Nathan Rosen: His life and science

A story of entanglement

J Avron

March 2021

EPR

From metaphysics to quantum computing

MAY 15, 1935 PHYSICAL REVIEW VOLUME 47

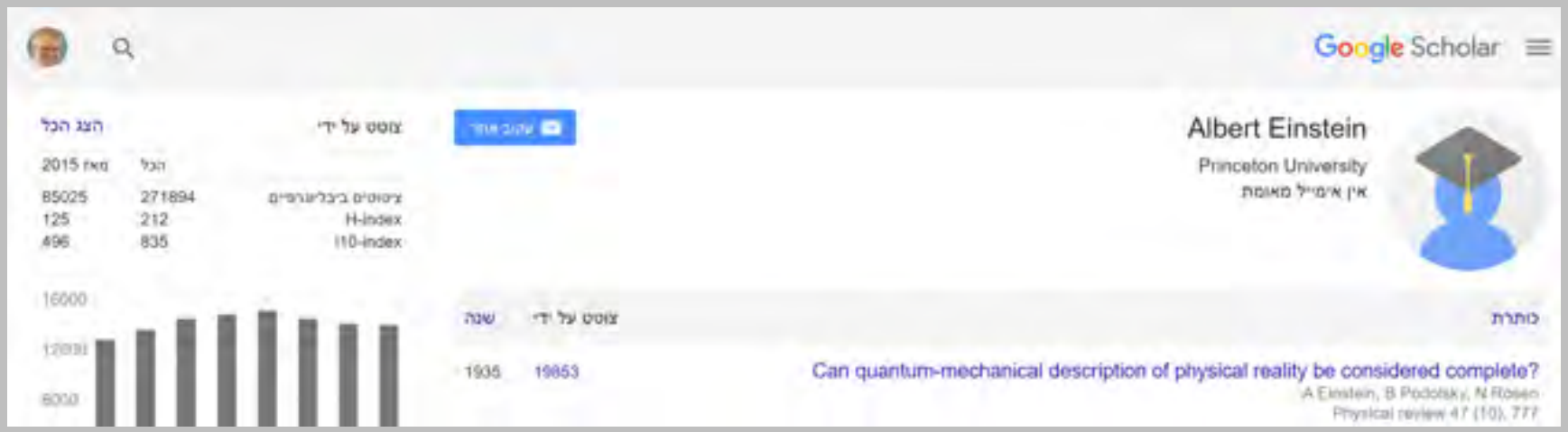
Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?

A. EINSTEIN, B. PODOLSKY AND N. ROSEN, *Institute for Advanced Study, Princeton, New Jersey*

(Received March 25, 1935)

In a complete theory there is an element corresponding to each element of reality. A sufficient condition for the reality of a physical quantity is the possibility of predicting it with certainty, without disturbing the system. In

quantum mechanics is not complete or (2) these two quantities cannot have simultaneous reality. Consideration of the problem of making predictions concerning a system on the basis of measurements made on another system that



From metaphysics to quantum computers

The story of entangled quantum states

- EPR: "Physical reality"
- Schrödinger: "entanglement"
- Technological resource

Say HaCohen lab

Nathan Rosen: Early years

1909-1931

Nathan Rosen

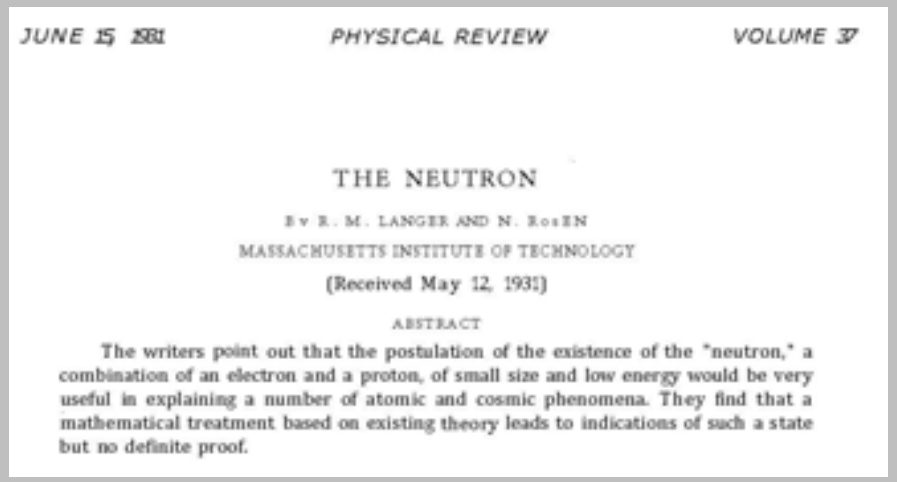
Spanish flu 1919-1921

Great depression 1929

MIT

1929-1932

Nathan Rosen



JUNE 15, 1931 PHYSICAL REVIEW VOLUME 37

THE NEUTRON

By R. M. LANGER AND N. ROSEN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

