientist of Permabit, a storage software startup.

1996–1999 Research Associate Professor at Boston University’s Center for Computational Science.

1987–1995 Research Scientist at the MIT Laboratory for Computer Science.

Research

For my Ph.D. research [1–5] I was privileged to work with Ed Fredkin, Tom Toffoli, Charles Bennett, and Gerard Vichniac, who comprised the MIT Information Mechanics Group. We studied “ideal” computers and computations that reflect the structure of microscopic physics (reversibility, locality, quantumness, etc.), and computational models of physics. In this context, I worked to reformulate the computing process to better match fundamental physical constraints, and to elucidate fundamental connections between theoretical physics and finite-state computation. I also had the incredible fortune to spend a year visiting with Richard Feynman, discussing these issues with him and helping him teach a class related to this topic.

During and after my Ph.D I devoted a substantial amount of time and effort to designing, building and programming computers that help us preview, and even begin to make practical, massively parallel applications that can harness the astronomical performance that will ultimately be available in a cellular automaton (CA) format on a very microscopic physical scale. Working closely with Tom Toffoli, who is a hardware and modeling genius, this work dominated my more theoretical physics research, and after I graduated the CAM-8 project took years of time and effort. In that project, stimulated by excitement over realistic lattice-gas models of fluids and the possibilities of virtual-processor CA hardware [2], we built desktop lattice-gas supercomputers [11, 18] and pursued a wide variety of scientific collaborations in large-scale volumetric physical simulations of materials, fluids, fields, digital logic, and also in general 3D image and data processing [19]. The next big leap forward possible in this kind of computation is clear, and I presented a paper on this at the ISCA computer architecture conference in 2000 [37]. Lattice-gas machine development led to several hardware patents on parallel virtual-processor simulation of fine-grained spatial processes and on scalable physical interconnect [14, 21, 36]. I am also first inventor on 35 issued patents based on ideas I worked on at my software startup [43–45]. These include a new category of erasure-resilient codes, a storage system optimized to store randomly-named (hash-named) blocks of data, and the architecture of a distributed storage system that recovers quickly from large numbers of simultaneous hardware failures.

My early research career is summarized pictorially in slides from a series of lectures I gave in 2002 at Caltech [40]. My best known physics research was done while jointly at Boston University and MIT: it uses quantum mechanics to identify macroscopic classical energy with the maximum rate of distinct microscopic dynamics: the maximum number of physical events per second [32]. I have spent most of my time as an independent researcher extending these ideas, identifying other basic dynamical quantities as counts of distinct states in time and space [51]. This finite distinctness makes classical dynamics effectively discrete, in the same way limited bandwidth makes signaling with a classical wave discrete: the state defined on a discrete set of points carries all of the information, and the rest is interpolation.

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Publications

My ten most cited publications have over 10,000 citations: a basic paper on quantum computing [25], the book Tom Toffoli and I wrote about our early work on physical modeling with cellular automata [4], the paper identifying energy as operations-per-second for physical dynamics [32], two early papers on reversible cellular automata [1,10], one of my storage patents [43], three papers on cellular automata machines [2,6,11], and a second storage patent [44]. In my opinion, though, my most significant hardware paper is the one I presented at ISCA 2000 [37], and I plan to do more to get its ideas out into the world. My most significant physics paper is just now being submitted for publication [51]; it illuminates a lot of basic physics in light of the relationship between dynamical quantities and counting distinct physical states.

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