

the set of possibilities available in principle in the Hilbert space. Each time the system of interest (or the memory of an apparatus, computer or nervous system) is forced into a superposition that violates environment-induced superselection rules, it will decohere on a time scale that is nearly instantaneous when the options are macroscopically distinguishable. This onset of decoherence is the apparent "collapse of the wavepacket." Thereafter each of the alternatives becomes a "matter of fact" to the observer who has recorded it: It will evolve on its own, with negligible chances of interference with the other alternatives, but with the correlation of the records with all the relevant states of the measured observables intact.

In spite of the Everett-like framework of this discussion, the picture that emerges in the end—when described from the point of view of an observer—is very much in accord with the views of Bohr.¹² A macroscopic observer will have recording and measuring devices that will behave classically. Any quantum measurement will lead to an almost instantaneous reduction of the wavepacket, so that the resulting mixture can safely be regarded as corresponding to just one unknown measurement outcome. According to the existential interpretation, what is perceived is not a "complete wavefunction of the universe" but a few characteristics of its specific branch consistent with all of the records the state of the observer happens to include. The freedom to partition the global state vector into nearly arbitrary sets of branches (present in the original work of Everett) has been constrained by the requirement that the effectively classical states should be able to persist on dynamical time scales, that is, for much longer than the decoherence time. The global wavefunction of the universe—save for the bundle of branches consistent with the identity of the observer, including in particular his or her records—is completely inaccessible. Such an observer will remember events, perceive specific "matters of fact" and agree about them with other observers.

A more extensive presentation of the issues, stimulated in part by the correspondence I have received in the wake of my PHYSICS TODAY article, can be found elsewhere.³ Reference 13 lists some of the recent papers relevant to this subject.

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WOJCIECH H. ZUREK

Los Alamos National Laboratory
Los Alamos, New Mexico
and the Santa Fe Institute
Santa Fe, New Mexico

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How Bubbles Blow Up (Other Things, That Is)

M. M. Chaudhri (July 1992, page 15) cited the bubble-enhanced detonation of explosive crystals as evidence of very rapid and highly efficient heat transfer. Since the 1960s, however, another possible mechanism has been known to those who study cavitation-

induced corrosion of ship propellers and the like.¹ When microbubbles in the vicinity of a surface collapse, they often "cave in" asymmetrically and form supersonic jets toward or away from the surface. The tremendous pressures induced by these jets seem a more likely mechanism of detonation than collapse heat.

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CHRIS MATZNER

Harvard University
Cambridge, Massachusetts

8/92

CHAUDHRI REPLIES: First, I should like to correct Chris Matzner: The jet from a collapsing bubble is not always supersonic; the jet velocity very much depends on the primary shock. In one of the papers I cited in my previous letter, Frank Philip Bowden and I showed that a jet with a velocity of 120 m/sec and a localized shock of approximately 1 kilobar were associated with the collapsing bubble that caused the explosion we photographed.¹ We showed that the localized shock was too weak to initiate the explosion. Later John E. Field and I showed that the impact on an explosive single crystal of silver azide (a sensitive primary explosive) of jets of velocities of up to 450 m/sec was unable to initiate an explosion.² Having eliminated these two causes and having made further experiments with gases of different gammas (ratios of the specific heats of the gases), we concluded that the heat from the collapsing bubble was the main cause of the explosion. Furthermore, this conclusion was supported by calculations of the heat available in the bubble and of the amount transferred to the adjacent crystal surface in the time available.

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M. M. CHAUDHRI

Cavendish Laboratory
University of Cambridge
Cambridge, England

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Different Angles on Errors in Textbooks

Jay M. Pasachoff suggests in his letter (July 1992, page 91) that other scientists follow his example and become involved in writing pre-college textbooks that are more correct than most present texts and urges that school