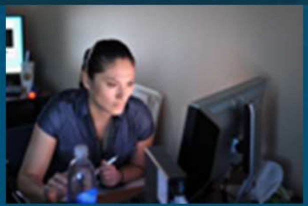
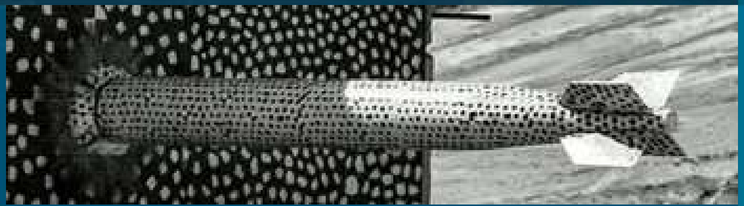
SAND2023-13498C

2023 Texas Symposium on Computing with Emerging Technologies (ComET)
University of Texas at Dallas
Session on Quantum & Superconductive Computing with Emerging Technologies

Sandia National Laboratories

Touchpoints Between Classical Reversible Computing and Superconducting/Quantum





Wednesday, May 10th, 2023

Michael P. Frank, Center for Computing Research

with Rupert Lewis (Quantum Phenomena Dept.)

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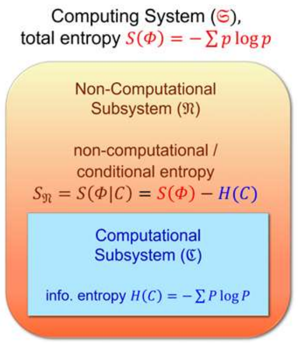
Touchpoints Between Classical Reversible Computing and Superconductive & Quantum Computing

See https://tinyurl.com/MikePFrank-Sandia for more

- Some historical roots:
  - Landauer's limit (1961) follows from the unitarity of QM, and it motivates reversible computing.
  - Konstantin Likharev's reversible *parametric quantron* (PQ, 1977+) was one of the first efficient superconductive logic styles, and simultaneously one of the first concrete engineering implementation concepts for reversible computing.
  - Richard Feynman's early ideas about quantum computing (1982, 1985) were inspired by his interactions with Ed Fredkin, who always urged him to think about physics in computational terms.
  - David Deutsch's (1989) concept of quantum circuits was a direct generalization of Fredkin & Toffoli's early (~1980) work on classical reversible logic circuits.
- Current noteworthy intersection points:
  - Yokohama National University's adiabatic quantum flux parametron (AQFP) approach to superconducting logic can be viewed a modern successor to Likharev's early PQ work
    - Includes a logically reversible logic family called reversible quantum flux parametron (RQFP), shown capable of circumventing Landauer's limit in simulation. (And working test chips have been fabbed!)
  - Recent work on *ballistic* models of superconducting reversible computing by groups at U. Maryland/LPS & at Sandia (& related theoretical studies by Jim Crutchfield @ UC Davis)
    - Heavily inspired by Fredkin & Toffoli's 1980 *billiard-ball model* of ballistic reversible computing.
  - Semiconducting/superconducting adiabatic/reversible logic can permit more energy-efficient *control and readout* in real engineering implementations of quantum computers!
    - E.g., see recent work by Erik DeBenedictis, zettaflops.org. (Slide shown during panel)



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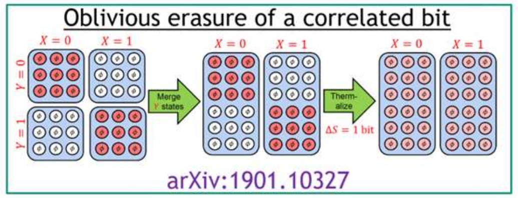

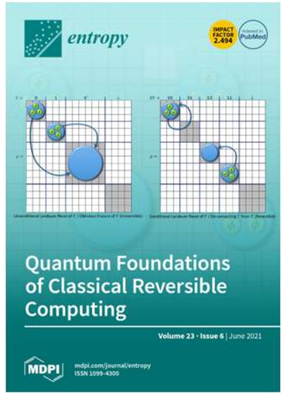

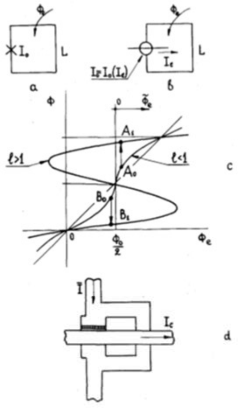

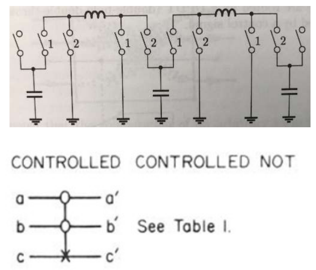

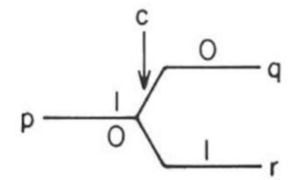

$H = q^* cp + r^* c^* p + p^* c^* q + p^* cr$