The Many Worlds of *Hugh*

After his now celebrated theory of multiple universes met scorn, Hugh Everett abandoned the world of academic physics. He turned to top-secret military research and led a tragic private life • • •

BY PETER BYRNE

KEY CONCEPTS

- Fifty years ago Hugh Everett devised the many-worlds interpretation of quantum mechanics, in which quantum effects spawn countless branches of the universe with different events occurring in each.
- The theory sounds like a bizarre hypothesis, but in fact Everett inferred it from the fundamental mathematics of quantum mechanics. Nevertheless, most physicists of the time dimissed it, and he had to abridge his Ph.D. thesis on the topic to make it seem less controversial.
- Discouraged, Everett left physics and worked on military and industrial mathematics and computing. Personally, he was emotionally withdrawn and a heavy drinker.
- He died when he was just 51, not living to see the recent respect accorded his ideas by physicists.

—The Editors

Hugh Everett III was a brilliant mathematician, an iconoclastic quantum theorist and, later, a successful defense contractor with access to the nation's most sensitive military secrets. He introduced a new conception of reality to physics and influenced the course of world history at a time when nuclear Armageddon loomed large. To science-fiction aficionados, he remains a folk hero: the man who invented a quantum theory of multiple universes. To his children, he was someone else again: an emotionally unavailable father; "a lump of furniture sitting at the dining room table," cigarette in hand. He was also a chain-smoking alcoholic who died prematurely.

At least that is how his history played out in our fork of the universe. If the many-worlds theory that Everett developed when he was a student at Princeton University in the mid-1950s is correct, his life took many other turns in an unfathomable number of branching universes.

Everett's revolutionary analysis broke apart a theoretical logjam in interpreting the *how* of quantum mechanics. Although the many-worlds idea is by no means universally accepted even today, his methods in devising the theory presaged the concept of quantum decoherence—a modern explanation of why the probabilistic weirdness of quantum mechanics resolves itself into the concrete world of our experience.

Everett's work is well known in physics and philosophical circles, but the tale of its discovery and of the rest of his life is known by relatively few. Archival research by Russian historian Eugene Shikhovtsev, myself and others and interviews I conducted with the late scientist's colleagues and friends, as well as with his rock-musician son, unveil the story of a radiant intelligence extinguished all too soon by personal demons.

Ridiculous Things

Everett's scientific journey began one night in 1954, he recounted two decades later, "after a slosh or two of sherry." He and his Princeton classmate Charles Misner and a visitor named Aage Petersen (then an assistant to Niels Bohr) were thinking up "ridiculous things about the implications of quantum mechanics." During this session Everett had the basic idea behind the many-worlds theory, and in the weeks that followed he began developing it into a dissertation.

The core of the idea was to interpret what the equations of quantum mechanics represent in the real world by having the mathematics of the theory itself show the way instead of by appending interpretational hypotheses to the math. In this way, the young man challenged the physics establishment of the day to reconsider its foundational notion of what constitutes physical reality.

In pursuing this endeavor, Everett boldly tackled the notorious measurement problem in quantum mechanics, which had bedeviled physicists since the 1920s. In a nutshell, the problem arises from a contradiction between how elementary particles (such as electrons and photons) interact at the microscopic, quantum level of reality and what happens when the particles

Everett

are measured from the macroscopic, classical level. In the quantum world, an elementary particle, or a collection of such particles, can exist in a superposition of two or more possible states of being. An electron, for example, can be in a superposition of different locations, velocities and orientations of its spin. Yet anytime scientists measure one of these properties with precision, they see a definite result—just one of the elements of the superposition, not a combination of them. Nor do we ever see macroscopic objects in superpositions. The measurement problem boils down to this question: How and why does the unique world of our experience emerge from the multiplicities of alternatives available in the superposed quantum world?

Physicists use mathematical entities called wave functions to represent quantum states. A wave function can be thought of as a list of all the possible configurations of a superposed quantum system, along with numbers that give the probability of each configuration's being the one, seemingly selected at random, that we will detect if we measure the system. The wave function treats each element of the superposition as equally real, if not necessarily equally probable from our point of view.

The Schrödinger equation delineates how a quantum system's wave function will change through time, an evolution that it predicts will be smooth and deterministic (that is, with no randomness). But that elegant mathematics seems to contradict what happens when humans observe a quantum system, such as an

