STANLEY L. JAKI, Seton Hall/USA

CHANCE OR REALITY:

INTERACTION IN NATURE VERSUS MEASUREMENT IN PHYSICS*

A title like this may seem to be an invitation into the realm of scientific and philosophical abstractions. Flesh and blood reality calls no less for such a title. A telling illustration of this was provided less than half a year ago in a TIME essay which dealt with "the importance of being lucky". The essay was written with an eye on President Reagan's luck. Indeed the chances were astronomical against the stopping of the assassin's bullet at 2 cm from the President's heart. Had the author of that essay waited two more weeks, he could have referred to another extremely lucky shot. That no vital organs —liver, pancreas, spinal column— were injured as a bullet criss-crossed through the pope's abdomen, could appear the kind of luck which is better called a miracle. Our secular culture, proud of its rationality, prefers to speak of mere luck. But as the TIME essayist pointed out, "people who believe in luck are not particularly rationalist either, since scientific rationalism has as much trouble dealing with luck as theology does. The best it [scientific rationalism] has to offer is Heisenberg's Uncertainty Principle, which states that it is absolutely impossible to predict the exact behavior of atomic particles".[1]

That an essayist who writes for a weekly magazine like TIME is allowed by the editor to mention Heisenberg's uncertainty principle, is a proof that the average educated man has already heard of it. It would be easy to show that the principle has become, since its formulation in 1927, as much the part of cultural atmosphere as was the case a hundred years ago with Darwinian natural selection, and with Newtonian physics over two hundred years ago. Both about Heisenberg's principle and of Darwin's natural selection it may also very well be true what Voltaire said two decades after Newton's

* Paper read during the 5th International Humanistic Symposium organised by the "Hellenic Society for Humanistic Studies" in Portaria/Pelion (16-22. 9. 1981) under the general subject "Freedom and Necessity in European Civilization. Perspectives of Modern Consciousness".

1. TIME, April 27, 1981, p. 79.

death: "Very few people read Newton because it is necessary to be learned in order to understand him. Yet everybody talks about him".[2]

Newton's laws imply that the future position of a particle can be predicted if one knows exactly the position (x), the mass (m), and the velocity (v) of a particle at a given moment (t). Heisenberg's principle states that a simultaneous measurement of these parameters cannot be done with lesser uncertainty than Planck's quantum (h). Or as the now famous formula has it, $\Delta x \cdot \Delta mv \geqq h$. The formula readily lends itself to the transformation into $\Delta E \cdot \Delta t \geqq h$, which expresses the minimum uncertainty in the simultaneous measurement of energy (E) and time (t). Both formulas have their equivalents for rotational motion. As almost all other major discoveries in physics, these uncertainty relations too had been in the air for some time before they received in Heisenberg's hands a derivation from general theoretical principles in 1927. A combination of the Compton effect and the De Broglie matter-wave formula could have yielded the Heisenberg formula already in 1924. That calculations of atomic processes are probabilistic in character had also been recognized before Max Born showed in 1926 that the ψ function, or the foundation of Schrödinger's wave mechanics, implies a probability distribution. So much in the way of technicalities about the uncertainty principle which in itself expresses the limits set to the precision of measuring physical interactions, limits which become significant only on the atomic level.

That there are limits, at least practical limits, to the precision achievable in physical measurements had been recognized by all physicists for centuries before Heisenberg. Descartes, Galileo, and Newton, all spoke of the difference between the exactness of all physical interactions and the invariable inaccuracy of their being measured by physicists. Theories of error and theories of the distribution of observational data about the most probable value (Gauss' curve) had been worked out in the early 19th century and systematically applied. The same century was not over yet when it became recognized through Lord Rayleigh's work that the wave nature of light sets a limit to the precision of optical instruments. Even this limitation did not appear worrisome as in principle ever shorter wavelengths could be resorted to. In other words, prior to Heisenberg physicists could safely believe in the limitless perfectibility of their measurements and in the agreement of any ideally perfect measurement with reality which obeyed complete exactness. In Laplace's well known statement, a superior intellect to whom all data were available, could calculate and predict all future configurations of all material bodies with complete

2. *Lettres philosophiques* (1734), in *Oeuvres complètes de Voltaire*, ed. L. Moland (Paris, Garnier Frères 1877-85), vol. XXII, p. 130.

precision. Everything, added Laplace, followed the paths of exact mechanical causality, not only the planets whose orbits even ordinary intellects could calculate with almost complete precision, but also individual vapor molecules about whose trajectories nothing could be determined[3].

The recognition that owing to Heisenberg's principle a theoretical limit prevailed over the perfectibility of instruments and observations did not in itself threaten belief in full physical determinism. True, it was no longer possible to hold that the ideal of perfect precision could ever be achieved. Yet, in most areas of physics there remained plenty of room for making measurements more accurate and, far more importantly, it could also be argued that the absence of complete precision in measurements was a statement very different from absence of complete determinism, or physical causality, in the interactions themselves. Insofar as the Heisenberg principle was taken as a mere limit on precision, it was still possible to retain a notion of chance as being opposite to cause and reality. The view which became a vogue during the Age of Reason, had in its grip not only physicists but also philosophers and poets even. "What we call chance is not and cannot be except the unknown cause of a known effect", declared Voltaire.[4] Schiller may have paraphrased Voltaire as he put in Wallenstein's mouth the words: "Happenstance does not exist".[5]

In both those statements, and many others could be quoted, chance is taken in the sense of non-entity, or the opposite of reality. The same sense also turns up in the late 19th century in a very important context, in T. H. Huxley's reminiscences on the reception of Darwin's theory. There Huxley took to task those who rejected Darwinism on the ground that it was a "reign of chance". "Do they believe", Huxley asked, "that anything in this universe happens without reason or without a cause? Do they really conceive that any event has no cause, and could not have been predicted by any one who had sufficient insight into the order of Nature?" The second question evoked

---

3. Laplace first made this statement in his *Théorie analytique des probabilités* (1812). The statement gained wide currency through its insertion into Laplace's popular exposition of the same topic, *Essai philosophique sur les probabilités* (1814). See its English translation from the sixth French edition, *A Philosophical Essay on Probabilities*, by F. W. Truscott and F. L. Emory, with an introductory note by E. T. Bell (New York, Dover 1951), p. 4.

4. Article "Atomes" in *Dictionnaire philosophique* (1764). See *Oeuvres complètes de Voltaire*, vol. XVII, p. 478.

5. *Wallenstein's Death*, Act II, Scene 1, lines 943-44. Schiller may have just as well relied on the dictum of Lessing, a leader of the German Enlightenment: "Nothing under the sun is ever accidental" (*Emilia Galotti*, IV). Alexander Pope, world-renowned British spokesman of rationalist optimism, attacked chance with no less resolve: "All chance, direction which thou canst not see" (*An Essay on Man*, I).

