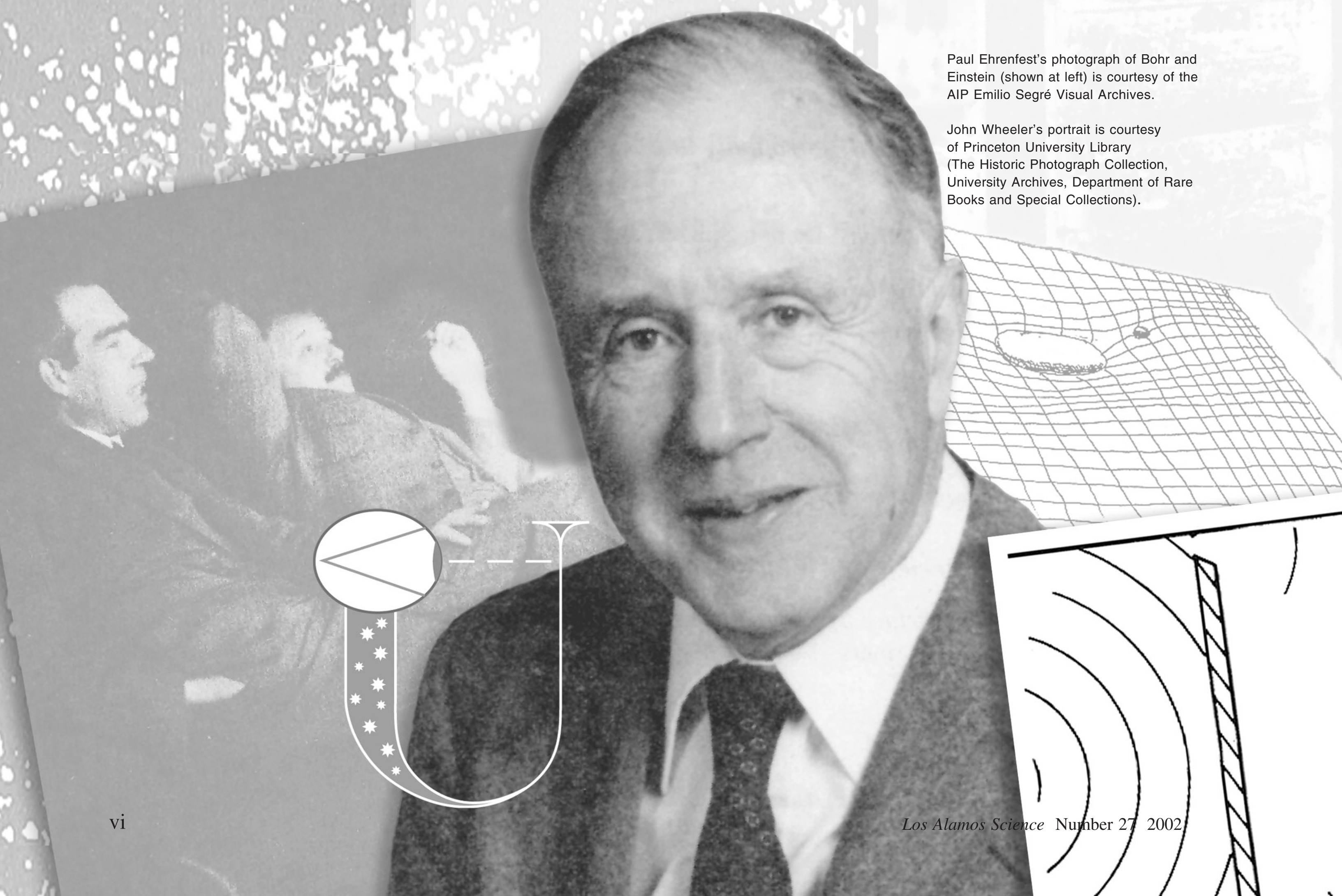
John Wheeler

On quantum theory and information

Planck's discovery of the quantum in 1900 drove a crack in the armor that still covers the deep and secret principle of existence. In the exploitation of that opening we are at the beginning, not the end.
—1982

Nothing [in quantum theory]… was more startling than Heisenberg's uncertainty principle, which denied the possibility of simultaneously measuring certain properties of motion. The uncertainty principle introduced us to quantum fluctuations, revealing empty space to be in fact a cauldron of activity.