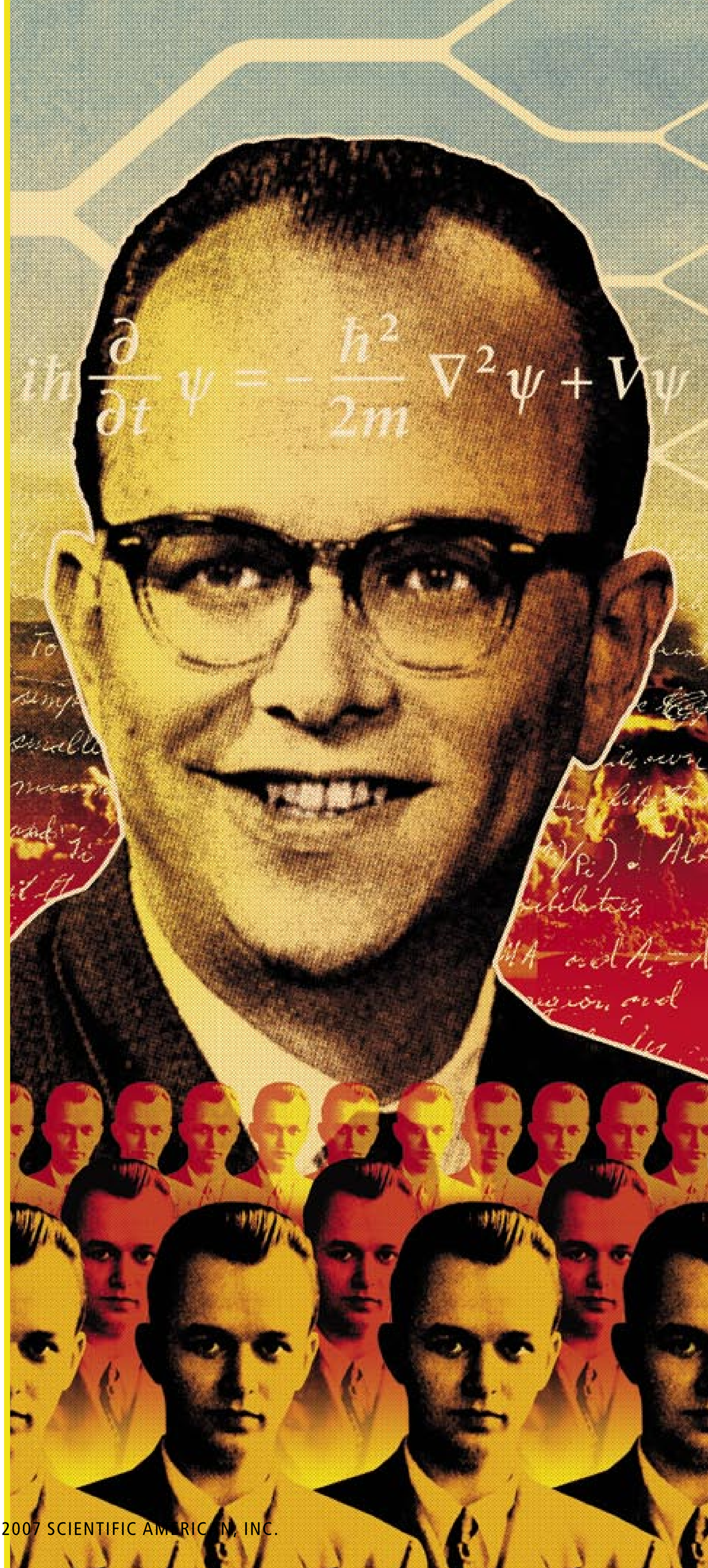


ILLUSTRATION BY SEAN McCABE; COURTESY OF PRINCETON UNIVERSITY LIBRARY (*young Everett*); COURTESY OF EUGENE SHIKHOVTSEV AND KENNETH W. FORD (*adult Everett*); U.S. DEPARTMENT OF ENERGY/PHOTO RESEARCHERS, INC. (*mushroom cloud*); COURTESY OF THE AMERICAN INSTITUTE OF PHYSICS, NIELS BOHR LIBRARY AND ARCHIVES (*handwriting*)

electron, with a scientific instrument (which itself may be regarded as a quantum-mechanical system). For at the moment of measurement, the wave function describing the superposition of alternatives appears to collapse into one member of the superposition, thereby interrupting the smooth evolution of the wave function and introducing discontinuity. A single measurement outcome emerges, banishing all the other possibilities from classically described reality. Which alternative is produced at the moment of measurement appears to be arbitrary; its selection does not evolve logically from the information-packed wave function of the electron before measurement. Nor does the mathematics of collapse emerge from the seamless flow of the Schrödinger equation. In fact, collapse has to be added as a postulate, as an additional process that seems to violate the equation.

Many of the founders of quantum mechanics, notably Bohr, Werner Heisenberg and John von Neumann, agreed on an interpretation of quantum mechanics—known as the Copenhagen interpretation—to deal with the measurement problem. This model of reality postulates that the mechanics of the quantum world reduce to, and only find meaning in terms of, classically observable phenomena—not the reverse.

This approach privileges the external observer, placing that observer in a classical realm that is distinct from the quantum realm of the object observed. Though unable to explain the nature of the boundary between the quantum and classical realms, the Copenhagenists nonetheless used quantum mechanics with great technical success. Entire generations of physicists were taught that the equations of quantum mechanics work only in one part of reality, the microscopic, while ceasing to be relevant in another, the macroscopic. It is all that most physicists ever need.

Universal Wave Function

In stark contrast, Everett addressed the measurement problem by merging the microscopic and macroscopic worlds. He made the observer an integral part of the system observed, introducing a universal wave function that links observers and objects as parts of a single quantum system. He described the macroscopic world quantum mechanically and thought of large objects as existing in quantum superpositions as well. Breaking with Bohr and Heisenberg, he dispensed with the need for the discontinuity of a wave-function collapse.