Laplace as did Huxley's description of a seashore where apparently nothing could be measured about the trajectory of individual vapor molecules arising from myriads of bubbles and flakes of foam. But, Huxley warned, "the man of science knows that here, as everywhere, perfect order is manifested; that there is not a curve of the waves, not a note in the howling chorus, not a rainbow glint on a bubble which is other than a necessary consequence of the ascertained laws of nature; and that with sufficient knowledge of the conditions competent physico-mathematical skill could account for, and indeed predict, every one of those 'chance' events". A scientist, Huxley declared, is a convert with only one act of faith, which is "the confession of the universality of order and of the absolute validity in all time and under all circumstances of the law of causation".[6]

Today, all Darwinists and almost all evolutionists speak in a manner of which the title of J. Monod's famous book, *Le Hasard et la Nécéssité*, is a capsule formula.[7] They think that chance and necessity can coexist in the very same process because they almost invariably endorse a dismissal of causality which Heisenberg was the first to tack on the principle of uncertainty. Already in 1927 Heisenberg declared: "Since all experiments are subjected to the laws of quantum mechanics and thereby to the equation [$\Delta x \cdot \Delta mv \geqq h$], the invalidity of the law of causality is definitely proved by quantum mechanics".[8] Clearly, this meaning given to the uncertainty principle should seem very drastic in comparison with the one which merely states the inability of physicists to secure precision to their measurements beyond a certain limit. Most educated laymen (at least in the Anglo-Saxon world) learned about that drastic meaning from Eddington's books and addresses. As early as 1927, he spoke of the emergence in the new physics "of an attitude more definitely hostile to determinism".[9]

The rest is fairly well known, although some highlights are worth re-

6. For the printed text of those reminiscences, see *The Life and Letters of Charles Darwin*, edited by F. Darwin (New York, Basic Books 1959), vol. 1, pp. 553-55.

7. First published in 1970. Monod explicitly refers to Heisenberg's uncertainty principle as he sets forth the notion of "pure chance, absolutely free but blind" and contrasts it with Laplace's statement. See *Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology*, translated from the French by A. Wainhouse (New York, Vintage Books 1971), pp. 112-15.

8. "*Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik*", "Zeitschrift für Physik" 43 (1927), p. 197. Heisenberg's paper was received by the editor on March 23 and appeared in early June.

9. He did so in his Gifford Lectures, delivered in the University of Edinburgh, January-March 1927. See *The Nature of the Physical World* (Cambridge, University Press 1928), p. 294.

calling. In accepting in 1933 the Nobel Prize, Heisenberg stated that on account of the principle of uncertainty one must forego "the objectification [of knowledge] to a greater extent than hitherto expected".[10] About the same time, John von Neumann analyzed the possibility of constructing a theory of which quantum mechanics with its probability calculations would be a particular case. That broader theory (later spoken of as a theory of hidden variables) would allow, in principle at least, complete precision in measurement and therefore exact predictability of atomic events. The answer was negative and von Neumann saw in this an imperative to endorse the drastic meaning of Heisenberg's principle: "There is at present no reason to speak of causality in nature — because no experiment indicates its presence and... quantum mechanics contradicts it". Causality, von Neumann added, was an age-old way of thinking which "has been done away with".[11]

Causality could easily be rejected in a philosophical atmosphere which had grown increasingly sceptical since the days of Hume and Kant. No more telling sign of that atmosphere would perhaps ever be found than the readiness of most leading physicists to accept such consequences of the rejection of causality as the denial of interaction at the fundamental level of nature and the dismissal of objective reality itself. Once statements about causality became a question of strict measurability, processes involving single atoms no longer retained any meaning. The radioactive decay of an atom could only be seen as a succession of states with no connection or interaction among those states.

The characterization of natural radioactivity as a spontaneous disintegration, a patently anthropomorphic term, was much more expressive of the logic at work than could appear on a cursory look. Once objective causality was abandoned, it became almost unavoidable to attribute volition to atoms in order to retain the semblance of coherent discourse and of a coherent nature. This came into the open already in 1927 in connection with cloud chamber tracks.[12] While the visible track was a unity, no connection could be assigned to the millions of ionized molecules because interaction between any two of them was not measurable. Was their succession, resulting in an obvious unity, a choice on the part of Nature? To answer affirmatively this

---

10. See *Nobel Lectures. Including Presentation Speeches and Laureates' Biographies. Physics* 1922-1941 (Amsterdam, Elsevier 1965), p. 301.

11. *Mathematical Foundations of Quantum Mechanics*, translated from the German by R. T. Beyer (Princeton, Princeton University Press 1955), p. 327.

12. The debate of Dirac and Heisenberg took place at the Solvay Congress, Bruxelles, October 24-29, 1927. The papers and procès-verbaux of the Congress are contained in *Electrons et photons* (Paris, Gauthier-Villars 1928). See especially pp. 261-63.

question posed by Dirac to Heisenberg was of course inadmissible within a science which since the days of Galileo and Descartes excluded from its domain any volition, purpose, and goal. But was it not even more incompatible with the spirit of physics to declare, as Heisenberg did, a purely physical situation non-existent because it was uninvestigable in the sense of not being exactly measurable? Indeed, was it in the spirit of the same science to doubt on the same ground the existence of external reality itself?

In this crucially decisive respect too the force of logic operating within any premise, especially if drastic, was not only inexorable but speedy as well. On the basis that it was impossible to differentiate with complete precision in space and time between the radioactive and non-radioactive isotopes of any atom, say potassium (kalium), Eddington declared in 1932: "The answer of modern physics is that strictly speaking there is not such a thing as a K_{39} atom but only an atom which has a high probability of being K_{39}".[13] From mere probability with respect to being it was only a short step to despair about the rationality of existence. Once more the physicists-turned-philosophers obeyed the call of logic with no delay. In speaking to a world-wide educated public on the pages of "Harper's Magazine" about the new vision of science, the future Nobel laureate, P. W. Bridgman declared: "The world is not a world of reason, understandable by the intellect of man... the world is not intrinsically reasonable or understandable". If such was the case the reality of the world itself was in question and Bridgman knew it: "A vision has come to the physicist in this experience which he will never forget; the possibility that the world may fade away, elude him, and become meaningless because of the nature of knowledge itself [that possibility] has never been envisaged before, at least by the physicist, and this possibility must forever keep him humble".[14] Yet if anyone, were he the most prominent of all physicists, discoursed about knowledge on the shallow grounds that all its merits stood and fell with exact measurability, the humility advocated in the same breath would not be any deeper and more persuasive than the discourse itself. Journalists hardly ever mindful of humility or of logic felt themselves free of all constraints in presenting to the general public the new world view imposed by atomic physics. In reminiscing of this in 1950, the prominent physicist H. Margenau wrote: "No simple slogan, save 'violation of causal reasoning' was deemed sufficiently dramatic to describe the revolutionary qualities of the new knowledge".[15]

13. *The Decline of Determinism*, "The Mathematical Gazette" 16 (1932), p. 74.

14. *The New Vision of Science*, "Harper's Magazine" 158 (1929), p. 450.

15. *The Nature of Physical Reality* (New York, McGraw Hill 1950), p. 418.

