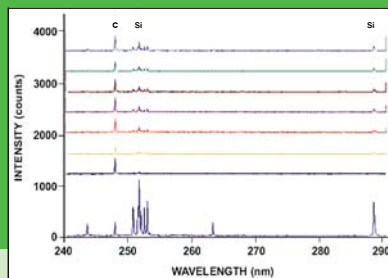


## Ocean Optics LIBS System Spectra of Silicon



LIBS spectra for silicon surface contamination ranging from 0 to 2%. The LIBS spectrum for a silicon-rich sample is shown at the bottom of the graph.

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regularity. "In for the penny, in for the pound," he wrote. Thus, a more accurate quote from Einstein about God and dice playing is the following:

"That the Lord should play with dice, all right; but that He should gamble according to definite rules, that is beyond me."<sup>1</sup>

## Reference

1. A. Einstein, quoted in J. Wheeler, W. Zurek, *Quantum Theory and Measurement*, Princeton U. Press, Princeton, NJ (1983), p. 8.

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I enjoyed Steven Weinberg's article except for the not-so-subtle knock on religion at the beginning, where he refers to "other supposed paths to truth," and the subhead, "Science sets itself apart from other paths to truth by recognizing that even its greatest practitioners sometimes err." If the point of the article is to show the superiority of science over other "supposed paths," Weinberg confuses the issue by ending with the claim that Einstein "made no mistakes" in his decisions about "great public issues," including his opposition to militarism, his refusal to support the Stalinist Soviet Union, and his enthusiastic Zionism. Since none of those public issues are ones in which science alone can provide answers, how did Einstein achieve such infallible knowledge about them without relying on paths to truth other than science? With all due respect for his undoubted genius in science, I think Weinberg's hostility to religion is blinding him to errors in elementary logic.

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How unfortunate that Steven Weinberg chose to insert a criticism of religion—"other supposed paths to truth"—in his article. That Einstein was not infallible seems to have little relevance to the question of whether the prophets of various religions are infallible, and the latter question seems to have little place in a piece about Einstein.

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While I very much enjoyed Steven Weinberg's article "Einstein's

Mistakes," I am puzzled by the author's statement about quantum mechanics: "The difficulty is not that quantum mechanics is probabilistic—that is something we apparently have to live with. The real difficulty is that it is also deterministic, or more precisely, that it combines a probabilistic interpretation with deterministic dynamics."

Quantum mechanics is an acausal deterministic theory in the sense that a physical system's state (mathematically described by a state vector) at a given initial time determines its state at a specified later time, but its state is not in one-to-one correspondence with sharp values of all its dynamical variables; that correspondence is probabilistic. Therefore events, identified by sharp values of those variables at one spacetime point, are not causally connected with other events. That is something we have to live with.

Why does the combination of these two attributes—acausality and determinism—constitute a special difficulty? Weinberg asks, "So where do the probabilistic rules of the Copenhagen interpretation come from?" Why do they have to come from anywhere other than from human brains? Nature exists out there, independent of human thought, but its mathematical description surely is a human construction rather than an immutable law given to us on a stone tablet.

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Einstein should be allowed his mistakes, like the rest of us, and Steven Weinberg understandably points out only the most newsworthy. I write to point out another misunderstanding—mistake, if you will—in Einstein's work only because it is often found in the literature today.

Einstein described diffusion as the motion of neutral particles on atomic (Brownian) length and time scales. He used a stochastic differential equation—a Langevin equation—in the high-friction limit to describe diffusive trajectories. Einstein did not discuss how his treatment could accommodate macroscopic boundary conditions or produce macroscopic flow, which is, after all, what Fick's law of diffusion is all about.

Langevin equations, in the spirit of Einstein's work, are widely used today to describe the motion and fluctuations of density of charged