Everett's radical new idea was to ask, What

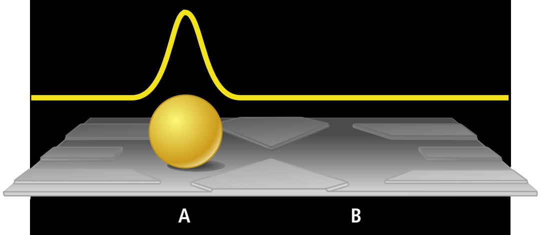
> "The Copenhagen Interpretation is hopelessly incomplete … as well as a philosophic monstrosity …"
> —*Hugh Everett*

[QUANTUM MEASUREMENT]

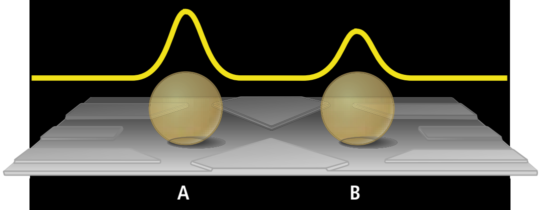
THE PROBLEM

An unresolved question in quantum mechanics is to understand fully how the quantum states of particles relate to the classical world we see around us.

Quantum mechanics represents the states of particles by mathematical entities called wave functions. For example, a wave function representing a particle at a definite location A (such as an electron in a nanoscopic trap) will have a peak at A and be zero everywhere else.



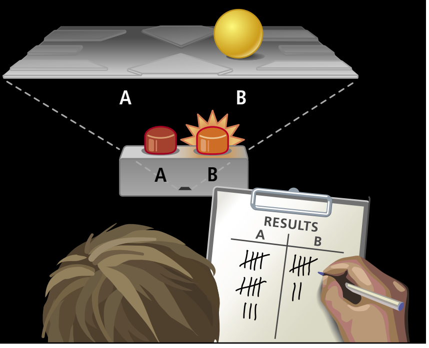
Much as ordinary waves can combine, so, too, can wave functions add together to form superpositions. Such wave functions represent particles that are in more than one alternative state at once. The amplitude of each peak relates to the probability of finding that alternative when a measurement is made.



Another way of thinking of the wave function is as a list of each alternative and its amplitude.

Position	Amplitude	Probability
A	0.8	64%
B	0.6	36%

But if an apparatus measures a particle in such a superposition, it produces a specific result—A or B, seemingly at random—not a combination of both, and the particle ceases to be in the superposition. Nor do we ever see macroscopic objects such as baseballs in superpositions.



[THE AUTHOR]

Peter Byrne (www.peterbyrne.info) is an investigative journalist and science writer based in northern California. He is writing a full-length biography of Hugh Everett. Byrne acknowledges a debt to Eugene Shikhovtsev of Kostromo, Russia, who was the first historian to study the life of Everett and who generously shared his research material; to the American Institute of Physics for financial support; to George E. Pugh and Kenneth Ford for their assistance; and to the physicists who reviewed the science in this article: Stephen Shenker, Leonard Susskind, David Deutsch, Wojciech H. Zurek, James B. Hartle, Cecile DeWitt-Morette and Max Tegmark.

R. V. SCHEIDE (*Byrne*); JEN CHRISTIANSEN (*illustration*)

if the continuous evolution of a wave function is not interrupted by acts of measurement? What if the Schrödinger equation always applies and applies to everything—objects and observers alike? What if no elements of superpositions are ever banished from reality? What would such a world appear like to us?

Everett saw that under those assumptions, the wave function of an observer would, in effect, bifurcate at each interaction of the observer with a superposed object. The universal wave function would contain branches for every alternative making up the object's superposition. Each branch has its own copy of the observer, a copy that perceived one of those alternatives as the outcome. According to a fundamental mathematical property of the Schrödinger equation, once formed, the branches do not influence one another. Thus, each branch embarks on a different future, independently of the others.

Consider a person measuring a particle that is in a superposition of two states, such as an electron in a superposition of location A and location B. In one branch, the person perceives that the electron is at A. In a nearly identical branch, a copy of the person perceives that the same electron is at B. Each copy of the person perceives herself or himself as being one of a kind and sees chance as cooking up one reality from a menu of physical possibilities, even though, in the full reality, every alternative on the menu happens.

Explaining how we would perceive such a universe requires putting an observer into the picture. But the branching process happens regardless of whether a human being is present. In general, at each interaction between physical systems the total wave function of the combined systems would tend to bifurcate in this way. Today's understanding of how the branches become independent and each turn out looking like the classical reality we are accustomed to is known as decoherence theory. It is an accepted part of standard modern quantum theory, although not everyone agrees with the Everettian interpretation that all the branches represent realities that exist.