(Received May 12, 1931)

ABSTRACT

The writers point out that the postulation of the existence of the "neutron," a combination of an electron and a proton, of small size and low energy would be very useful in explaining a number of atomic and cosmic phenomena. They find that a mathematical treatment based on existing theory leads to indications of such a state but no definite proof.

John Slater

The IAS, Princeton

Founding 1930

Evening News

CITY-COUNTY EDITION
WALL ST. COMPLETE

TWO CENTS

Louis Bamberger and Mrs. Fuld Give $5,000,000 to Establish Institute of Advanced Learning

Donors of Institute Fund

Initial Endowment Announced For Graduate Foundation In Newark or Vicinity

Cites "Duress"

The usefulness of useless knowledge

Blue sky research

... in a world steeped in irrational hatred, men and women-old and young-detach themselves from the angry current of daily life to devote themselves to the cultivation of beauty, to the extension of knowledge, just as though fanatics were not simultaneously engaged in spreading pain, ugliness, and suffering

Unless [the world] is made a better world, a fairer world, millions will continue to go to their graves silent, saddened, and embittered.

Abraham Flexner

Einstein auspicious visit to America

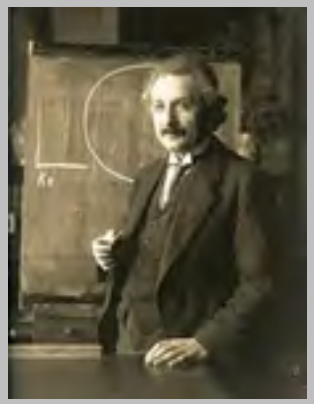
1933

Caltech

Bücherverbrennung

Einstein Podolsky and Rosen 1934-1935

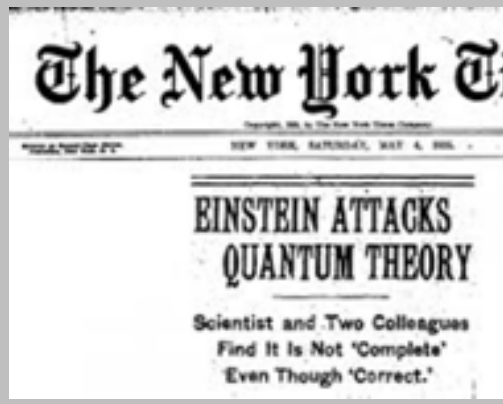
The NYT scandal



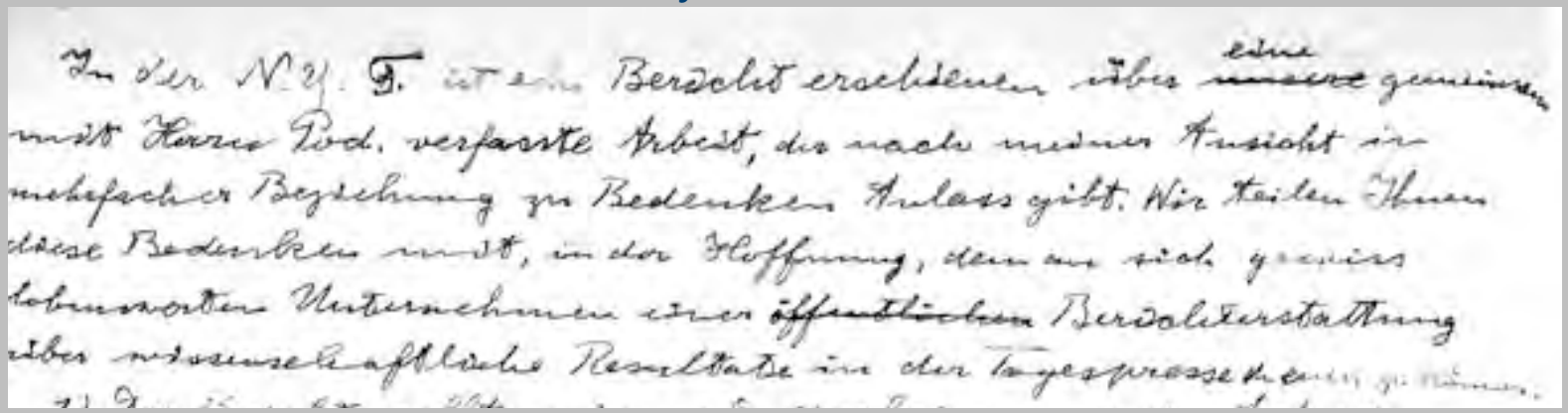
You know him

Boris Podolsky

Rosen



NYT



I deprecate advance publication of any announcement in regard to such matters in the secular press.

EPR argument

The curious properties of Entangled states

$$\int dp e^{ipL} |p\rangle_A \otimes |-p\rangle_B = \int dx |x\rangle_A \otimes |x+L\rangle_B$$

