The Cultural Values of Science
Pontifical Academy of Sciences, *Scripta Varia* 105, Vatican City 2003
www.pas.va/content/dam/accademia/pdf/sv105/sv105-jaki.pdf

# FROM WORLD VIEWS TO SCIENCE AND BACK

STANLEY L. JAKI

There are world views from which it is not possible to go to science. Such a world view is the one in which the many bubbles on the perspiring body of Brahma represent so many worlds that pop up randomly and in an infinite number through infinite space and time. I would not, however, be surprised if some scientists would take this world view for an anticipation of the multiverse theory, which in recent years has received the attention of leading newspapers. The latest case is the Tuesday, October 29, 2002 issue of *The New York Times*, where the headline of the Science Section declares: 'A New View of Our Universe: Only One of Many'. My reason for not being surprised is that the millions of years of world cycles as set forth in the Vedantas have repeatedly been taken as an anticipation of the vast phases of cosmic processes implied either in the Big Bang or in a cyclic cosmological model, such as that of an oscillating universe.

The article quoted many prominent astronomers in support of that idea of an infinite number of universes, but none of them cared to recall what Eddington succinctly stated in 1935: 'That queer quantity "infinity" is the very mischief, and no rational physicist should have anything to do with it'.[1] This statement is valid regardless of whether it comes from a great scientist or not. Infinity cannot be measured. Its introduction into science has always meant catastrophes. Unfortunately, a hundred years after Planck's great feat in 1900, its true significance is still to sink into broader scientific consciousness. With his feat Planck undermined the notion of physical infinity, although Planck himself failed to realize this, when he applied

[1] A.S. Eddington, *New Pathways in Science* (Cambridge: Cambridge University Press, 1935), p. 217.

finite series to account for the shape of black body radiation.[2] For as long as one tries to explain that shape with infinitesimal calculus, and not with the summation of discreet entities, there looms large what is called the infinity catastrophe in the ultraviolet region of black body radiation.

Another ancient world view from which it was impossible to advance to science was the combination of Confucian and Taoist world views. Joseph Needham of Cambridge offered a hollow rhetoric when he claimed that in ancient China the Taoists tried to move from a view of the world represented by a human body, to what Needham called the suppleness of the world lines of General Relativity.[3] Lately one of the most prominent experts of American constitutional law claimed that General Relativity justifies a supple interpretation of the laws, and indeed of any law. In plain language he meant to say, that one can twist and turn the law, provided one does it with sophistication. Such is the case whenever a non-scientist wraps his claims in profuse references to science, about which most in his audience know next to nothing. The legal expert was Laurence Tribe, professor at Harvard, who got a BS degree in physics before he entered Law School.[4] But I wonder whether a mere bachelor's degree in physics makes one an expert in General Relativity, which, incidentally, is the most rigid physical theory ever proposed. As Einstein himself warned, if only one of its predictions were to be contradicted by experiment, the whole theory would have to be abandoned.[5] In fact, any good physical theory is subject to this fate. Newton himself warned that if the orbits of the planets were not found to be re-entrant, his physics should be entirely recast. So much for some ancient world views that imply infinity or endless cycles for the universe.

Still another ancient world view, from which there was no advancing to science, was that of the ancient Egyptians. They viewed the world as the

[2] See my essay, 'Numbers Decide: or Planck's Constant and Some Constants of Philosophy', in J. Gonzalo (ed.), *Planck's Constant 1900-2000: An Academic Session at UAM, April 11, 2000* (Madrid. UEA Ediciones, 2000), pp. 108-134.

[3] In his *Science and Civilization in Ancient China* (Cambridge: University Press, 1954-), vol. II, pp. 146-51 and 425-29.

[4] See my article, 'Patterns versus Principles: The Pseudo-scientific Roots of Law's Debacle', *Notre Dame Law Review* (Fall 1993), pp. 135-57. Reprinted in my *Patterns or Principles and Other Essays* (Bryn Mawr MD: Intercollegiate Studies Institute, 1995), pp. 1-25.

[5] Einstein stated this in a public lecture he gave in Prague in 1920. See H. Steuwert (ed.), *Historical and Philosophical Perspectives of Science* (Minneapolis: University of Minnesota Press, 1970), p. 9.

combination of a horizontal male body, that of the deity Geb, which represents the earth, and, overarching it, the female body of the deity Nut, which represents the sky. A splendid picture of this is in the burial chambers of Rameses VI in the Valley of Kings. In this view the world is taken for a huge, all encompassing organism, a view dominating all ancient cultures and responsible in all of them for the invariable stillbirths of science. Stillbirths, because promising starts led to nowhere.[6] Such starts were, for instance, the marvelous technological feats of the Egyptians of old in technology. But they could not generalize plain arithmetic skills into general propositions.