Everett was not the first physicist to criticize the Copenhagen collapse postulate as inadequate. But he broke new ground by deriving a mathematically consistent theory of a universal wave function from the equations of quantum mechanics itself. The existence of multiple universes emerged as a consequence of his theory, not a predicate. In a footnote in his thesis, Everett wrote: "From the viewpoint of the theory, all elements of a superposition (all 'branches')

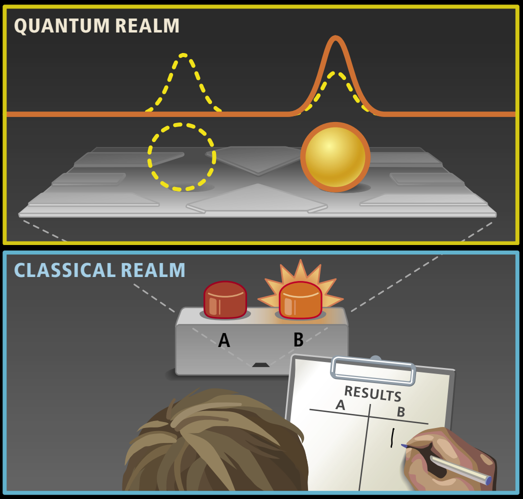
[QUANTUM MEASUREMENT]

TWO ANSWERS

The Copenhagen interpretation and Hugh Everett's many-worlds interpretation provide two strikingly different answers to the measurement problem. (There are several other hypotheses as well.)

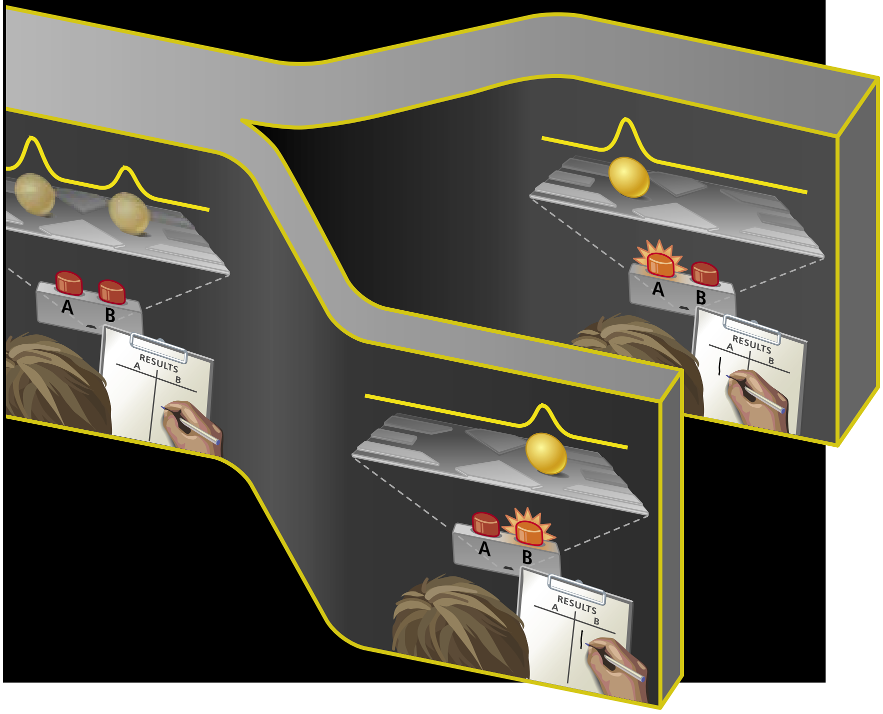
COPENHAGEN INTERPRETATION

According to Niels Bohr and others, apparatuses (and people) that make measurements reside in a classical realm that is separate from the quantum realm. When such a classical apparatus measures a superposed state, it causes the quantum wave function to collapse randomly into one of the alternatives, with all the others disappearing. The equations of quantum mechanics did not explain why such collapse should occur; it was added as a separate postulate.



MANY-WORLDS INTERPRETATION

Everett's revolutionary contribution was to analyze the measurement process with the apparatus (and people) viewed as just another quantum system, obeying the usual equations and principles of quantum mechanics. He concluded from this analysis that the end result would be a superposition of the alternative measurement outcomes and that the components of the superposition would be like separate arms of a branching universe. We do not perceive these superpositions of the macro world, because the copy of us in each branch can be aware of only what is in our branch.



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are ‘actual,’ none any more ‘real’ than the rest.”

The draft containing all these ideas provoked a remarkable behind-the-scenes struggle, uncovered about five years ago in archival research by Olival Freire, Jr., a historian of science at the Federal University of Bahia in Brazil. In the spring of 1956 Everett’s academic adviser at Princeton, John Archibald Wheeler, took the draft dissertation to Copenhagen to convince the Royal Danish Academy of Sciences and Letters to publish it. He wrote to Everett that he had “three long and strong discussions about it” with Bohr and Petersen. Wheeler also shared his student’s work with several other physicists at Bohr’s Institute for Theoretical Physics, including Alexander W. Stern.