Alice can predict Bob's X_B or P_B
without disturbing Bob's particle

Bohr

$$[X_B, P_B] = i\hbar$$

Counterfactual
Alice can measure either X_A or P_A not both

Spooky action at a distance

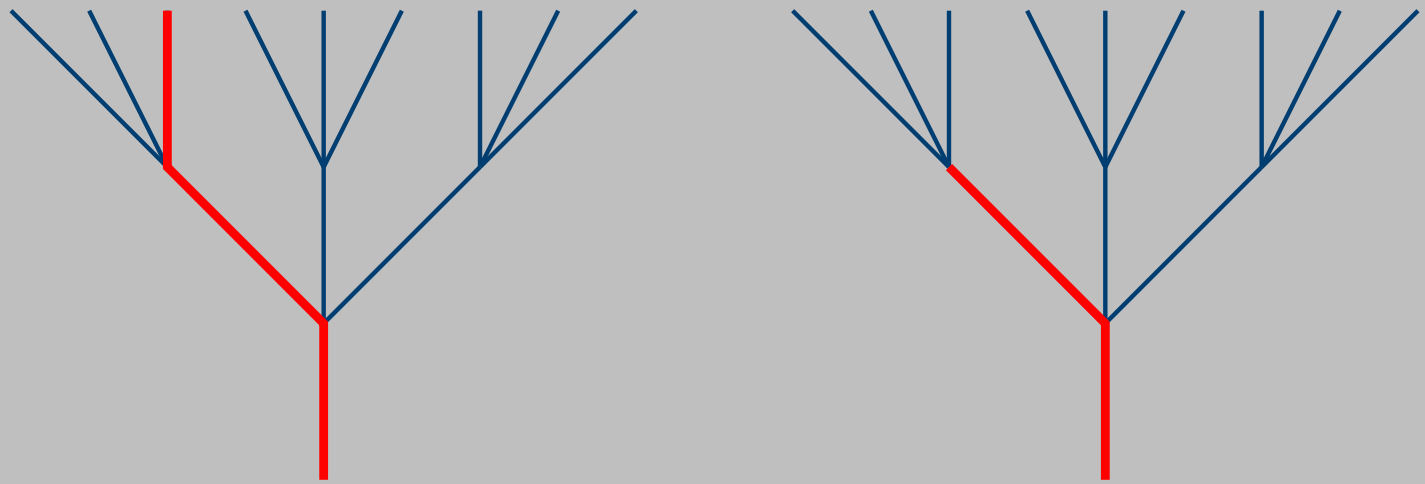
QM is non-signaling

Is the moon there when nobody looks

The Copenhagen notion of reality is bizarre

Observation

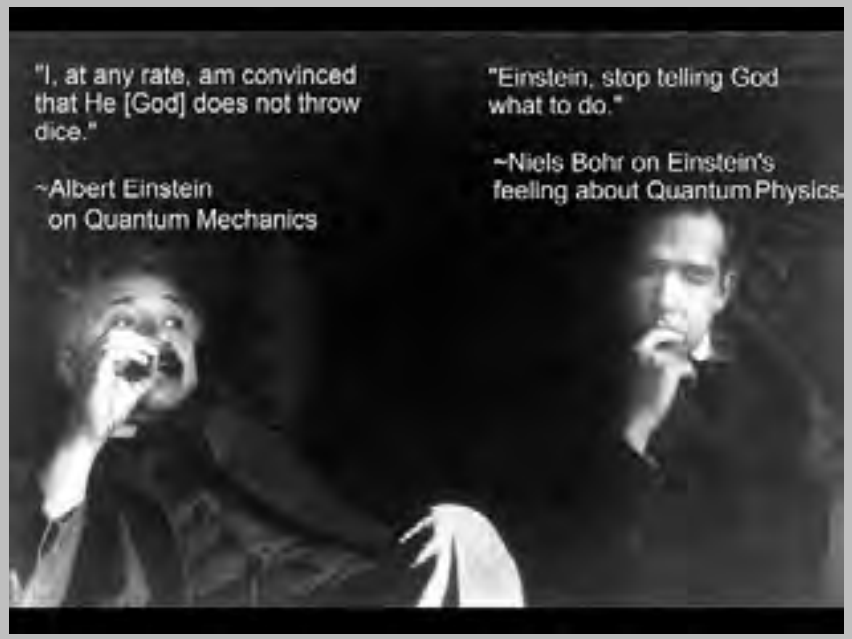
- Classical: Reveals
- Quantum: prepares



Evolution as a tree of diminishing potentialities (Frohlich)

The Einstein Bohr correspondence

The notion of reality in QM is bizarre



.. you had erected some dummy Einstein for yourself, which you then knocked down with great pomp

Lingering uneasiness

Shut up and calculate

