

Opening Remarks - QIPA School

by

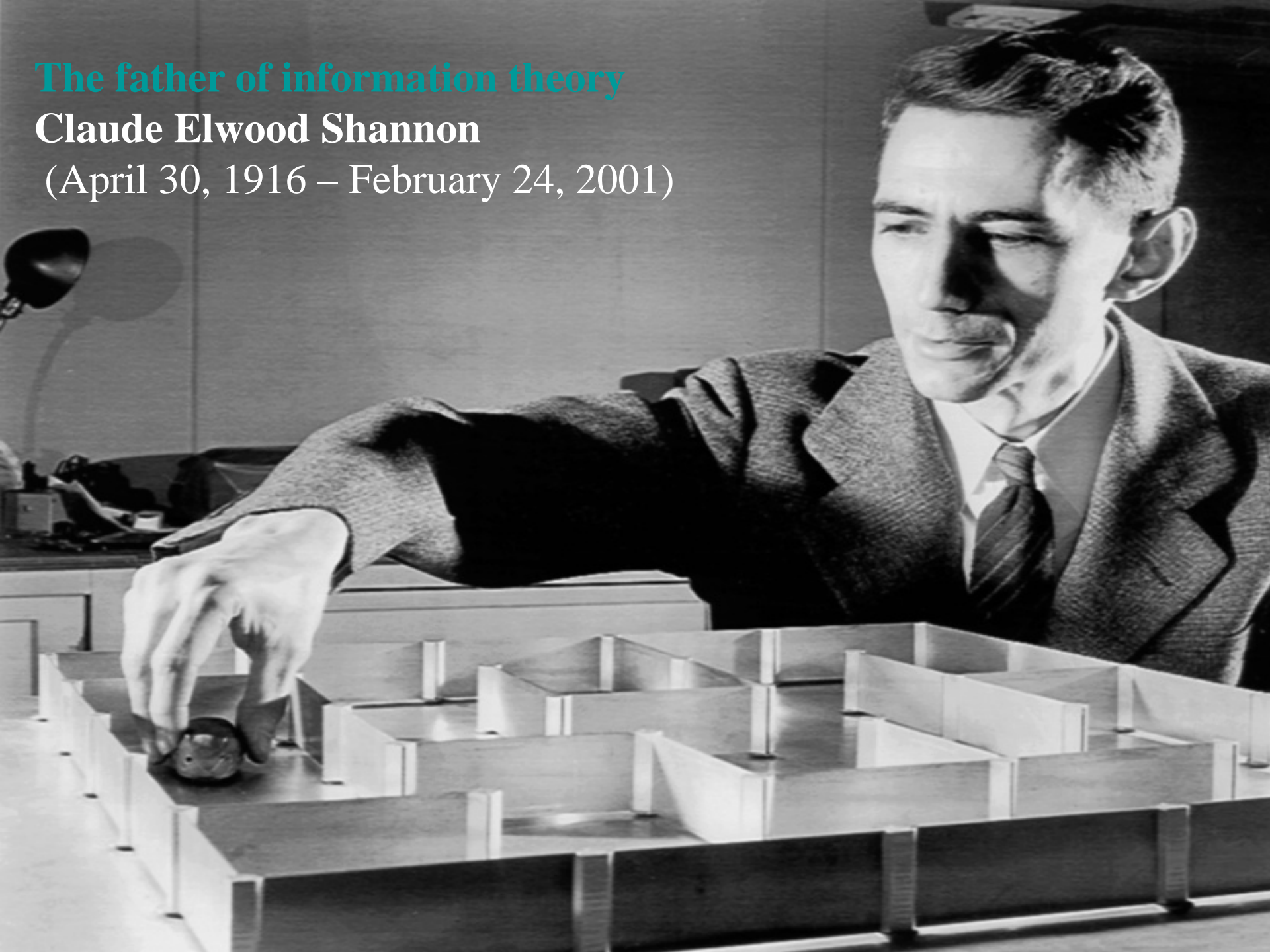
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The father of information theory