Splits

Wheeler’s letter to Everett reported: “Your beautiful wave function formalism of course remains unshaken; but all of us feel that the real issue is the words that are to be attached to the quantities of the formalism.” For one thing, Wheeler was troubled by Everett’s use of “splitting” humans and cannonballs as scientific metaphors. His letter revealed the Copenhagenists’ discomfort over the meaning of Everett’s work. Stern dismissed Everett’s theory as “theology,” and Wheeler himself was reluctant to challenge Bohr. In a long, politic letter to Stern, he explicated and excused Everett’s theory as an extension, not a refutation, of the prevailing interpretation of quantum mechanics:

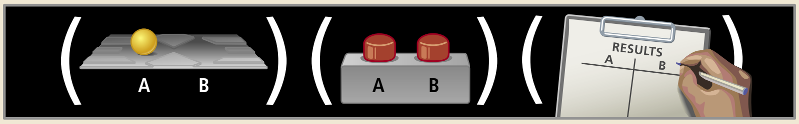
> I think I may say that this very fine and able and independently thinking young man has gradually come to accept the present approach to the measurement problem as correct and self-consistent, despite a few traces that remain in the present thesis draft of a past dubious attitude. So, to avoid any possible misunderstanding, let me say that Everett’s thesis is not meant to *question* the present approach to the measurement problem, but to accept it and *generalize* it. [Emphasis in original.]

Everett would have completely disagreed with Wheeler’s description of his opinion of the Copenhagen interpretation. For example, a year later, when responding to criticisms from Bryce S. DeWitt, editor of the journal *Reviews of Modern Physics*, he wrote:

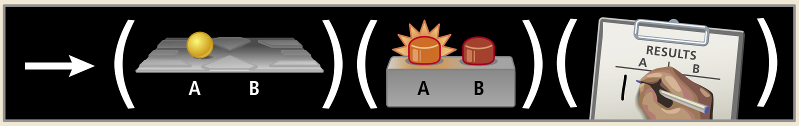
> The Copenhagen Interpretation is hopelessly incomplete because of its a priori reliance

Inferring the Many Worlds

Everett supposed that everything in existence is a quantum system and obeys the Schrödinger equation. He carefully analyzed what happens when quantum measuring apparatuses and observers interact with superposed quantum objects. Thus, he considered the mathematics of a “universal wave function” that included the state of the apparatus and the observer as well as that of the object. The three states multiply together to yield the total state, as shown below:

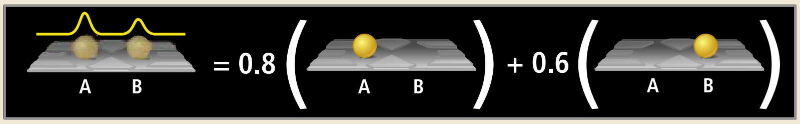


In the state depicted above, the particle is at location A with 100 percent certainty before the measurement is made. In that case (which has no puzzling superpositions), the Schrödinger equation describes how the total state evolves to a final quantum state that has no ambiguity: The interaction between particle and apparatus triggers the “A” indicator. The light travels to the observer, who sees it and forms a memory that the A indicator has flashed (*below*).



A similar completely clear-cut evolution occurs if the particle definitely began at location B. The process depicted is highly idealized, but the idealizations do not alter the conclusions.

So what happens if the particle is instead prepared in a superposition before the measurement is made? In the mathematical description, superpositions are just sums:

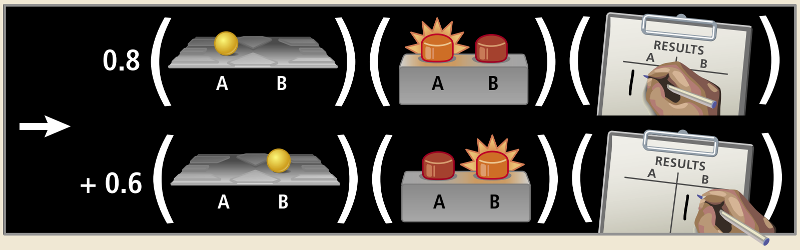


The numbers shown in this example correspond to a 64 percent likelihood of seeing the A outcome (0.64 is 0.8 squared) and a 36 percent chance of seeing the B outcome.

When the sum above is included in the initial total quantum state of the object, apparatus and observer, the result is a total state that is itself a superposition of two alternatives:

$$\mathbf{(0.8\ A + 0.6\ B) \times Apparatus \times Observer =}$$
$$\mathbf{0.8\ (A \times Apparatus \times Observer) + 0.6\ (B \times Apparatus \times Observer)}$$

Thanks to a property of the Schrödinger equation known as linearity, when this superposed total state evolves, each component (that is, the two pieces on each side of the “+” sign) evolves as it would if it were all that was present. And so the final total state is a superposition of the individual final states obtained when the particle started at a definite location:



The linearity property and a property of the states called orthogonality ensure that as time continues on, these two pieces of wave function never affect each other. A more modern analysis called decoherence theory explains that point in greater detail and depth. The “A” branch, with an observer in a state of total certainty of having seen the A light flash, proceeds on just as if it were the entirety of the wave function, as does the “B” branch. Figures that depict the universe splitting into branches with different histories represent this process. The branching is not added; it is entirely there to be found in the mathematics.

Everett further verified that the mathematics works out consistently in more complicated situations, such as those involving multiple measurements and observers. A lingering puzzle, which continues to be reanalyzed and hotly debated, is to understand in what sense branch A “occurs” 64 percent of the time and branch B only 36 percent in this model.

