

Commentary

What I think about Now

In a commentary in the July 2012 issue of *PHYSICS TODAY* (page 8), I maintain that stubborn problems in the interpretation of quantum mechanics melt away if one takes literally Niels Bohr's dictum that the purpose of science is not to reveal "the real essence of the phenomena" but to find "relations between the manifold aspects of our experience."¹ (See also letters and my further remarks, *PHYSICS TODAY*, December 2012, page 8, and July 2013, page 8.)

This same view of science, that it is a tool each of us uses to organize our own experience, also disposes of the vexing but entirely classical problem of "the Now." Rudolf Carnap states the problem succinctly in his report of a conversation with Albert Einstein:

Einstein said that the problem of the Now worried him seriously. He explained that the experience of the Now means something special for man, something essentially different from the past and the future, but that this important difference does not and cannot occur within physics. That this experience cannot be grasped by science seemed to him a matter of painful but inevitable resignation.²

The issue here is not, as you might think, that the simultaneity of events in different places depends on frame of reference. Events whose temporal ordering is ambiguous relative to an event that I experience Now are irrelevant, because they are outside the backward and forward light cones of my Now and cannot affect or be affected by what I experience Now. Whether or not I choose to regard them as contemporary with my Now is entirely a matter of personal convention. The actual issue is that physics seems to have nothing whatever to say about the Now even at a single place, but deals only with relations between one time and another, in spite of the fact that the present moment is immediately evident as such to each and every one of us.

Any person's Now is a special event for that person as it is happening. By an "event" I mean an experience whose duration and location are restricted enough that it can usefully be repre-

sented as a point in space and time. My Now is distinguished from other events I have experienced by being the actual current state of affairs. I can distinguish it from earlier events (former Nows) that I merely remember and from later events that I can only imagine. My remembered past terminates in my Now. The status of any particular event as my Now is fleeting, since it fades into a memory with the emergence of subsequent Nows.

Obvious as the human content of the preceding paragraph is, such a Now is absent from the conventional physical description of spacetime. In physics, all the events experienced by a person constitute a time-like curve in spacetime, and there is nothing about any point that gives it a special status as Now. My experience of the Now suggests that my world line ought to terminate in something like a glowing point, signifying my Now. That glow should move in the direction of increasing time, as my world line grows to accommodate more of my experience. There is nothing like this in the conventional physical description of my spacetime trajectory.

The problem of the Now will not be solved by discovering new physics behind that missing glowing point. It is solved by identifying the mistake that leads us to conclude, against all our experience, that there is no place for the Now in our existing physical description of the world.

There are actually two mistakes. The first lies in a deeply ingrained refusal to acknowledge that whenever I use science, it has a subject (me) as well as an object (my external world). It is the well-established habit of each of us to leave ourselves—the subject—completely out of the story told by physics.

The second mistake is the promotion of spacetime from a four-dimensional diagram that we each find extremely useful into what Bohr calls a "real essence." My diagram, drawn in any fixed inertial frame, enables me to represent events from my past experience, together with my possible conjectures, deductions, or expectations for events that are not in my past or that escaped my direct attention. By identifying my diagram with an objective reality, I fool

myself into regarding the diagram as a four-dimensional arena in which my life is lived. The events we experience are complex, extended entities, and the clocks we use to locate our experiences in time are macroscopic devices. To represent our actual experiences as a collection of mathematical points in a continuous spacetime is a brilliant strategic simplification, but we ought not to confuse a cartoon that concisely attempts to represent our experience with the experience itself.

If I take my Now as the reality it clearly is, and if I recognize that spacetime is an abstract diagram that I use to represent my experience, then the problem of the Now disappears. At any moment I can plot my past experience in my diagram as a continuous time-like curve that terminates in the Now. As my Now recedes into memory it ceases to be the real state of affairs and is replaced in my expanding diagram by subsequent Nows.

The motion of my Now along my trajectory in my diagram reflects the simple fact that as my wristwatch advances, I acquire more experiences to record in the diagram. My Now advances at one second of personal experience for each second that passes on my watch. According to special relativity, this means a second of personal experience for each second of proper time along my trajectory. The connection between my ongoing experience and a geometric feature of my diagram is just my diagrammatic representation of the fact that if asked "What time is it now [Now]?" I look at my watch and report what I read.

There is thus no problem of the Now for any single person. But is there a problem in combining the Nows of many different people? Here we must recognize another obvious fact of human experience. If two people are together at a single event, then if that event happens to be Now for either one of them, then it must be Now for them both. When we are interacting face-to-face, it is simply unimaginable that a live encounter for me could be only a memory for you, or vice versa.