Claude Elwood Shannon

(April 30, 1916 – February 24, 2001)



Classical Information Processing and Applications

Driven originally by **Bell Telephone Labs** and led by

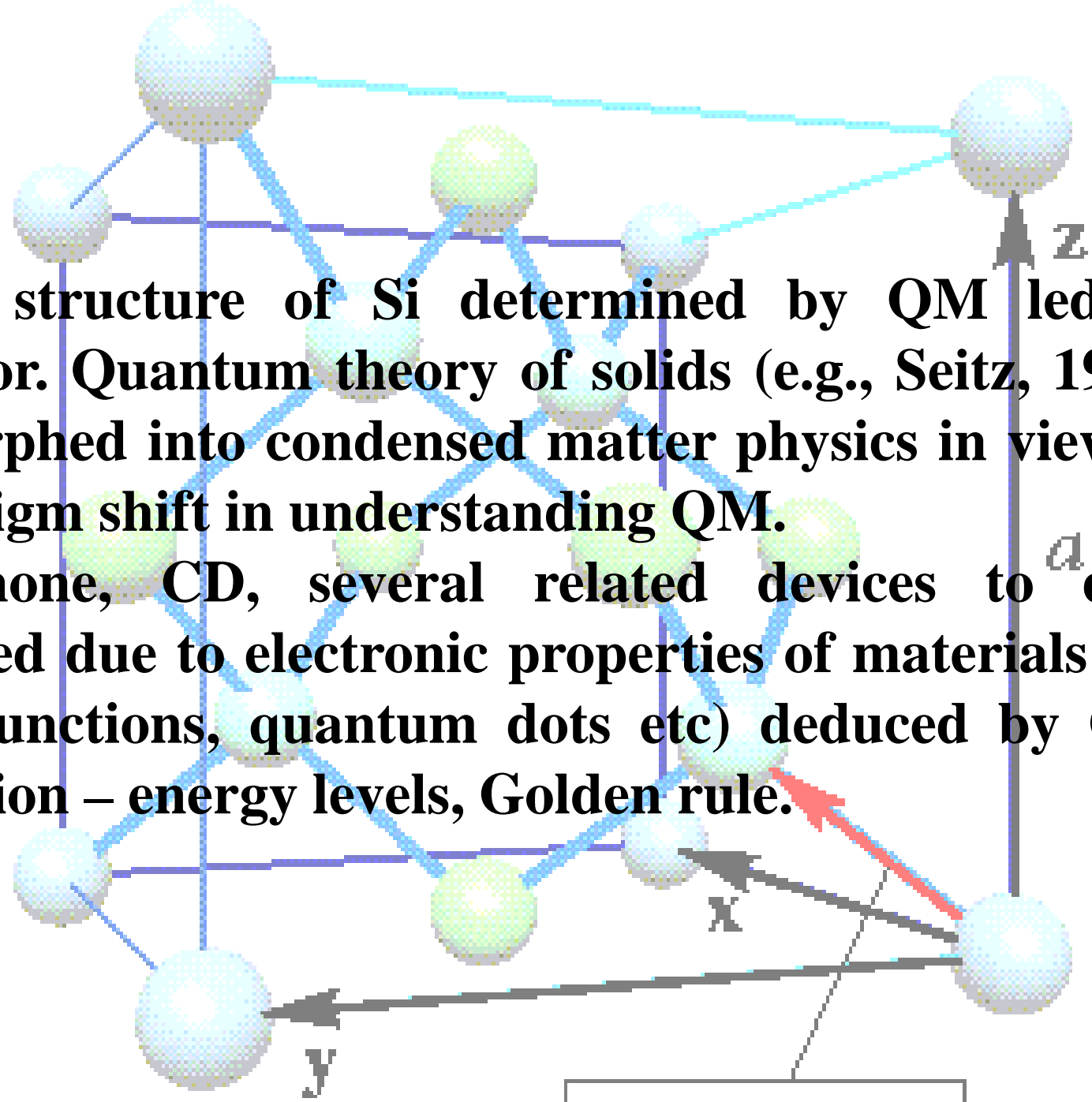
Shannon (1945 onwards) used binary (0,1)/(no,yes)

– Boolean rep. – **CBIT** developed Communication. Coding, Algorithms etc.