—Graham P. Collins, staff editor

JEN CHRISTIANSEN

> on classical physics … as well as a philosophic monstrosity with a “reality” concept for the macroscopic world and denial of the same for the microcosm.

While Wheeler was off in Europe arguing his case, Everett was in danger of losing his student draft deferment. To avoid going to boot camp, he decided to take a research job at the Pentagon. He moved to the Washington, D.C., area and never came back to theoretical physics.

During the next year, however, he communicated long-distance with Wheeler as he reluctantly whittled down his thesis to a quarter of its original length. In April 1957 Everett’s thesis committee accepted the abridged version—without the “splits.” Three months later *Reviews of Modern Physics* published the shortened version, entitled “‘Relative State’ Formulation of Quantum Mechanics.” In the same issue, a companion paper by Wheeler lauded his student’s discovery.

When the paper appeared in print, it slipped into instant obscurity. Wheeler gradually distanced himself from association with Everett’s theory, but he kept in touch with the theorist, encouraging him, in vain, to do more work in quantum mechanics. In an interview last year, Wheeler, then 95, commented that “[Everett] was disappointed, perhaps bitter, at the nonreaction to his theory. How I wish that I had kept up the sessions with Everett. The questions that he brought up were important.”

Nuclear Military Strategies

Princeton awarded Everett his doctorate nearly a year after he had begun his first project for the Pentagon: calculating potential mortality rates from radioactive fallout in a nuclear war. He soon headed the mathematics division in the Pentagon’s nearly invisible but extremely influential Weapons Systems Evaluation Group (WSEG). Everett advised high-level officials in the Eisenhower and Kennedy administrations on the best methods for selecting hydrogen bomb targets and structuring the nuclear triad of bombers, submarines and missiles for optimal punch in a nuclear strike.

In 1960 he helped write WSEG No. 50, a catalytic report that remains classified to this day. According to Everett’s friend and WSEG colleague George E. Pugh, as well as historians, WSEG No. 50 rationalized and promoted military strategies that were operative for decades, including the concept of Mutually Assured Destruction. WSEG provided nuclear warfare policymakers with enough scary information about the global effects of radioactive fallout that many became convinced of the merit of waging a perpetual standoff—as opposed to, as some powerful people were advocating, launching preemptive first strikes on the Soviet Union, China and other communist countries.

One final chapter in the struggle over Everett’s theory also played out in this period. In the spring of 1959 Bohr granted Everett an interview in Copenhagen. They met several times during a six-week period but to little effect: Bohr did not shift his position, and Everett did not reenter quantum physics research. The excursion was not a complete failure, though. One afternoon, while drinking beer at the Hotel Østerport, Everett wrote out on hotel stationery an important refinement of the other mathematical tour de force for which he is renowned, the generalized Lagrange multiplier method, also known as the Everett algorithm. The method simplifies searches for optimum solutions to complex logistical problems—ranging from the deployment of nuclear weapons to just-in-time industrial production schedules to the routing of buses for maximizing the desegregation of school districts.

In 1964 Everett, Pugh and several other WSEG colleagues founded a private defense company, Lambda Corporation. Among other activities, it designed mathematical models of anti-ballistic missile systems and computerized nuclear war games that, according to Pugh, were used by the military for years. Everett became enamored of inventing applications for Bayes’ theorem, a mathematical method of correlating the probabilities of future events with past experience. In 1971 Everett built a prototype Bayes-

NIELS BOHR (*center*) **meets Everett** (*near right*) **at Princeton University in November 1954, the year Everett first had the many-worlds idea. Bohr never accepted the theory. Other graduate students present are** (*left to right*) **Charles W. Misner, Hale F. Trotter and David K. Harrison.**

PHOTOGRAPH BY ALAN RICHARDS, COURTESY OF AIP EMILIO SEGRÈ VISUAL ARCHIVES

MORE TO EXPLORE

The Many-Worlds Interpretation of Quantum Mechanics. Edited by Bryce S. DeWitt and Neill Graham. Princeton University Press, 1973.

The Fabric of Reality. David Deutsch. Penguin Books, 1997.

Biographical Sketch of Hugh Everett, III. Eugene Shikhovtsev. 2003. Online at **http://space.mit.edu/home/tegmark/everett**

Science and Ultimate Reality: Quantum Theory, Cosmology, and Complexity. Edited by John D. Barrow, Paul C. W. Davies and Charles L. Harper, Jr. Cambridge University Press, 2004.

Things the Grandchildren Should Know. Mark Everett. Little, Brown (in press).

ian machine, a computer program that learns from experience and simplifies decision making by deducing probable outcomes, much like the human faculty of common sense. Under contract to the Pentagon, Lambda used the Bayesian method to invent techniques for tracking trajectories of incoming ballistic missiles.

In 1973 Everett left Lambda and started a data-processing company, DBS, with Lambda colleague Donald Reisler. DBS researched weapons applications but specialized in analyzing the socioeconomic effects of government affirmative action programs. When they first met, Reisler recalls, Everett "sheepishly" asked whether he had ever read his 1957 paper. "I thought for an instant and replied, 'Oh, my God, you are *that* Everett, the crazy one who wrote that insane paper,'" Reisler says. "I had read it in graduate school and chuckled, rejected it out of hand." The two became close friends but agreed not to talk about multiple universes again.