Prominent voices of opposition were not lacking but they were largely drowned out in the celebration of non-causal reasoning as reality was given innumerable fare-well parties. Today, only some historians of science recall Einstein's famous declaration which he sent to "Nature" as his contribution to the bicentenary of Newton's death in 1927: "It is only in the quantum theory that Newton's differential method becomes inadequate, and indeed strict causality fails us. But the last word has not yet been said. May the spirit of Newton's method give us the power to restore unison between physical reality and the profoundest characteristic of Newton's teaching — strict causality".[16] The statement revealed both Einstein's instinctive attachment to causality and also his inarticulatness as a philosopher. He failed to see that lack of precision in measurements and predictions is not logically equivalent to absence of causality. Much lesser minds than Einstein perceived clearly, right there and then, this all important point. Nothing in the way of rigor can indeed be added to the concluding phrase of a letter written in 1930 to the editor of "Nature" by a today completely forgotten teacher at the University of Liverpool: "Every argument, that, since some change cannot be 'determined' in the sense of 'ascertained', it is therefore not 'determined' in the absolutely different sense of 'caused', is a fallacy of equivocation".[17]

In short, during the half a dozen years that followed the enunciation by Heisenberg of the principle of uncertainty, almost immediately a drastic meaning was grafted on it, a meaning thoroughly philosophical. In that case too the implications of a philosophical position were quickly drawn. Once the scientific inability to measure reality with complete exactitude was given a philosophical garb, it led with philosophical exactness to the inability to grasp and hold reality. Reality's place was taken by chance, not the chance that stands for ignorance, but which stands for a philosophical ghost residing in the shadowy realm between being and non-being. This is why in quantum mechanics no question is ever raised about the sense in which chance is real, that is part of being, although the quality of being operational is blissfully and unquestioningly attributed to that very same chance.

During the same half a dozen years also the battle lines were firmly drawn. One side was formed by the vast majority of leading physicists,

---

16. "Nature", March 26, 1927, p. 467.

17. "Nature", Dec. 27, 1930, p. 995. Turner attached his remarks to the assertion made by the Nobel laureate physicist, G. P. Thomson, in his book, *The Atom* (London, T. Butterworth 1930, p. 190), that "physics is moving away from the rigid determinism of the older materialism into something vaguely approaching a conception of free will". The assertion is a perfect example of the kind of vagueness incompatible with philosophy.

all followers of the Copenhagen interpretation of quantum mechanics, all evasive about questions concerning being, and in that sense all anti-realists. The chief injunction of Niels Bohr, leader of the Copenhagen school, was that all statements about ontology or being must be avoided.[18] The philosophical instructiveness of his writings lies in the consistency with which he obeyed that injunction. The other side was formed by a very small number of prominent physicists — Planck, Max von Laue, Schrödinger, and later de Broglie, with Einstein as their leader. A most distinguished though a very pathetic group indeed. It was nothing short of pathetic that Einstein was lured to a battleground where he could only lose. The ground related to the possibility of devising thought experiments in which the position and momentum could be measured with complete exactness. Einstein assumed a box filled with electromagnetic radiation which was not absorbed by the box because its walls were on the inside perfect mirrors. The box also had a shutter and a clockwork in one of its walls. Once the box was weighed, the clockwork opened the shutter at a preset moment, so that one photon could escape. Thus, at a given time the total mass (energy) of the box diminished, a change that could be ascertained by measuring the box again. Einstein claimed that the experiment made possible the simultaneous measurement of energy and time with complete accuracy, but Bohr was able to show that the weighing process implied a simultaneous measurement of the position and momentum of the scale, a measurement subject to the Heisenberg uncertainty.[19]

No thought experiment immune to that uncertainty can indeed be devised for the simple reason that every measurement ultimately implies the use of light waves. Observation of the results demands the reading of a scale, usually a pointer needle, which can only be done if light is reflected from it into the observer's eyes. But as the light wave is reflected from the needle momentum is transferred to it, and the observation of position becomes the simultaneous observation of position and momentum, and there Heisenberg's principle sets a limit to the precision that can be achieved. There lies the doubtful source of endless references to the observer's role, references replete with subjectivism, as if the observer as such created reality and nature. Apart from that, even if it were in theory possible to devise a thought experiment with absolute precision, would this in itself be a proof of causality and reality? Obviously not. The very assertion of causality and reality imply a kind of

18. See for details my Gifford Lectures, *The Road of Science and the Ways to God* (Chicago, University of Chicago Press; Edinburgh, Scottish Academic Press, 1978), pp. 211-12.

19. For description, discussion and diagrams, see N. Bohr, *Atomic Physics and Human Knowledge* (New York, John Wiley 1958), pp. 32-66.

reasoning or rather mental judgment which is very different from statements of mathematical physics.

That such is the case has been amply illustrated by Einstein's inability to articulate himself over many years as he waged his battle against the Copenhagen school. Undoubtedly, Einstein could coin impressive phrases, especially in private. His correspondence with Born, which covers over 40 years, is particularly relevant because Born never gave up hope of converting Einstein to quantum mechanics, that is, to its Copenhagen interpretation. Einstein's replies to Born abound in remarkable, at times dramatic lines. In one letter (March 3, 1947), Einstein referred to his little finger as his ultimate proof that quantum mechanics would one day be superseded by a non-probabilistic theory: "I cannot however base this conviction on logical reasons, but can only produce my little finger as a witness, that is, I offer no authority which would be able to command any kind of respect outside my own hands".[20] A pathetic phrase indeed. Not because of the gigantic role attributed to a little finger, but because of the place, the very first place or primacy attributed to logical reasons. Einstein clearly put the emphasis on «logical», not on «reason», let alone on reality.

Similar reflections are in order about Einstein's famous claims that God does not play dice, a claim he made repeatedly in the same correspondence. Take, for instance, the passage from his letter of December 4, 1926, to Born: "Quantum mechanics is certainly imposing. But an inner voice tells me that it is not yet the real thing. The theory says a lot, but does not really bring us any closer to the secret of the 'old one'. I, at any rate, am convinced that *He* is not playing dice".[21] Here too drama goes hand in hand with philosophical poverty. The real thing is not so much reality as perfect calculation, and the God in question is not the One Who Is, but merely someone who can calculate with perfect accuracy and therefore is in no need to play dice. Again there is drama but no philosophical depth in Einstein's remark that, as he put it in a letter to Schrödinger, the Copenhagen people play a dangerous game with reality.[22]

Einstein's public utterances were not much help. They could only convert the believer, that is, those who being realists, needed no conversion. At any

---

20. *The Born-Einstein Letters: Correspondence between Albert Einstein and Max and Hedwig Born* (New York, Walker and Company 1971), p. 158.

21. Ibid., p. 91. For other uses by Einstein of the same phrase, see ibid., pp. 149 and 199.

22. Letter of December 22, 1950 of Einstein to Schrödinger in *Letters on Wave Mechanics: Schrödinger, Planck, Einstein, Lorentz*, edited by K. Przibram, translated with an introduction by M. J. Klein (New York, Philosophical Library 1967), p. 36.

rate, conversion is far more than a solid argument. This is why a solid argument must not pretend to imply something which is conversion itself. Einstein made that mistake time and again as he spoke of reality as an object of belief not of knowledge. His famous statement, "Belief in an external world independent of the percipient subject is the foundation of all science",[23] has, for all its longing for reality, a fideistic, or at least a Kantian ring. It is in this fideism toward reality that lies the root of Einstein's inability to make clear over four decades a crucial point in his correspondence with Born, which contains most of his reasonings on the subject, chance versus reality. In battling with Born, Einstein had to take a ground in which no room was left for belief as part of a rigorous argument. But since Einstein made of reality an object of belief, his argument about causality remained hanging in the mid-air of non-reality. So the two, Born and Einstein, talked over 40 years over one another's head until W. Pauli, prompted by Born's frustration, made matters clear and very revealing as well. On learning from Born that Einstein did not wish to continue their correspondence on causality, Pauli wrote to Born that Einstein's principal concern was reality. Causality came second. It made no sense on Born's part, Pauli continued, to dispute causality without facing up to the primary point for Einstein, that is, reality. Such was a perfect clarification of the true order between causality and reality, a clarification which Born did not communicate to Einstein. Einstein was already 73 and in poor health. Feelings too cooled between Einstein and Born. But the most important reason for Born's failure to mention to Einstein Pauli's letter lies undoubtedly in Pauli's revealing comment on the whole dispute. Pauli took the view, which certainly would have outraged Einstein, that questions about reality were as metaphysical and useless as was the concern of medieval philosophers about the number of angels that could be put on a pinhead.[24]