Strange as this may seem, even the ancient Greeks are an illustration of this pattern of stillborn science. Ptolemaic astronomy, their scientifically best world, was not a world view at all. Apart from some phrases in its introduction, the *Almagest* of Ptolemy is a sheer geometrical formalism, which tells us nothing about the physical nature of the celestial sphere, of the stars and the planets, not even of the moon and of the earth, let alone of the force which moves all of them. There is some world view in Ptolemy's *Hypotyposes,* where he presents the planets as living beings, as a group of well drilled dancers or soldiers. As such, so Ptolemy claims, the planets do not bump into one another in going through their intricate paths. Neither Ptolemy, nor anyone in Late Antiquity or even later tried to go from the fantasies of the *Hypotyposes,* let alone from the astrological vagaries of Ptolemy's *Tetrabiblos*, to the science of the *Almagest*, a science of sheer geometrical formalism, which tells us nothing about the nature of the physical world.

The world view of the *Hypotyposes* harked back to the organismic world view which, after it had been proposed by Socrates in the *Phaedo,* reappeared briefly in the third part of Plato's *Timaeus.* The full working out of that world view, in which the world, at least in its sublunary part, is a huge digestive living organism, had to wait for Aristotle, who provided it in his *De Coelo* and *Meteorologica*. Within that world view everything under the moon's orb moves to achieve what is best for it, and the larger the mass or nature of a given body, the greater desire it has to move towards its natural place. From this it would follow that a mass a hundred times larger than another, would fall a hundred times faster and would reach the ground from the same height in a hundred times shorter time.

[6] For a detailed exposition of this view, see my *Science and Creation: From Eternal Cycles to an Oscillating Universe* (Edinburgh: Scottish Academic Press, 1974), chs. 1-6, that deal with six great ancient cultures.

Aristotle or the Aristotelians never drew that conclusion, for a reason which cannot really be fathomed. Perhaps it was an intellectual torpor on their part, or perhaps they recoiled from facing an obvious fallacy, which anyone could have exposed by standing on a chair, or on the edge of a roof. In all late Antiquity only Joannes Philoponus spoke up against the nonsensical nature of that Aristotelian law, but without referring to any experiment or citing any quantitative data.

Socrates chose that animistic view of the universe in reaction to the mechanistic world view of the Ionian *physikoi*. He read about that world view in a book to which Anaxagoras gave the title *On the Mind*. On reading it, Socrates first found that a mechanistic view seemed to explain everything, including the mind. But on reflection Socrates also found that it did not explain why beings such as humans, who had a mind, acted for a purpose, or for something which they thought was the best for them. Surely, Socrates argued, the mechanistic view did not explain why he had chosen not to accept the scheme of his friends, who bought off the jailkeeper so that Socrates might escape the hemlock waiting for him, although his limbs would have undoubtedly chosen to flee from prison.

Galileo did not face up to these questions as he tried to demolish the Aristotelian world view. Nor could he do so in terms of his own world view, a combination of Platonism and atomism. From Platonism Galileo developed the absurd idea that man's knowledge of quantities was as perfect as God's notion of them. From atomism he derived the view that secondary qualities such as taste and colors were mere subjective experiences and therefore not real.

It is not easy to trace the steps whereby the younger Galileo moved from the Aristotelian ideas of motion and mass toward a strictly geometrical formalism. Most likely he was at one point swayed by the power of numbers and geometrical figures in interpreting physical phenomena. The power itself has two aspects. One is the quantitative exactness, which only numbers have, the other is their full applicability wherever there are physical bodies.

Strangely, Galileo nowhere refers to the passage in the Book of Wisdom, according to which 'God disposed everything according to measure, number, and weight'. About that passage, E. Curtius, a Protestant historian of Medieval literature, stated half a century ago that it was the most often quoted biblical passage in that literature.[7] The passage may show Platonic

[7] E.R. Curtius, *European Literature and the Latin Middle Ages*, translated from the German by W.R. Trask (London: Routledge and Kegan Paul, 1953), p. 504.

influences as that Book was composed in Alexandria about 150 BC. But as the Book of Wisdom has always been part of the Catholic Canon of inspired books, Catholics like Galileo surely had to take it seriously. To what extent they did is another matter.