Three-Martini Lunches

Despite all these successes, Everett's life was blighted in many ways. He had a reputation for drinking, and friends say the problem seemed only to grow with time. According to Reisler, his partner usually enjoyed a three-martini lunch, sleeping it off in his office—although he still managed to be productive.

Yet his hedonism did not reflect a relaxed, playful attitude toward life. "He was not a sympathetic person," Reisler says. "He brought a cold, brutal logic to the study of things. Civil-rights entitlements made no sense to him."

John Y. Barry, a former colleague of Everett's at WSEG, also questioned his ethics. In the mid-1970s Barry convinced his employers at J. P. Morgan to hire Everett to develop a Bayesian method of predicting movement in the stock market. By several accounts, Everett succeeded—and then refused to turn the product over to J. P. Morgan. "He used us," Barry recalls. "[He was] a brilliant, innovative, slippery, untrustworthy, probably alcoholic individual."

Everett was egocentric. "Hugh liked to espouse a form of extreme solipsism," says Elaine Tsiang, a former employee at DBS. "Although he took pains to distance his [many-worlds] theory from any theory of mind or consciousness, obviously we all owed our existence relative to the world he had brought into being."

And he barely knew his children, Elizabeth and Mark.

As Everett pursued his entrepreneurial career, the world of physics was starting to take a hard look at his once ignored theory. DeWitt swung around 180 degrees and became its most devoted champion. In 1967 he wrote an article presenting the Wheeler-DeWitt equation: a universal wave function that a theory of quantum gravity should satisfy. He credited Everett for having demonstrated the need for such an approach. DeWitt and his graduate student Neill Graham then edited a book of physics papers, *The Many-Worlds Interpretation of Quantum Mechanics,* which featured the unamputated version of Everett's dissertation. The epigram "many worlds" stuck fast, popularized in the science-fiction magazine *Analog* in 1976.

Not everybody agrees, however, that the Copenhagen interpretation needs to give way. Cornell University physicist N. David Mermin maintains that the Everett interpretation treats the wave function as part of the objectively real world, whereas he sees it as merely a mathematical tool. "A wave function is a human construction," Mermin says. "Its purpose is to enable us to make sense of our macroscopic observations. My point of view is exactly the opposite of the many-worlds interpretation. Quantum mechanics is a device for enabling us to make our observations coherent, and to say that we are inside of quantum mechanics and that quantum mechanics must apply to our perceptions is inconsistent."

But many working physicists say that Everett's theory should be taken seriously.

"When I heard about Everett's interpretation in the late 1970s," says Stephen Shenker, a theoretical physicist at Stanford University, "I thought it was kind of crazy. Now most of the people I know that think about string theory and quantum cosmology think about something along an Everett-style interpretation. And because of recent developments in quantum computation, these questions are no longer academic."

One of the pioneers of decoherence, Wojciech H. Zurek, a fellow at Los Alamos National Laboratory, comments that "Everett's accomplishment was to insist that quantum theory should be universal, that there should not be a division of the universe into something which is a priori classical and something which is a priori quantum. He gave us all a ticket to use quantum theory the way we use it now to describe measurement as a whole."

String theorist Juan Maldacena of the Institute for Advanced Study in Princeton, N.J., reflects a common attitude among his colleagues: "When I think about the Everett theory quantum

EVERETT'S TIMELINE

November 11, 1930: Born in Washington, D.C.

1943: Albert Einstein replies to a letter that the adolescent Everett sent him about an irresistible force meeting an immovable object.

Fall 1953: Enters graduate physics program at Princeton University. Studies quantum mechanics under Eugene Wigner and John Archibald Wheeler.

June 1956: Takes research job with the Pentagon's Weapons Systems Evaluation Group (WSEG).

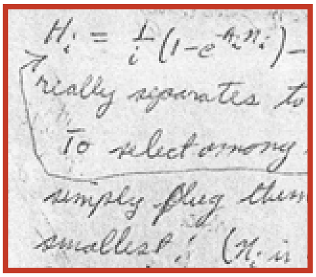
November 1956: Marries Nancy Gore.

November 1956: Appointed head of mathematics division of WSEG.

June 1957: Awarded Ph.D.

July 1957: Daughter Elizabeth born.

Spring 1959: While at the Hotel Østerport in Copenhagen, Everett devises an important refinement to a method for finding optimum solutions to complex logistical problems.



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1959–1960: Helps to draft report WSEG No. 50 on nuclear military strategies.

January 1961: Personally briefs incoming Secretary of Defense Robert S. McNamara on WSEG's analysis of nuclear war-fighting options.

April 1963: Son Mark born.

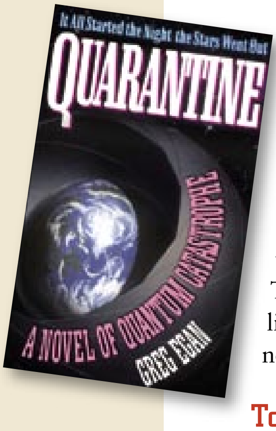
1964: Everett and others from WSEG start Lambda Corporation, a defense contractor.