Nobody understands QM

QM needs no interpretation

I don't like it, sorry I had to do with it

Only correlations are real

Einstein Rosen Bridge

Wormhole

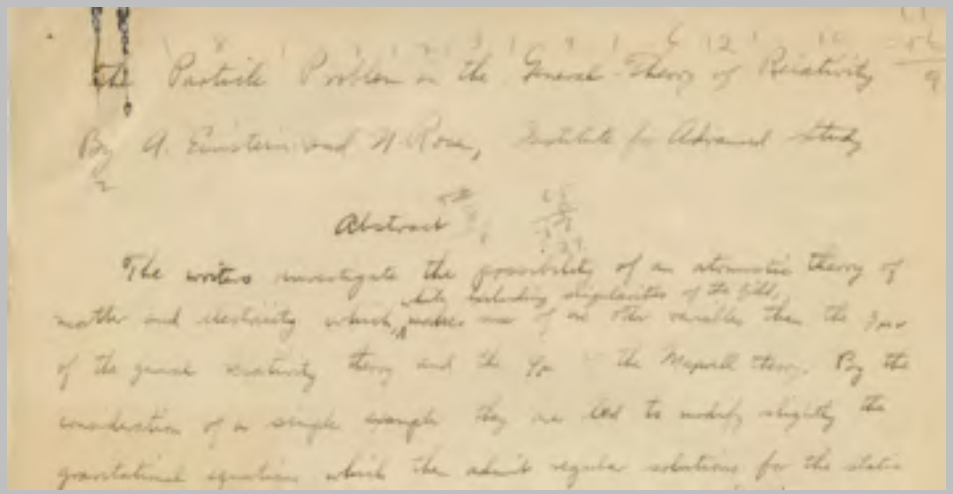
JULY 1, 1935 PHYSICAL REVIEW VOLUME 48

The Particle Problem in the General Theory of Relativity

A. EINSTEIN AND N. ROSEN, *Institute for Advanced Study, Princeton*

(Received May 8, 1935)

The writers investigate the possibility of an atomistic theory of matter and electricity which, while excluding singularities of the field, makes use of no other variables found. The combined system of gravitational and electromagnetic equations are treated similarly and lead to a similar interpretation. The most natural elementary