And this leads to that world view, which alone of all ancient world views came into a major interplay, indeed a conflict, with science. I mean the biblical world view. Within that view the world is merely a huge bedouin tent, with a floor, the earth, and a roof, the firmament. The sun, the moon, and the stars are mere decorations on that roof, the firmament, and the earth is a dish floating on waters which had no contours. Science could show no mercy to that world view.

There are quite a few who gloat over the primitiveness of the biblical world view. The late Fred Hoyle used to dismiss that view as 'the merest daub' compared with the world view of modern science.[8] Well, that world view was not even a daub when compared with the spherical world view of the Greeks.

Hoyle, who died a few years ago, should have known something about our modern scientific world view, but apparently he did not want to recognize it. He held that life on earth originated from spores that were carried from some other parts of our galaxy to the earth. He should have known that our galaxy is for the most part terribly hostile to life and therefore hardly any of those spores could have survived even a part of that long journey. The book *Rare Earth*, published two years ago by Peter Ward and Donald Brownlee, both members of the National Academy of Science, is a massive presentation of the evidence that there is little scientific ground to speculate about life, let alone intellectual life, as popping up everywhere in our galaxy. Even weaker, if possible, are the chances for life in galaxies which, unlike our galaxy, a perfect spiral, have very irregular shapes.

The world view within which life and intelligent life are ubiquitous in the universe has always been a dream, even though dressed up in science. And as it has been presented as science, it was demolished by science again and again.[9] The interesting thing is that the latest phase in that demolition has been overlooked for decades, as no attention was paid to warnings less massive than that large book, about the inevitability of that demolition. But some people in science never give up, as they promote their philosophical

[8] F. Hoyle, *The Nature of the Universe* (New York: Harper and Brothers, 1950), p. 138.

[9] See A.O. Lovejoy, *The Great Chain of Being: A Study of the History of an Idea* (1936; New York: Harper Torchbooks, 1960).

or ideological world views with profuse references to science. The protagonists of SETI (Search for Extraterrestrial Intelligence), who took part in our Plenary Meeting two years ago, have now begun to look for life which is not carbon based. Not only can they give no specifics about such a life, but they have recently hired an 'exotheologian'.[10] About a hundred and fifty years ago Moleschott and Vogt speculated about intelligent life based on phosphorus, but they stopped when it was found that the brains of geese were very rich in phosphorus. As is well known, in not a few languages geese are the epitome of stupidity. Ironically, the atomic number, 14, of silicon is just one less than that of phosphorus.

So much for the more general parts of the enterprise which is to go from world views to science. There are some specific and more profound parts as well. Profound because they are philosophical, although in some other sense very elementary. About half a century ago Karl Popper made popular a by then very old truth, that all science is cosmology.[11] This at least means that any decent scientific theory must lay a claim to universal validity, and no branch of science can be more universal in its intent than cosmology.

Cosmology, scientific or other, begins with a view of the cosmos or the world, or to use the felicitous German word, with a *Weltanschauung*. Now to have a world we must have things, unless one is a radical Platonist or a solipsist, or an advocate of an extreme form of the Copenhagen interpretation of quantum mechanics. According to that interpretation, one's mere thought is influencing one's observation, and indeed creates things, and indeed universes. These brave thinkers have still to explain why one's mere thought of a hundred dollar bill, or a bill of a hundred euros, does not produce one such entity. Tellingly those brave theorists have not yet approached with their ideas the World Bank, which certainly needs plenty of money.

All knowledge of a thing begins with the registering of its existence. Things are objects whose purpose is to object to the mind. Any philosophical or scientific system which begins with ideas instead of things puts the cart before the horse. This is so because only by means of things can ideas be conveyed to others.[12] This registering largely happens through siz-

[10] See D. Overbye, 'When it's Not Enough to Say "Take Me to Your Leader"', *The New York Times*, March 2, 2002, p. F1.

[11] K.R. Popper, *The Logic of Scientific Discovery* (1959; New York: Harper Torchbooks, 1968), p. 15.

[12] A basic theme and recurring argument in my *Means to Message: A Treatise on Truth* (Grand Rapids. MI: W.B. Eerdmans, 1999).

ing up the quantitative dimensions of a thing. Some people may be repelled by the fact that Aristotle had already pointed this out in his *Categories* (6b), but a truth may still be a truth even though proposed more than two thousand years ago. At any rate, in the same context Aristotle also stated that there is one category of words, those belonging to the category of quantities, about which the phrase 'more or less' cannot be predicated. These words are numbers. The number six cannot be more or less six. Numbers are rigid entities and they demand a rigid accounting.