1973: Leaves Lambda and forms data-processing company DBS.

July 19, 1982: Dies in bed of a heart attack.

Fictional Spin-offs

Stories of parallel worlds and alternate histories have long been as common as blackberries. Here are three diverse tales that reference Everett's many-worlds theory.



- ***The Coming of the Quantum Cats*, by Frederik Pohl (Spectra, 1986):** Copies of the characters travel back and forth across the slew of alternative timelines from which they hail.
- ***Quarantine*, by Greg Egan (HarperCollins, 1992):** Quantum superpositions—and what happens when they are observed—are central to the plot and are a key to the ultimate fate of humanity.
- ***His Dark Materials* trilogy, by Philip Pullman (Knopf, 1995–2000):** This fantasy roams across several parallel worlds. In one, a physicist mentions Everett and his 1957 hypothesis; in another, two experimental theologians have proposed a many-worlds heresy.

COURTESY OF HARPERCOLLINS (*book cover*)

mechanically, it is the most reasonable thing to believe. In everyday life, I do not believe it."

In 1977 DeWitt and Wheeler invited Everett, who hated public speaking, to make a presentation on his interpretation at the University of Texas at Austin. He wore a rumpled black suit and chain-smoked throughout the seminar. David Deutsch, now at the University of Oxford and a founder of the field of quantum computation (itself inspired by Everett's theory), was there. "Everett was before his time," Deutsch says in summing up Everett's contribution. "He represents the refusal to relinquish objective explanation. A great deal of harm was done to progress in both physics and philosophy by the abdication of the original purpose of those fields: to explain the world. We got irretrievably bogged down in formalisms, and things were regarded as progress which are not explanatory, and the vacuum was filled by mysticism and religion and every kind of rubbish. Everett is important because he stood out against it."

After the Texas visit, Wheeler tried to hook Everett up with the Institute for Theoretical Physics in Santa Barbara, Calif. Everett reportedly was interested, but nothing came of the plan.

Totality of Experience

Everett died in bed on July 19, 1982. He was just 51. His son, Mark, then a teenager, remembers finding his father's lifeless body that morning. Feeling the cold body, Mark realized he had no memory of ever touching his dad before. "I did not know how to feel about the fact that my father just died," he told me. "I didn't really have any relationship with him."

Not long afterward, Mark moved to Los Angeles. He became a successful songwriter and the lead singer for a popular rock band, Eels. Many of his songs express the sadness he experienced as the son of a depressed, alcoholic, emotionally detached man. It was not until years after his father's death that Mark learned of Everett's career and accomplishments.

Mark's sister, Elizabeth, made the first of many suicide attempts in June 1982, only a month before Everett died. Mark discovered her unconscious on the bathroom floor and got her to the hospital just in time. When he returned home later that night, he recalled, his father "looked up from his newspaper and said, 'I didn't know she was that sad.'" In 1996 Elizabeth killed herself with an overdose of sleeping pills, leaving a note in her purse saying she was going to join her father in another universe.

In a 2005 song, "Things the Grandchildren Should Know," Mark wrote: "I never really understood/what it must have been like for him/living inside his head." His solipsistically inclined father would have understood that dilemma. "Once we have granted that any physical theory is essentially only a model for the world of experience," Everett concluded in the unedited version of his dissertation, "we must renounce all hope of finding anything like *the* correct theory ... simply because the totality of experience is never accessible to us." ■

SCI AM

See **www.SciAm.com/ontheweb** for materials related to this article, including the 1959 Hotel Østerport note and other interpretations of quantum mechanics.

THEORY'S TIMELINE

Winter 1954–1955: Everett begins writing doctoral dissertation on quantum mechanics.

January 1956: Everett hands in completed draft thesis, "The Theory of the Universal Wave Function."

Spring 1956: Wheeler takes the thesis to Copenhagen to discuss with Niels Bohr and other leading physicists. They react negatively to it.

August 1956–March 1957: Wheeler and Everett rewrite the thesis, drastically abridging it.

April 1957: Thesis committee accepts the abridged dissertation, "'Relative State' Formulation of Quantum Mechanics."

May 1957: Bryce S. DeWitt (editor of *Reviews of Modern Physics*) insists in a letter to Wheeler that "the real world does not branch."

July 1957: *Reviews of Modern Physics* publishes abridged thesis, along with a praiseful assessment of the theory by Wheeler.

Spring 1959: Everett meets Bohr in Copenhagen, but neither budges in his position on the theory.

March 1970: Dieter Zeh publishes a seminal paper on decoherence. He credits Everett's work.

September 1970: DeWitt publishes review article in *Physics Today*, promoting Everett's theory.

1973: DeWitt and Neill Graham publish both versions of the thesis as well as other papers in a book.

December 1976: Science-fiction magazine *Analog* popularizes the theory.

July 1985: David Deutsch proposes quantum computer that could exploit Everettian parallelism.

July 2007: Fiftieth anniversary of Everett's *Reviews of Modern Physics* paper marked by a conference at the University of Oxford and on the cover of *Nature*.