From the US to USSR and back

Kiev and Chapell Hill

Kiev 1937-1939
Khmelnitsky square

Molotov

Chapell Hill 1941-1952

Technion

The 1950's

Dori

Technion 1950

Grad students

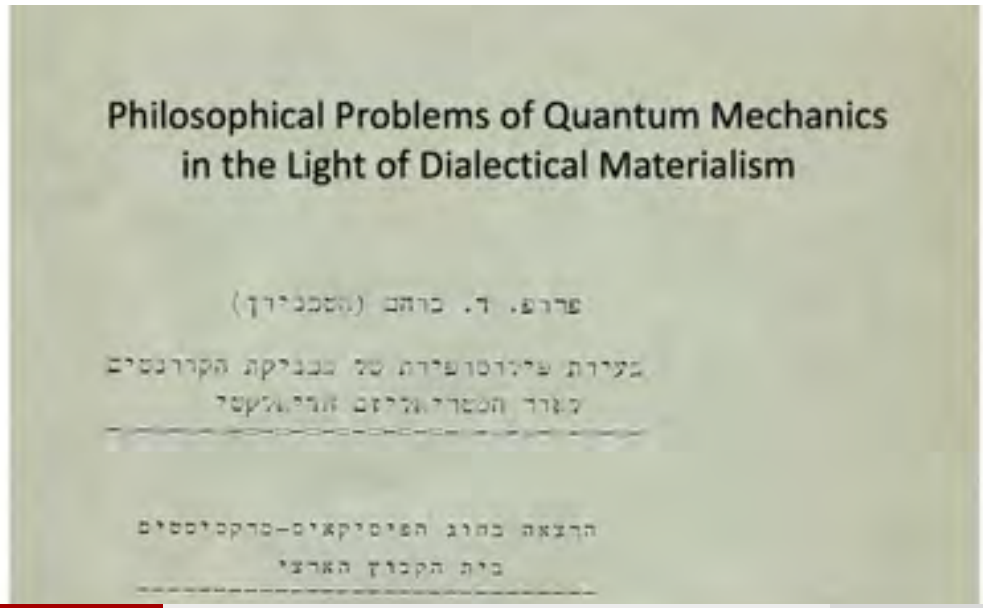
Phone

Aharonov, Bohm, Peres & Zak

The 1950's




1/30/2021 Gmail - Boom


Philosophical Problems of Quantum Mechanics
in the Light of Dialectical Materialism

The new campus in Neve Shaanan

BGU–The 1960's

Entangled states and impossible correlations

Bell and the GHZ game

	A	B	C	
Q_1	X_A	X_B	X_C	-1
Q_2	Y_A	Y_B	X_C	1
Q_3	X_A	Y_B	Y_C	1
Q_4	Y_A	X_B	Y_C	1

Can't satisfy table with $X_j, Y_j \in \pm 1$

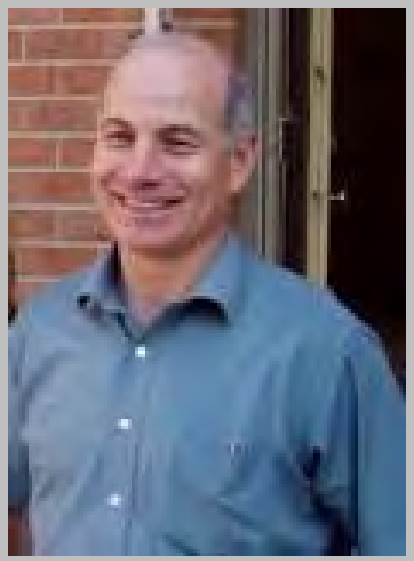
- Pauli: $X^2 = Y^2 = \mathbb{1},\ \{X, Y\} = 0$
- $Q_1 = X \otimes X \otimes X, \ldots, Q_4 = Y \otimes X \otimes Y$
- $Q_j^2 = \mathbb{1}, \quad [Q_j, Q_k] = 0$
- Entangled state for correct answers:

GHZ

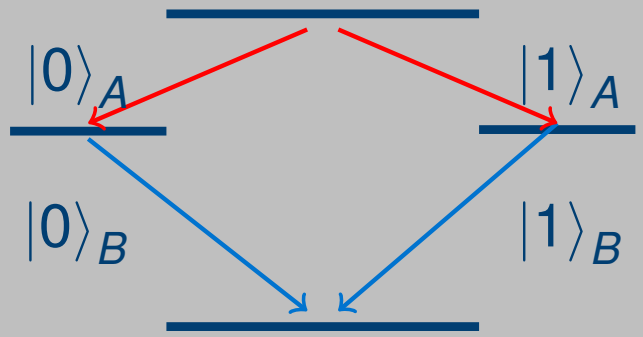
$$|0\rangle_A \otimes |0\rangle_B \otimes |0\rangle_C - |1\rangle_A \otimes |1\rangle_B \otimes |1\rangle_C$$