Introduced Information content – def. ENTROPY (von Neumann)

Subsequently many theoretical developments continuing to this day!



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- Band structure of Si determined by QM led to transistor. Quantum theory of solids (e.g., Seitz, 1940) has morphed into condensed matter physics in view of a paradigm shift in understanding QM.
 - Telephone, CD, several related devices to ^adate developed due to electronic properties of materials (Si, hetero-junctions, quantum dots etc) deduced by QM calculation – energy levels, Golden rule.



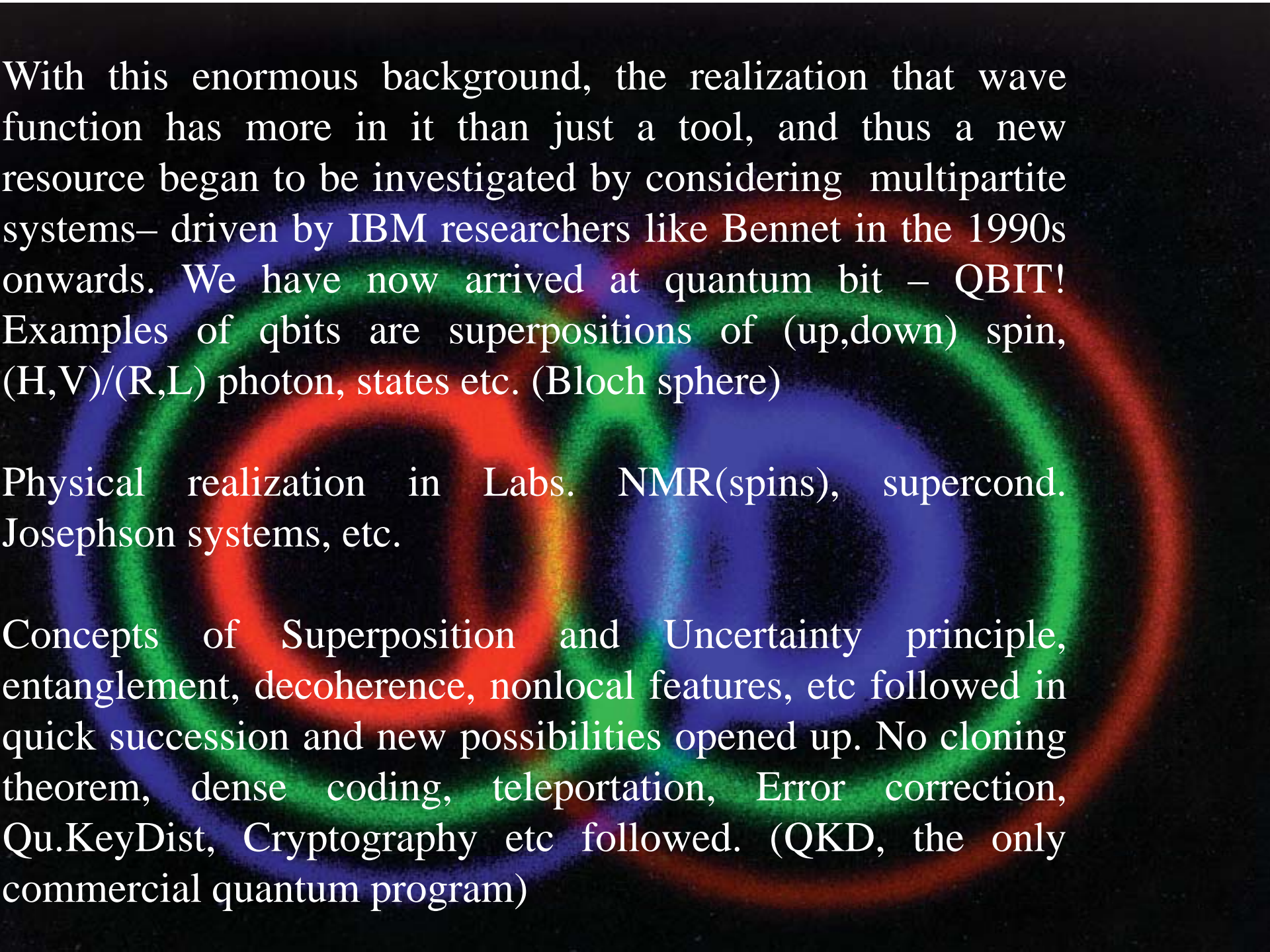
Parallel development based on the above - IBM Labs (Computer). Also between these two Labs, lasers (solid state) were developed.