Einstein died without seeing any change in the respective strengths of the two camps. In 1981, a quarter of a century after his death, the situation remains the same. This should be a warning to those who read too much into

23. "Maxwell's Influence on the Development of the Conception of Physical Reality", in *James Clerk Maxwell: A Commemoration Volume 1831-1931*. Essays by Sir J. J. Thomson et al., (Cambridge, University Press 1931), p. 66. The continuation of the statement, "But since our sense-perceptions inform us only indirectly of this external world, or Physical Reality, it is only by speculation that it can become comprehensible to us", reveals Einstein's inability, that for all his longing for realism, he could not free himself of the shackles of Kant's philosophy which he imbued as a youth.

24. *The Born-Einstein Letters,* pp. 221 and 223.

the occasional admission of this or that prominent representative of the Copenhagen school that quantum mechanics may not be the last word in physics. Nothing changed when Professor Dirac, who first made a name for himself with a still classic book on quantum mechanics in 1930, declared in the Jerusalem Einstein Centennial Conference in 1979:

> "It seems clear that present quantum mechanics is not in its final form. Some further changes will be needed, just about as drastic as the changes which one had made in passing from Bohr's orbit to quantum mechanics. Some day a new relativistic quantum mechanics will have determinism in the way that Einstein wanted. This determinism will be introduced only at the expense of abandoning some other preconceptions which physicists now hold, and which it is not sensible to try to get at now... So under these conditions I think it is very likely, or at any rate quite possible that in the long run Einstein will turn out to be correct even though for the time being physicists have to accept the Bohr probability interpretation — especially if they have examinations in front of them".[25]

If such a statement, prominent as it is, does not produce a spirited reaction, and it did not produce any, then it should be easier to understand why other efforts to break through the walls of the Copenhagen fortress have been ineffective. Illustrations are the very weak responses to books and articles written by D. Bohm, P. Vigier and others in the 1950s and 1960s, on behalf of a theory which permits exact calculations of atomic phenomena, an outcome which, very wrongly, is taken for proof of causality. Such a theory is usually referred to as a hidden variable theory, because it implies that beneath the quantum level deterministic, though hidden factors are at play.[26] Instead of providing a safe foundation for a philosophy which assumes strict, deterministic causality on the physical level, the hidden variable theory makes matters even more confused for those who base their philosophy on the techniques of mathematical physics. Such seems to be the unintended message of the famous theorem proposed by John S. Bell in 1964. Any hidden variable theory, which wants to keep also the statistical predictions of quantum mechanics, leads, in Bell's words, to the conclusion that "there must be a mechanism whereby the setting of one measuring device can influence the reading of another instrument, however remote. Moreover, the signal involved

25. The statement saw print only through its having been quoted by R. Resnick, *Misconceptions about Einstein: His Work and his Views*, «Journal of Chemical Education» 52 (1980), p. 860.

26. For a still very useful and amply documented discussion, see *A Survey of Hidden-Variables Theories* by F. J. Belinfante (Oxford, Pergamon Press 1973).

must propagate simultaneously, so that such a theory could not be Lorentz invariant".[27] It may of course be true that in Bell's paper not all possible types of hidden variable theories were taken into account. Regardless of this, Bell's theorem is a strong reminder of the impossibility of strict localization by measurement, an impossibility implied in Heisenberg's principle. If this impossibility is then taken in a philosophical sense, and if one still wants to keep the idea of a coherent physical world, then instantaneous communication between instruments is to be assumed. Now if instruments can communicate with one another, then why not minds? Have not minds, under the impact of computer development, become largely taken for natural counterparts of artificial intelligence? Indeed, Bell's paper provided much encouragement to advocates of ESP (extrasensory perception) and TK (telekinesis).[28] The phot*on*, which is the exchange particle of electromagnetic interactions in quantum mechanics, and the gravit*on* of gravitational forces have now a mental counterpart under the name of mind*on*, the presumed exchange particle in ESP and TK, and ultimately in all mental interactions, including any ordinary discourse.

The mindon is one example of the philosophical fruits of the drastic meaning of Heisenberg's principle, a meaning about which one cannot emphasize enough that it is a philosophical meaning going far beyond the purely scientific realm. In addition to the mindon, the philosophical history of quantum mechanics provided other telling examples of how the logic operating within a philosophical claim, such as that drastic meaning, unfolds its true nature as time goes on. The last decade witnessed, for instance, the proposition (and a very valid one), that Heisenberg's principle leads to the multiworld theory which states that there are as many worlds as there are observers.[29] If such is the case, the fact that scientists, each of whom has his own individual world, or perhaps even better, is his own individual world, still understand one another, becomes a mystery, or perhaps a sheer miracle.

27. *On the Einstein-Podolsky-Rosen Paradox*, "Physics" 1 (1964), p. 199.

28. As can readily be gathered from *The Roots of Coincidence*, by A. Koestler (London, Hutchinson 1972), a book devoted to the support of the claim that modern physics validates experiments on ESP and TK. It tells much of Koestler's philosophy that he ends with an advocacy of a world-mind into which all individual minds are diffused to the extent of losing their identity. The saving of free will on the basis of modern physics exacts indeed a very heavy price.

29. For a brief account, see the concluding section, "Many-World Theories", in M. Jammer, *The Philosophy of Quantum Mechanics: The Interpretations of Quantum Mechanics in Historical Perspective* (New York, John Wiley 1974), pp. 507-21. For a criticism of Jammer's philosophically facile presentation of those theories, see my *The Road of Science and the Ways to God.*

Modern scientists and philosophers would not, of course, propose a miracle for the explanation of that mystery, as did Malebranche and Leibniz, who explicitly considered such a situation. Another example of the same process leading to a philosophically disturbing situation is the principle of "man-centered objectivity", advocated recently by the prominent French physicist Bernard d'Espagnat.[30] No comment is deserved by solipsism, which has for long been recognized as an inevitable implication of the drastic meaning of Heisenberg's principle.