From useless knowledge to quantum technology

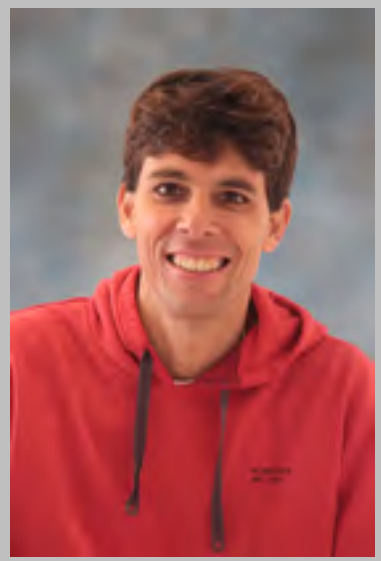
Entangled states on demand



David Gershoni



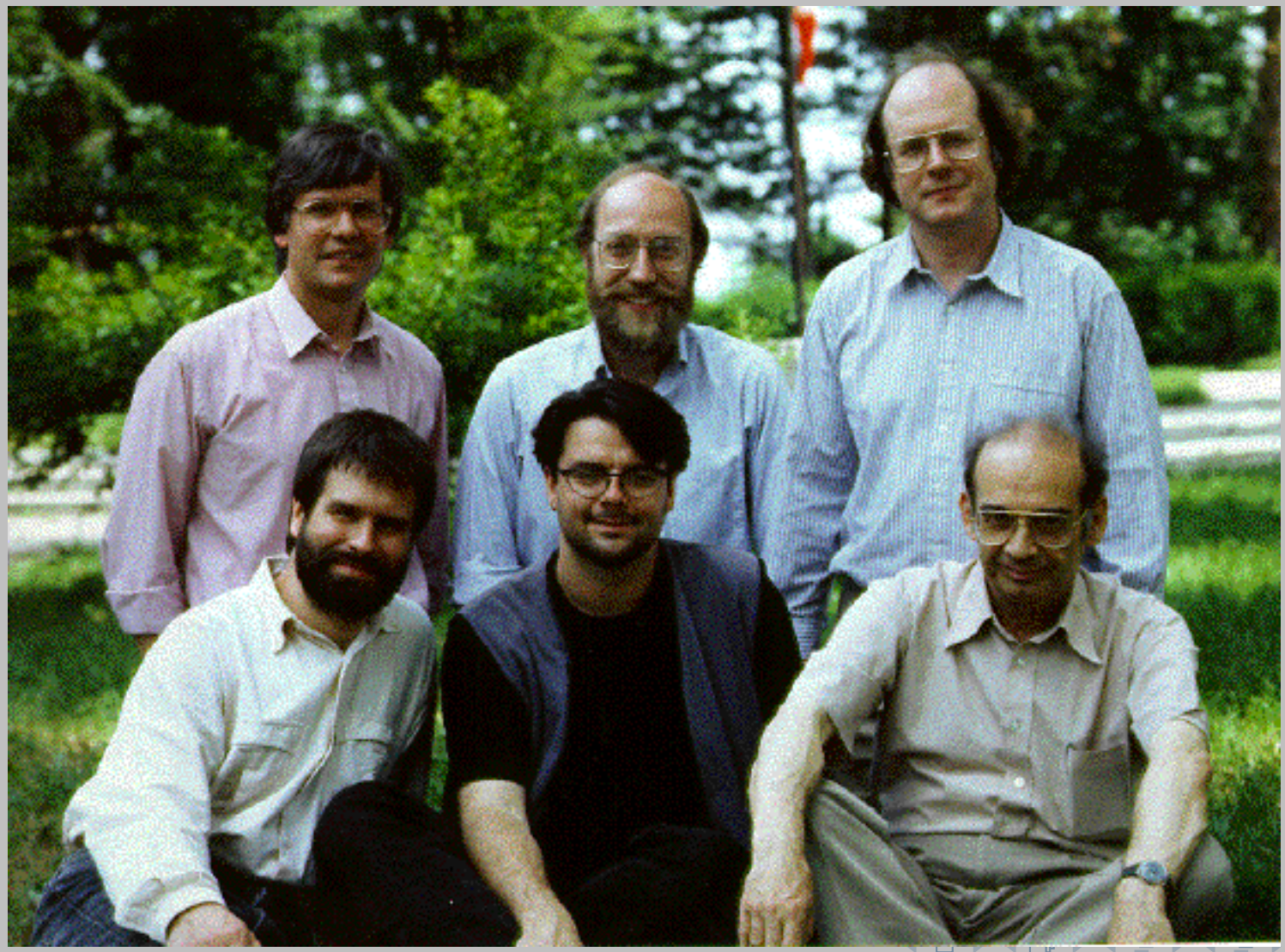
$$|0\rangle_A \otimes |0\rangle_B + |1\rangle_A \otimes |1\rangle_B$$



Netanel Lindner

Teleporting unknown quantum state

Bennett, Brassard, Crepau, Josza, Peres, Wootters 1993



The end

18 Dec 1995