Iphone, Ipad, Ipod are the blend of these two technologies!

DID NOT USE SHANNON INFORMATION CONTENT IN WAVE FUNCTION (already known to Hirschman, Jr. 1957!)

All this is entirely “one particle” description!!!

Only in the 1960s Landauer (IBM) emphasized “Information is physical” and Wheeler famously said “It from Bit”.



With this enormous background, the realization that wave function has more in it than just a tool, and thus a new resource began to be investigated by considering multipartite systems— driven by IBM researchers like Bennet in the 1990s onwards. We have now arrived at quantum bit – QBIT! Examples of qbits are superpositions of (up,down) spin, (H,V)/(R,L) photon, states etc. (Bloch sphere)

Physical realization in Labs. NMR(spins), supercond. Josephson systems, etc.

Concepts of Superposition and Uncertainty principle, entanglement, decoherence, nonlocal features, etc followed in quick succession and new possibilities opened up. No cloning theorem, dense coding, teleportation, Error correction, Qu.KeyDist, Cryptography etc followed. (QKD, the only commercial quantum program)



From Bell Labs, Grover developed search algorithm and Shor, the factorization scheme, which were far superior to respective classical counterparts!

“Measurement” plays a serious role.

These days work goes on now World-wide at breakneck speed!
TOTAL SURPRISE INDEED!!!

**THIS QUANTIZATION OF EVERYTHING SHANNON
ET AL DID and more HAS GIVEN THE POSSIBILITY OF A
QUANTUM COMPUTER!**

Question: Can these purely quantum ideas be implemented in a classical computer? Partial answer “Quantum simulators”

Applications/Implications: Techniques developed in Quantum Information Science has enormous applications in Computer Science, Quantum Statistical Mechanics, Many Particle Physics, Field theory, Black hole physics, Open Quantum systems,.....

Problem facing implementation in the Lab. and eventually industry is scaling – i.e., in classical systems, large numbers of cbits could be put together easily. Decoherence is detrimental because of interaction with environment. The solid state systems are more \vulnerable (there is a small problem with nonlocality!) than the optical systems because photons do not interact with each other and are less vulnerable to environment!

HRI should be congratulated on forming a group on this subject with three brilliant and energetic young physicists

- Aditi (the First one) Sen,
- Arun (the SUN) Pati, and
- Ujjwal (the resplendent) Sen.

It should be remarked that Arun Pati had in previous years arranged Conferences of this kind in the Institute of Physics, Bhubaneswar. There are other groups in India – in Chennai and Kolkata. Hopefully all these groups will prosper together in a coherent way! I hope that some experimental groups examining these issues are formed which would keep the theorists honest! I only know of Anil Kumar of IISc, working on NMR systems.