Unfortunately, only on occasion does one find a prominent spokesman of that drastic meaning who is ready to admit that on the basis of that drastic meaning he is not allowed to say that a thief took his wallet, but only that he has the sensation of his wallet having been taken away.[31] What this shows is that the world as articulated in terms of that drastic meaning is a world of philosophical robbery. Those who engage in a dispute with its proponents lend their support to a situation in which thieves can freely operate without the possibility of ever being apprehended. Such an outcome, in which to be and not to be are ultimately indistinguishable, is not something to cheer about. Worse, this outcome should have appeared a foregone conclusion half a century ago, at least to those taking a long look at some lines in Bertrand Russell's *Outline of Philosophy*, a book published in 1927, the year when Heisenberg formulated his uncertainty principle. The principle, as I have said, had for some time been in the air, and if anyone then Bertrand Russell could sense the kind of philosophical atmosphere generated by some scientists in 1925 and 1926 when he was writing his book. According to Bertrand Russell: "For aught we know an atom may consist entirely of the radiations which come out of it. It is useless to argue that radiations cannot come out of nothing... Matter is a convenient formula for describing what happens where it isn't".[32] Forty years later the difference between material and strictly non-material was emphatically rejected by H. Margenau: "The quantum mechanical interactions of physical psi fields... are wholly non-material, yet they are described by the most important and most basic equations of present day quantum mechanics... which regulate the behavior of very abstract

30. In a letter to the editor of "Scientific American" 242 (May 1980), pp. 8-9. No more philosophical merit is contained in the reification of quantum states through which V. Weiskopf believed to have vindicated external reality in his criticism (also in a letter to the same editor, ibid, pp. 6-7) of d'Espagnat's article, *Quantum Theory and Reality*, "Scientific American" 241 (Nov. 1979), pp. 158-81.

31. Based on a private dispute of this author with a Nobel laureate physicist.

32. Quoted from the American edition which has the title *Philosophy* (New York, Norton and Norton 1927), pp. 156-59.

fields, certainly in many cases non-material fields, often as tenuous as the square root of probability". No less revealingly Margenau added that the physicist's psi —he had in mind Schrödinger's ψ function— "has a certain abstractness and vagueness of interpretation in common with the parapsychologist's psi".[33]

There are still some who seek a resolution in modern atomic physics to the age-old contrast between freedom and determinism. About speculations, which center on the uncertainty of the motion of electrons in the firing of synapses as a clue to the influence of mind on matter and to the mind's freedom to choose, one remark should suffice. The very same Eddington, who ultimately inspired those speculations, had realized their futility at a very early date.[34] What Eddington failed to recognize was that the ultimate reason behind the failure of such speculations is the difference between quantum mechanics as a science, and the drastic philosophy which its scientific architects, including Eddington himself, erected around that science. The science of quantum mechanics states only the impossibility of perfect accuracy in measurements. The philosophy of quantum mechanics states ultimately the impossibility of distinguishing between material and non-material, and even between being and non-being. Physicists who fail to realize what this means for their science should remind themselves of a remark of James R. Newman, for many years the editor of "Scientific American" and always full of admiration for the work of physicists: "The more creative physicists have in recent years cultivated philosophy. They are usually disinclined to admit to this weakness. But there is no escape, even if it be only to embrace anti-philosophical philosophies. For the physicist has come to realize that if he throws philosophy into the fire, his own subject goes with it".[35]

At any rate, if it is impossible to distinguish between being and non-being, then efforts to say anything about freedom and determinism become utterly meaningless. Of course, scientists, including the leading spokesmen of the Copenhagen school, would never admit that they were not truly free as they searched for and made their great discoveries. For if they were not

33. "ESP in the Framework of Modern Science", in *Science and the ESP*, edited by J. R. Smythies (London, Routledge and K. Paul 1967), p. 209.

34. Eddington, who suggested in 1934 in his lectures at Cornell University (*New Pathways of Science*, Cambridge, University Press, 1935, p. 88) that calculations of the width of uncertainty may be an indication of the "measure" of human freedom, declared such suggestions to be nonsensical in his *The Philosophy of Physical Science* (London, Macmillan 1939), p. 182.

35. Such is the conclusion of Newman's long review of D. Bohm's *Causality and Chance in Modern Physics* (1957) in "Scientific American" 198 (Jan. 1958), p. 116.

free, what is the ground for their receiving awards and Nobel Prizes? But if they admit that they were free, their philosophy of quantum mechanics must face up to at least one certainty on the most fundamental level of existence. That they do not see this contradiction provides only one more example of the truth of Einstein's statement, "The man of science is a poor philosopher".[36] He was indeed one, in the sense that he could never articulate his good philosophical instinct. He failed to write even a short article on his recognition that science was merely a refinement of common sense. He did not even suspect that Scottish philosophers, who in the second half of the 18th century made the term common sense fashionable,[37] did not steer philosophical development toward that realism which he wanted to vindicate. But Einstein at least recognized that the science of physics entitled no one to sit in judgment over the question of freedom versus determinism. Although once more his statements were not articulate, they were certainly dramatic. It is not the uranium but the heart of man that should be purified, he said to a journalist in the wake of Hiroshima.[38] About the same time he admitted to one of his biographers that he never derived a single ethical value from physics.[39] His most revealing statement in this connections is from his correspondence with Born. Still during World War II Born urged Einstein to propose the formation of an International League of physicists to prevent the turning of physics into a tool of global destruction. Einstein replied: "The medical men have achieved amazingly little with a code of ethics, and even less of an ethical influence is to be expected from pure scientists with their mechanised and specialised way if thinking".[40]

Einstein's description of scientific thinking as mechanized may seem to contradict his own repeated statements that there was no logical, that is, mechanical way to discoveries. Discoveries, great conceptual novelties are few and far between in science. For most of the time most scientists reason within an already given conceptual framework. In view of the univocal character of their whole subject matter, or the quantitative aspects of entities and

36. "Physics and Reality" (1936), in *Out of My Later Years* (New York, Philosophical Library 1950), p. 59.

37. The emphasis laid by T. Reid and his followers on the instinctiveness of common sense lent ultimately support to theories of knowledge steeped in emotionalism if not plain irrationalism. See for details, E. Gilson, *Réalisme Thomiste et Critique de la Connaissance* (Paris, Vrin 1939), pp. 14-22.

38. In an interview with M. Amrine, "The New York Times Magazine", June 23, 1946, pp. 42-44.

39. P. Michelmore, *Einstein: Profile of the Man* (New York, Dodd, 1962), p. 251.

40. *The Born-Einstein Letters*, p. 148.

their interactions, their reasonings often resemble the operation of a logic machine. Yet even then reasoning as a free act of understanding is very different from a purely mechanical operation. Interestingly, it was at a time, during the second half of the 19th century, when classical deterministic physics seemed to come within the explanation of all physical interaction, that leading physicists (Maxwell, Lord Kelvin, Helmholtz and many others) stressed the incompetence of physics in matters relating to freedom.[41] A major echo of that emphasis came in our century from none other than A. H. Compton whose work was indispensable for the formulation of Heisenberg's principle. In a lecture series given at Yale in 1934 Compton declared that one's inner conviction to move one's finger at will carried greater and more immediate evidence than all the evidence of the laws of physics and if freedom and physics were ever to be found in conflict physics was to be corrected and not our freedom to be doubted ever so slightly.[42]

Proponents of the drastic meaning of Heisenberg's principle still have to face up to some problems with all the seriousness required by the issues at stake. One problem is the definition of chance. Do they mean something ontological or something which is merely a mathematical device? If they mean the latter, they should ask themselves whether there is a mathematical theory of randomness which would not include at least one, subtly concealed non-random parameter in the ensemble. If they have something ontological in mind, they should ask themselves whether, within their perspective, chance can be anything but a negation of ontological causality. In that case they should ponder the problem of non-being as the cause of something that is a being. For such is ultimately the problem of a physical interaction in which either the effect comes into being without a cause, or it contains a surplus with respect to its cause. In a more specific sense they should face up to the problem of absolute chance and absolute chaos. It may help them if they recall that this problem was not first posed by modern quantum mechanics and Heisenberg's principle. The problem was much discussed in connection with natural selection as postulated by Darwinian evolution. Unlike T. H. Huxley, many Darwinists were inclined to take that selection for a purely random process. Had not such been the case, the famed logician, Charles S. Peirce, would not have, almost exactly a hundred years ago, begun his comments on Darwinism with the following phrase: "A truly evolutionary

