Notes of an Ex-Physics Student

More years ago than I care to admit – although physicists will be able to date it – my professor came running into the laboratory where I happened to be working, waving a copy of PHYSICAL REVIEW LETTERS. "They have found the neutrino," he yelled. "Can you imagine that?" Well, we could imagine it; but imagine it was all we could do.

Something of the same excitement returned as I sat through recent conferences on quantum physics and quantum measurement (SN: 1/11/86, pp. 26, 28; 2/1/86, p. 70; 2/8/86, p. 87), and I wondered how to convey it without being accused of biasing the news. It is worth quoting quantum physics specialist Anthony J. Leggett of the University of Illinois at Urbana-Champaign, as he puts the point on it: "The quantum measurement paradox is no longer a matter of 'theology.' It has become an experimental subject."

Theology is a subject in which one cannot do experiments. All one can hope is to be able to bring some experience to the contemplation of it. In our beginning physics courses we had discussed all these famous thought experiments that demonstrate the points and arguments of the new physics: Schrödinger's cat, Einstein's box, quantum interference, Einstein-Podolsky-Rosen paradox, single slit, double slit, etc., etc. Memories of their details began to surface as I listened to the talk in Cambridge and in New York.

Suddenly these experiments that nobody could ever do are on the agenda in serious laboratories. Nobody could do them because the "real" world with its multiple connections, its dissipation, its gritty frictional hardness, made them impossible. The cleverness of experimental physicists is now getting around these difficulties. Sam Werner of the University of Missouri at Columbia proposes to hang a neutron-diffraction apparatus upside-down from the ceiling – I'm not making this up – to test the effect of gravity on neutrons, particularly their wavelike behaviors.

Years ago the neutrino was a kind of ghost invoked by theory for its purposes. I doubt that my professor ever expected to see evidence of an actual one in his lifetime. Likewise I did not expect to see results of these quantum mechanical experiments in mine. The whole thing comes as a tremendous surprise. The leaders of the New York Academy of Sciences say that when they were asked to convene a meeting on quantum measurement, they hesitated. They were not sure there was really anything new to talk about. When they began to probe, they discovered this rich underground. Suddenly the relevant question is: "How many wave equations can collapse on the point of a pin?" The ancient question about the dancing angels, whether they can be said to act in space and time, now recurs about neutrons and photons.

In the beginning of quantum mechanics we had learned about the strange wave-particle duality and the uncertainties and correspondences that flow from it. We had pondered the paradox of quantum measurement: that when you make a measurement the wave function collapses. That means the act of measurement seriously alters the state of whatever is measured. Under those circumstances, does measurement mean anything? Is there any reality to the phenomena it purports to present? Is there any deeper reality under the phenomena, a reality that the phenomena represent or mediate to the world? And finally, we had an introduction to the Copenhagen school's answer to all this. Nick Herbert, in his book *Quantum Reality* (Anchor Press, N.Y., 1985), describes the Copenhagen view succinctly: "There is no deeper reality."

It was not for this that one had come to the study of physics. In those days philosophy seemed to be going in circles. Literature was suffused with a kind of secular cloud of unknowing. We read Sartre, Camus, Kafka, Rilke, Hesse. Theology was stuck in the secular city, too. Might as well just read Sartre: *Huis clos.* I had come to physics looking for some reliable reality, and here was another glance into the same old abyss.

It was possible, however, to recoil, and I think most physicists did. In the first place the Bohrean bugaboos were safely put away in the microcosmic world where we couldn't really touch them nor they us. If the Copenhagen interpretation was and is, as Herbert calls it, "establishment physics," it was that in the sense that people threw occasional grains of incense on its altar and then backed away.

In the second place there was the Einstein-de Broglie school with their continued intimations of neoclassical reality. They implied that if we could really come to grips with the questions instead of just talking about them, we would find "hidden variables." We would discover things that resolved the paradoxes that inspired this Danish vision of nothingness, and reality would again be hard and reliable. One could cling to such a hope.

Today we are coming to those grips. Physicists are beginning this mutual touching, quantum by quantum. That is the excitement. In physics it is indeed the best of times and the worst of times (and it would *be* very heaven to be young). And when we have been through these endeavors, perhaps some of us will feel that we have been to the guillotine and back. – *D. E. Thomsen*