The commonality of my Now and your Now whenever we are together

requires that our Nows must coincide at each of two consecutive meetings. That is just what we find whenever any of us move apart and then come back together. But at the slow relative speeds at which we move, the possibly complicating effect of relativistic time dilation on the advances of our individual Nows is utterly negligible compared with the psychological width (many milliseconds) of each of our private Now experiences. Can our Nows coincide when we come back together no matter how rapidly we move back and forth?

The twin “paradox”—the relativistic requirement that personal time keep pace with proper time—assures us that according to physics, the Nows of the traveling and the stay-at-home twin will indeed coincide at their reunion if they have coincided at their separation, even when the departure and return involve speeds comparable to the speed of light. Far from having nothing to say about the Now, physics actually describes it in a way that makes psychological sense, even in a world of many people, all moving about at relativistic speeds.

Erwin Schrödinger had it almost exactly right when he wrote to Arnold

Sommerfeld about an “emergency decree” that quantum mechanics “deal only with the object-subject relation. Although this holds, after all, for any description of nature, it evidently holds in a much more radical and far-reaching sense in quantum mechanics.”³ My only reservation is that although quantum mechanics has indeed forced us—well, at this point only some of us—to recognize that physics is about the object-subject relation, this holds in just as radical and far-reaching a sense in classical physics too.

References

1. N. Bohr, *Atomic Theory and the Description of Nature*, Cambridge U. Press, Cambridge, UK (1934), p. 18.
2. R. Carnap, *The Philosophy of Rudolf Carnap*, P. A. Schilpp, ed., Open Court, La Salle, IL (1963), p. 37.
3. E. Schrödinger, *Eine Entdeckung von ganz ausserordentlicher Tragweite: Schrödingers Briefwechsel zur Wellenmechanik und zum Katzenparadoxon*, K. von Meyenn, ed., Springer, Berlin (2011), p. 490.

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Letters

Early chaos theory

The article “Chaos at fifty” by Adilison Motter and David Campbell (PHYSICS TODAY, May 2013, page 27) pays a well-deserved homage to Edward Lorenz for his contribution to chaos theory and meteorology. However, I take exception to the statement at the beginning of the article that “in 1963 an MIT meteorologist revealed deterministic predictability to be an illusion and gave birth to a field that still thrives.” On the contrary, the exponential growth of errors in some deterministic systems and the practical consequences for predictability have been appreciated by scientists for more than a century. I am particularly fond of what Henri Poincaré says in “Le hasard,” chapter 4 of his book *Science et Méthode* (Ernest Flammarion, 1908; my translation):

A small cause, that escapes us, determines a considerable effect that we cannot ignore, and we then say that this effect is due to chance. If we knew exactly the laws of nature and the situation of the universe at the initial instant, we could predict exactly the situation of this same universe at a later instant.

But Poincaré remarks that we know the initial situation only approximately, and that it may happen that small differences in initial conditions generate large differences later, so that prediction becomes impossible. Poincaré offers meteorology as an example:

Why do meteorologists have such difficulty in predicting the weather with any certainty? . . . [They see] that a cyclone will appear, but they are unable to say where; a tenth of a degree added or subtracted at some arbitrary place, the cyclone appears here and not there, and causes destructions in countries which it would have spared. If one had been aware of this tenth of a degree, one could have known it in advance, but the observations were not spaced closely enough, and were not precise enough, and this is why everything seems due to chance. Here again we find the same contrast between a tiny cause, that the observer cannot measure, and considerable effects, which may be appalling disasters.

So, Poincaré knew about the butterfly effect 50 years before Lorenz. Lorenz’s contribution is not so much the



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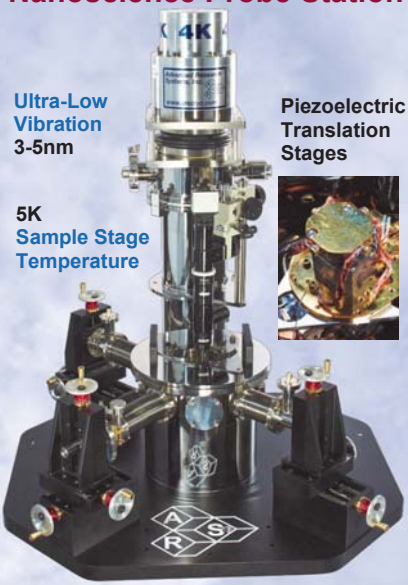
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