41. See Chapter ix, "Physics and Ethics", in my *The Relevance of Physics* (Chicago, University of Chicago Press 1966).

42. *The Freedom of Man* (New Haven, Conn., Yale University Press 1935), p. 26.

philosophy of nature would suppose that in the beginning —infinitely remote— there was a chaos of unpersonalized feeling, which being without connection or regularity would properly be without existence".[43]

That the passage from non-existence to existence on the basis of perfect chaos or pure chance bothers few scientists and philosophers today, tells much of the true measure of their sensitivity to what really matters. The fearless logic, with which the implications of the drastic meaning of Heisenberg's principle have been drawn, has not been matched by a fear of that logic which is the art of going wrong with confidence. Admiration is certainly owed to a thinker, say, a St. Augustin, who after much pondering on such a deep problem and immediate experience as time declares: When you don't ask me about it I know what it is; when you ask me, I don't know. Chance may be a problem, though hardly deeper than any branch of probability calculus and it is certainly not an experience, not even in atomic physics. Proponents of the drastic meaning of Heisenberg's principle failed to come up with the kind of chance which Schrödinger once pointedly described as "intelligible chance".[44] About chance in that drastic meaning it hardly can

43. *Collected Papers of Charles Sanders Peirce*, edited by Charles Hartsthorne and Paul Weiss (Cambridge, Mass., Harvard University Press 1931-35) vol. VI, § 33. The rest of the passage is no less expressive of the true logic of absolute or pure chance as implied in typical evolutionary theory: "This feeling, sporting here and there in pure arbitrariness, would have started the germ of a generalizing tendency. Its other sportings would be evanescent, but this would have a growing virtue. Thus, the tendency to habit would be started; and from this, with the other principles of evolution, all the regularities of the universe would be evolved. At any time, however, an element of pure chance survives and will remain until the world becomes an absolutely perfect, rational, and symmetrical system, in which mind is at last crystallized in the infinitely distant future". Compared with this dash in a few lines from the non-being of pure arbitrariness to an absolutely perfect system while pure chance remains always at work, Aristotle's often decried one-page-long derivation on a priori grounds in his *On the Heavens* of the shape and structure of the universe should appear a very sober enterprise.

44. E. Schrödinger, *What is Life and Other Scientific Essays* (Garden City, N.Y., Doubleday 1956), p. 199. Schrödinger was right in seeing "intelligible chance" at work both in Boltzmann's statistical theory and in genetic mutations because both imply several clearly defined parameters.

Note added in proofs (Oct. 31, 1981). The result, as reported in "Physical Review Letters" (Aug. 17, 1981, pp. 460-63), of the experiments of A. Aspect et al., on the linear polarization correlation of photons emitted in a radiation cascade of calcium, strongly suggests the incompatibility of quantum mechanics and of all hidden variables theories which retain the relativity principle that no signal can travel faster than light. The result can, however, have no bearing on the question of causality if it is true, as was argued throughout this paper, that causality is not a function of the possibility of measuring with be claimed that one knows what it is when not asked about it. The fact, an often observed fact, however, is a baffled silence given for answer when the debate is shifted from techanicalities covering up that drastic meaning to the plain and blunt question: What i s chance?

If that drastic meaning of chance is vindicated on the ground that knowledge is to be suspended about everything which is not directly observable, only the realm of philosophical poverty and insensitivity is extended beyond limit. Instead of rehashing the old though ever timely subject of universals, let me rely on the principle that one illustration is worth a thousand definitions. Claude Bernard was a famed student of life processes all his life both as an experimentalist and as a philosopher. He studied at length the question whether life was to be explained in a mechanistic or in a vitalistic framework. To someone pressing him on this point, he once gave the terse reply: I have never observed life. He, of course, would have never stated that he did not know life, in spite of the fact that he never observed it. To know life, and to know an immense range of entities, stretching from mere matter through organic life to men (including the physicists of the Copenhagen persuasion), much more is needed than mere observation. Much the same surplus is contained in our knowledge of physical interactions versus measurements in physics. Knowledge of that interaction existed long before physics and physicists. That knowledge relied of course on a rough, commonsense estimate of the equality of effect with cause. To make the certainty of that knowledge an exclusive function of measurements with no uncertainty involves not so much a scientific impossibility as an elementary error in logic. Ancient Greek philosophers gave it the name, μετάβασις εἰς ἄλλο γένος, the favorite technique of those who thrive on confusion and also of those who somewhat innocently dupe themselves. In this age of quantum mechanics and of lucky and unlucky shots of all sorts, one may prefer the name 'philosophical quantum jump', a most fatal jump indeed if judged by its consequences for our understanding of measurements in physics, interactions in nature, chance, determinism, to say nothing of such far deeper and more crucial topics as freedom and reality itself.

---

absolute precision. That the result is being played up in a counter-ontological sense is as much part of the contemporary philosophical malaise as is the taking of hidden variables theories as equivalent to ontological causality because they imply exact localization in space. Only somersaults in logic can make 'exact' appear identical to 'real'.

ΤΥΧΗ Ή ΠΡΑΓΜΑΤΙΚΟΤΗΤΑ;

ΑΛΛΗΛΕΠΙΔΡΑΣΗ ΣΤΗ ΦΥΣΗ ΚΑΙ ΜΕΤΡΗΣΗ ΣΤΗ ΦΥΙΚΗ

Περίληψη.