If the world "out there" is writhing like a barrel of eels, why do we detect a barrel of concrete when we look? To put the question differently, where is the boundary between the random uncertainty of the quantum world, where particles spring into and out of existence, and the orderly certainty of the classical world, where we live, see, and measure? This question…is as deep as any in modern physics. It drove the years-long debate between Bohr and Einstein. . . . Every physical quantity derives its ultimate significance from bits, binary yes-or-no indications, a conclusion which we epitomize in the phrase, it from bit.
—1998



Paul Ehrenfest's photograph of Bohr and Einstein (shown at left) is courtesy of the AIP Emilio Segré Visual Archives.

John Wheeler's portrait is courtesy of Princeton University Library (The Historic Photograph Collection, University Archives, Department of Rare Books and Special Collections).

It is wrong to think of that past [ascribed to a quantum phenomenon] as “already existing” in all detail. The past is theory. The past has no existence except as it is recorded in the present. By deciding what questions our quantum registering equipment shall put in the present we have an undeniable choice in what we have the right to say about the past.
—1980

I have been led to think of analogies between the way a computer works and the way the universe works.The computer is built on yes-no logic. So, perhaps, is the universe. Did an electron pass through slit A or did it not? Did it cause counter B to click or counter C to click? These are the iron posts of observation.Yet one enormous difference separates the computer and the universe—chance. In principle, the output of a computer is precisely determined by the input. Chance plays no role. In the universe, by contrast, chance plays a dominant role. The laws of physics tell us only what may happen. Actual measurement tells us what is happening (or what did happen). Despite this difference, it is not unreasonable to imagine that information sits at the core of physics, just as it sits at the core of a computer.
—1998

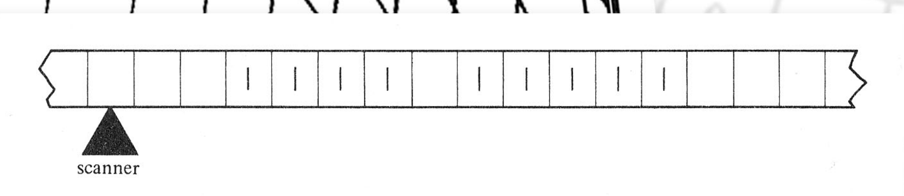
Wheeler, J. A. 1980. Beyond the Black Hole.In *Some Strangeness in Proportion*. Edited by H. Wolf. Reading, MA: Addison-Wesley.

———. 1982. The Computer and the Universe. *Int. J. Theor. Phys.* **21** (6/7).

Wheeler, J. A, and K. Ford. 1998. It from Bit. In *Geons, Black Holes & Quantum Foam.* New York: W. W. Norton & Company, Inc.

Drawings by John Wheeler surround his portrait. At upper right, matter (the large stone) tells space-time how to curve, and space-time tells matter (the pebble) how to move. The waves from two slits are shown to interfere (below). At lower left is the Eye of the Universe. These drawings and additional images in the background are from *Geons, Black Holes, and Quantum Foam* (see reference above).

The drawing of Alan Turing’s automatic adding machine (shown below) is from *Alan Turing,The Enigma* (see reference at lower right).



Two Giants of Classical Information Theory

If we do not wish to admit that the Second Law has been violated, we must conclude that the intervention which establishes the coupling between [the measuring instrument and the thermodynamic system] must be accompanied by a production of entropy.
—Leo Szilard, 1929, On the Decrease of Entropy in a Thermodynamic System by the Intervention of Intelligent Beings, *Zeit. Phys.* **53**: 840.

Drawing by David R. Delano

Computing is normally done by [a person] writing symbols on paper. . . . I assume that the calculation is carried out on one-dimensional paper, i.e., on a tape divided into squares. I shall also suppose that the number of symbols . . . is finite . . . The behaviour of the computer at any moment is determined by the symbols which he is observing, and his ‘state of mind.’ . . . We may suppose . . . the number of states of mind which need to be taken into account is finite. . . . the use of more complicated states of mind can be avoided by writing more symbols on the tape . . . . Every [simple] operation consists of some change in the physical system consisting of the computer and his tape. [And so, Alan Turing begins to describe his automatic machine that can perform all possible deterministic algorithms.]
—Alan Turing, 1937, On Computable Numbers with an Application to the Entscheidungsproblem, *Proc. Lond. Math. Soc.* **2**: 42. (Excerpts reprinted in Andrew Hodges’ *Alan Turing: The Enigma,* New York: Simon and Schuster, 1983.)