Στὴν ἀρχὴ τῆς ἀβεβαιότητας, ὅπως διαμορφώθηκε ἀπὸ τὸν Heisenberg τὸ 1927, ἔχουν ἀποδοθεῖ δύο πολὺ διαφορετικὲς ἑρμηνεῖες. Σύμφωνα μὲ τὴν πρώτη, ἡ ἀρχὴ αὐτὴ δηλώνει ἁπλὰ τὰ ὅρια τῆς ἀκρίβειας ποὺ μπορεῖ νὰ ἐπιτευχθεῖ σὲ μετρήσεις χρήσιμες γιὰ τὴν πρόβλεψη τῆς ἐμφάνισης φυσικῶν γεγονότων. Σύμφωνα μὲ αὐτὴ τὴν ἑρμηνεία, ἡ ἀρχὴ τῆς ἀβεβαιότητας δὲν ἐπιβάλλει καμιὰ οὐσιαστικὴ ἀπομάκρυνση ἀπὸ τὸν βασικὸ ἰσχυρισμὸ τῆς Κλασικῆς Φυσικῆς, ὅτι οἱ ἀλληλεπιδράσεις στὴ φύση εἶναι αὐστηρὰ καθορισμένες. Γιὰ τοὺς κλασικοὺς φυσικοὺς ἡ ἀρχὴ τοῦ αὐστηροῦ «ντετερμινισμοῦ» (αἰτιοκρατίας) δὲν ἐξαρτιόταν ἀπὸ τὴ δυνατότητα μέτρησης μὲ ἀπόλυτη ἀκρίβεια. Ἀκόμη, εἶχαν πλήρη ἐπίγνωση τῆς ἀδυναμίας νὰ ἐπιτευχθεῖ στὴν πράξη ἀπόλυτη ἀκρίβεια στὶς μετρήσεις. Παρ᾽ ὅλα αὐτά, οἱ φυσικοὶ αὐτοὶ ἐπέμεναν στὴ θεωρητικὴ δυνατότητα μιᾶς τέτοιας ἀκρίβειας, ποὺ συνοψίζεται στὴν Λαπλασιακὴ ἀντίληψη ἑνὸς ἀνωτέρου πνεύματος, γιὰ τὸ ὁποῖο ὅλοι οἱ μελλοντικοὶ συνδυασμοὶ τῆς ὕλης εἶναι ὑπολογίσιμοι, γιατὶ τὸ σύνολο τῶν ἀρχικῶν συνθηκῶν τοῦ εἶναι γνωστὸ γιὰ κάθε στιγμὴ καὶ μὲ ἀπόλυτη ἀκρίβεια. Ἐνῶ ἡ πίστη στὴ δυνατότητα τῆς μέτρησης μὲ ἀπόλυτη ἀκρίβεια ἐθεωρεῖτο κατὰ τὸν 18ο καὶ 19ο αἰώνα, ἔστω συχνὰ καὶ κάπως ἀ-λογικά, ὡς τεκμήριο αὐστηροῦ «ντετερμινισμοῦ» στὶς ὑλικὲς ἀλληλεπιδράσεις, ἡ ἔννοια τοῦ τυχαίου, τόσο στοὺς φιλοσοφικοὺς ὅσο καὶ στοὺς ἐπιστημονικοὺς κύκλους, ἀπορρίπτονταν μὲ τὴν ἀναγωγή της σὲ ἀπουσία αὐστηρῆς καὶ πλήρους αἰτιοκρατίας.

Ἀρκετὰ διαφορετικὴ ἐμφανίζεται ἡ πεποίθηση πολλῶν φιλοσόφων καὶ φυσικῶν ἀπὸ τὴ στιγμὴ ποὺ διαμορφώθηκε ἡ ἀρχὴ τῆς ἀβεβαιότητας. Ἀποδίδουν τώρα στὴν ἀρχὴ αὐτὴ μιὰ σημασία, ἡ ὁποία ἰσοδυναμεῖ μὲ τὴν ἀπουσία αὐστηρῆς αἰτιοκρατίας στὶς ὑλικὲς ἀλληλεπιδράσεις τουλάχιστον στὸ ἀτομικὸ καὶ σωματιδιακὸ ἐπίπεδο, ὅπου ἡ ἀβεβαιότητα τῆς σύγχρονης μέτρησης συζυγῶν μεταβλητῶν, ὅπως ἡ θέση καὶ ἡ ἀδράνεια ἢ ἡ ἐνέργεια καὶ ὁ χρόνος, ἰσοῦται —καὶ πολὺ συχνὰ εἶναι μεγαλύτερη— ἀπὸ τὸ μέγεθος ποὺ πρόκειται νὰ καθοριστεῖ. Τὰ πρῶτα ἕξη χρόνια μετὰ τὴ διατύπωση τῆς ἀρχῆς, ἡ δεύτερη αὐτὴ ἑρμηνεία ἐκφράστηκε καθαρὰ ἀπὸ διακεκριμένους φυσικούς, οἱ ὁποῖοι διατύπωσαν καὶ ὁρισμένες ἀπὸ τὶς βαρυσήμαντες, ἀπὸ φιλοσοφικὴ ἄποψη, καὶ ἀποκαλυπτικὲς συνέπειες τῆς ἑρμηνείας. Τὴν ἀπόρριψη τοῦ αὐστηροῦ «ντετερμινισμοῦ» ἀκολούθησε γρήγορα ἡ ἀπόρριψη τῆς αἰτιότητας καθ᾽ αὑτῆς καὶ ἀμφισβητήθηκε ἀκόμη καὶ ἡ ἴδια ἡ ἀντι-

κειμενικότητα τῆς ὑλικῆς ὕπαρξης. Ἡ Σχολὴ τῆς Κοπεγχάγης εἶναι ἔκτοτε ὁ κυριότερος ὑποστηρικτὴς αὐτῆς τῆς δεύτερης ἑρμηνείας τῆς ἀρχῆς τῆς ἀβεβαιότητας.

Μιὰ μικρὴ ὁμάδα διακεκριμένων φυσικῶν, μὲ ἐπικεφαλῆς τὸν Einstein, ἀντιστάθηκε σθεναρὰ σὲ μιὰ τέτοια φιλοσοφία τῆς φυσικῆς καὶ τῆς φύσης. Στὴν ἀντίθεσή τους αὐτὴ ἐπέλεξαν ὡστόσο λανθασμένη προσέγγιση, ἡ ὁποία κατὰ κάποιο τρόπο ἀποτελοῦσε ἐπανάληψη τῆς ἀφελοῦς ἀντίληψης ὁρισμένων κλασικῶν φυσικῶν, ὅτι ἡ δυνατότητα ἀκριβοῦς μέτρησης —ὅσο θεωρητικὴ κι ἂν εἶναι— ἰσοδυναμοῦσε μὲ ἐπίδειξη αὐστηρῆς ὀντολογικῆς αἰτιότητας. Ὁ Niels Bohr, ὁ κύριος ἐκπρόσωπος τῆς Σχολῆς τῆς Κοπεγχάγης, πέτυχε νὰ δείξει ὅτι, ἐφόσον στὴ διαδικασία μετρήσεων ἐξαρτιόταν κανεὶς ἀπὸ τὴν ἠλεκτρομαγνητικὴ ἀκτινοβολία (φῶς) ἢ ἀπὸ ἕνα ρεῦμα τῶν κβάντα τοῦ Plank, οἱ προσπάθειες τοῦ Einstein καὶ ἄλλων νὰ ἐπινοήσουν ἰδανικὲς μετρήσεις μὲ ἀπόλυτη ἀκρίβεια ἦταν καταδικασμένες νὰ ἀποτύχουν. Ἀπεναντίας ὁ Einstein μποροῦσε νὰ ἐπιμείνει μόνο στὴν ἀντίληψή του γιὰ τὴν πραγματικότητα χωρὶς ὅμως νὰ τὴν διατυπώνει ποτὲ μὲ ἱκανοποιητικὸ φιλοσοφικὰ τρόπο. Ὁπωσδήποτε στὴ διαμάχη μεταξὺ τοῦ Einstein καὶ τοῦ Max Born, ἡ ὁποία κράτησε δεκαετίες, συνειδητοποιήθηκε καὶ ἀπὸ τὶς δύο πλευρές, ἂν καὶ ἀρκετὰ ἀργά, ὅτι τὸ βασικὸ ζήτημα δὲν ἦταν ἡ δυνατότητα μέτρησης μὲ ἀπόλυτη ἀκρίβεια ἀλλὰ ἡ πραγματικότητα καθ' αὑτὴν καὶ ὅτι τὸ πρόβλημα τοῦ αὐστηροῦ «ντετερμινισμοῦ» ἀποτελοῦσε πόρισμα τῆς ἀντίληψης γιὰ τὴν πραγματικότητα.

Μιὰ ἄλλη ὄψη τῆς διαμάχης ποὺ προέκυψε ἀπὸ τὴν δεύτερη ἑρμηνεία τῆς ἀρχῆς τῆς ἀβεβαιότητας τοῦ Heisenberg σχετίζεται μὲ τὴν δυνατότητα ἐπινόησης μιᾶς θεωρίας λανθανουσῶν παραμέτρων. Μιὰ τέτοια θεωρία θὰ ἐξασφάλιζε βέβαια μὲ ἀπόλυτη ἀκρίβεια τὴν μετρησιμότητα σὲ ἕνα ὑποθετικὸ ἐπίπεδο κάτω ἀπὸ τὶς περιοχὲς ποὺ καθορίζονται ἀπὸ τὰ κβάντα (ἀτομικὴ καὶ πυρηνική), θὰ ἄφηνε ὅμως ἀνέπαφη τὴν πιθανολογικὴ ἑρμηνεία τῶν μετρήσεων στὸ ἐπίπεδο τῶν κβάντα. Ὁποιαδήποτε κι ἂν εἶναι ἡ τελικὴ ἐπιτυχία τῶν θεωριῶν λανθανουσῶν παραμέτρων —ποὺ καμιὰ ἀπὸ αὐτὲς δὲν ἔχει τύχει εὐρύτερης ἀποδοχῆς ἀκόμη—, θὰ ἀποδείξουν μόνο τὴ δυνατότητα μέτρησης μὲ ἀπόλυτη ἀκρίβεια τῶν συζυγῶν μεταβλητῶν, πράγμα ποὺ δὲν εἶναι καθόλου ταυτόσημο μὲ τὴν ἀπόδειξη τῆς αἰτιοκρατίας.

Ἡ παραθεώρηση αὐτῆς τῆς διαφορᾶς ἀποτελεῖ τὴν πηγὴ παρανοήσεων ἀναφορικὰ μὲ τὴν ἐπίδραση στὸ πρόβλημα πειραμάτων ἐμπνευσμένων ἀπὸ τὴν θεωρία τοῦ J. S. Bell, ὁ ὁποῖος τὸ 1964 ὑποστήριξε ὅτι μιὰ θεωρία λανθανουσῶν παραμέτρων, ἡ ὁποία περιλαμβάνει τὴν Κβαντομηχανική, ὑπονοεῖ προβλέψεις διάφορες ἀπὸ αὐτὲς ποὺ προκύπτουν μὲ βάση τὴν Κβαντομηχανικὴ καὶ μόνο. Πολὺ μεγαλύτερη σημασία ἀπὸ αὐτὰ τὰ κυρίως τεχνικὰ σημεῖα ἐμφανίζουν οἱ φιλοσοφικὲς προεκτάσεις, οἱ ὁποῖες προέκυψαν πρόσφατα, μέσα καὶ ἔξω ἀπὸ τὴν Φυσική, ἀπὸ τὴν δεύτερη ἑρμηνεία τῆς ἀρχῆς τῆς ἀβεβαιότητας. Μέσα στὴ Φυσικὴ ἐμφανίζεται ἡ θεωρία τῶν πολλαπλῶν κόσμων καὶ ἡ ἀρχὴ τῆς ἀνθρωπο-κεντρικῆς ἀντικειμενικότητας. Ἡ δεύτερη θὰ φαινόταν ἀντιφατικὴ ἀκόμη καὶ μὲ μιὰ ἁπλὴ θεώρηση. Ἡ πρώτη δὲν λέει τίποτα λιγότερο ἀπὸ τὸ ὅτι ὑπάρχουν τόσοι κόσμοι ὅσοι καὶ παρατηρητές. Ἔξω ἀπὸ τὴν Φυσικὴ ἰσχυρισμοὶ τῆς παραψυχολογίας, τῆς τηλεκίνησης καὶ τῆς ἐξω-αἰσθητηριακῆς ἀντίληψης δικαιώθηκαν μὲ μιὰ ἀναφορὰ στὴν ἀρχὴ τῆς ἀβεβαιότητας, ἡ ὁποία κατὰ κάποιο τρόπο εἶναι τὸ νευρικὸ κέντρο τῆς θεωρίας τῶν κβάντα.

Ἡ ἀρχὴ τῆς ἀβεβαιότητας, ἡ ὁποία μὲ τὴ δεύτερη ἑρμηνεία της ἐνέπνευσε ἐντελῶς ὑποκειμενικὲς ἀπόψεις γιὰ τὴν πραγματικότητα, θὰ ἔπρεπε νὰ φαίνεται ἐκ πρώτης ὄψεως ὕποπτη ὡς ὁδηγὸς γιὰ τὴν ἐπίλυση τῆς σύγκρουσης μεταξὺ τῆς ἐλεύθερης θέλησης καὶ τοῦ «ντετερμινισμοῦ». Θεωρίες οἱ ὁποῖες σκοπεύουν στὴν ὑπεράσπιση τῆς ἐλευθερίας τῆς βούλησης καταφεύγοντας στὴν Κβαντομηχανικὴ εἶναι ἐνδογενῶς ἐλαττωματικὲς γιὰ δύο λόγους: Πρῶτον, ἡ αἰτιοκρατία στὴ φύση δὲν μπορεῖ νὰ χρησιμοποιηθεῖ ὡς ἀντεπιχείρημα γιὰ τὴν ἀνθρώπινη ἐλευθερία, ἡ ὁποία ἐπιβάλλεται μὲ πολὺ ἀμεσότερη τεκμηρίωση, πράγμα ποὺ τονίζεται συχνὰ ἀπὸ διακεκριμένους φυσικούς. Δεύτερον, ὅλες αὐτὲς οἱ θεωρίες ἀδυνατοῦν νὰ δώσουν μιὰ ὀρθὴ ἀπάντηση στὸ ἐρώτημα γιὰ τὸ τυχαῖο. Ἀποτελεῖ μήπως τὸ τυχαῖο ἁπλὸ στατιστικὸ φορμαλισμὸ ἢ μήπως ἀντιπροσωπεύει τὸν ἐξυπονοούμενο ἰσχυρισμό, ὅτι μπορεῖ κάτι νὰ προκύψει ἀπὸ τὸ τίποτε; Τὸ τυχαῖο, ὅπως ἀντιπαρατίθεται στὸ πραγματικό, ἀποτελεῖ τὴν θεμελιώδη ἐναλλακτικὴ ἄποψη, στὰ πλαίσια τῆς ὁποίας πρέπει νὰ ἀντιμετωπίζονται οἱ διαμάχες ποὺ ἐκδηλώθηκαν μὲ τὴν ἀρχὴ τῆς ἀβεβαιότητας σχετικὰ μὲ τὴν αἰτιοκρατία καὶ τὴν ἐλευθερία. Ἀποτελεῖ σημεῖο τῆς φιλοσοφικῆς φτώχειας τῶν καιρῶν μας τὸ ὅτι τόσο οἱ ἐπιστήμονες ὅσο καὶ οἱ φιλόσοφοι συζητοῦν πλατειὰ γιὰ τὸ τυχαῖο, ἐνῶ στὸ βάθος τοῦ ἀποδίδουν μιὰ σημασία ἀντι-οντολογική, ποὺ συνεπῶς δὲν μπορεῖ νὰ εἶναι οὔτε φιλοσοφικὴ οὔτε ἐπιστημονική.

(Μετάφραση Γ. Παπαγούνου)