This was the reason why the biblical world view came into conflict with science and was demolished by it. The point failed to be appraised in its true significance by Bellarmine, the most insightful defender of that view against Galileo. Insightful because Bellarmine hedged his bet by referring to the possibility of an eventual demonstration of the earth's motion. Two hundred and fifty years later Newman rallied to Bellarmine's defense when he wrote, in 1877, a new and very long introduction to a re-edition of a book of his he had first published as an Anglican concerning the interpretation of the Bible.[13] Believing as he did that the Bible stood for a divine revelation of utmost importance for man's ultimate purpose, Newman argued that the Church, or rather the Holy Office, was right in urging Galileo to hold his guns until he had convincing arguments that the earth did indeed move. As is well known the first such convincing argument came only two hundred years after Galileo. But, I am afraid to say, Newman, a great student of logic and of Aristotle's *Categories*, failed to consider a point, although Saint Augustine had already considered it.

Augustine readily conceded that, contrary to the biblical view of a flat earth, science had conclusively shown that the earth was spherical.[14] Augustine merely failed to say in some detail that what science showed about the earth was a set of measurements which are always quantitative. But Augustine made at least the general statement that if the human intellect established something convincingly about the physical world, the contrary statements of the Bible must be reinterpreted. There could only be one truth, Augustine argued, as long as God was one, and man was made in the image of God. But then Augustine came to the firmament, whose

[13] J.H. Newman, *The Via Media of the Anglican Church* (London: Longmans, Green and Co., 1897), vol. 1, p. lvi.

[14] He did so in his *De Genesi ad litteram* on which he worked for almost two decades. For a discussion, see my *Genesis 1 through the Ages* (2d rev. ed.; Royal Oak, Mich.: Real View Books, 1998), pp. 85-86.

existence, so he felt, the Bible stated emphatically. He also seemed to know that there were, even in Ptolemaic astronomy, serious reasons against supposing that the sky was a solid roof, a firmament. Still he felt that the Bible was to be vindicated about the firmament, and so he looked for a firmament. He claimed to have found it in the path of Saturn. From Ptolemaic astrology, that is from the *Tetrabiblos*, Augustine took Saturn for a cold body, which as such, he reasoned, had to produce a vapory layer in its wake. This vapory layer Augustine called the firmament.

Now Bellarmine and all the learned theologians he consulted, must have fully known of the futility of such an explanation. By its very futility it should have reminded them that great perils were in store if one took a stance on behalf of a proposition, say the immobility of the earth, which lent itself to quantitative determination. For against such a determination no authority, divine or human, could be invoked.

All this should make it clear that the quantitative determinations of science have a decisive impact on the validity of any world view. But the reverse of this is also true. Quantitative determinations have no say about anything except the quantitative aspects of things, let alone about realities that go beyond things, such as questions of free will, purpose, and the registering of existence itself. The meaning of the verb *is* cannot be evaluated in terms of grams, or centimeters, of fluid ounces.

It became a fashion to think that quantum mechanics justified speaking of free will. Eddington was one of the few, who within a year realized that the fashion was 'a plain nonsense'.[15] Just as pervasive has been the misconception that Darwinian evolution disposed of purpose. Well, if evolution is a purposeless process, why does it issue in beings, humans, who consciously can do nothing except for some purpose? And why is it that some evolutionists devote their whole life to the purpose of proving that there is no purpose?[16] Of course, those who claim that God created every species and for a purpose, must show that such is indeed what the Bible states.

As they take the phrase of Genesis 1, that God created all plants and animals 'according to their kind', to mean that He produced each kind with a special creation, they seem to forget that what is good for the gan-

[15] See A.S. Eddington, *The Philosophy of Physical Science* (London: Macmillan, 1939), p. 128, for his repudiation of what he had stated in his *The New Pathways of Science* (Cambridge: University Press, 1935), p. 88.

[16] He did so in his Vanuxem Lectures, *The Function of Reason* (Princeton: Princeton University Press, 1929), p. 12.

der is also good for the goose. If one takes one phrase of Genesis 1 for science, then all its other phrases can and should be taken for science. Then one comes up against the firmament, against light coming before the sun, against the sun's coming at the same time as the moon and the stars, and against the coming of the plants before sunlight is on hand. There is plenty of good reason to assume that God did not want to land man in a series of patent absurdities.

The consideration of these points should be a powerful motivation for looking at Genesis 1 not so much as a revealed world view, but rather as a view that merely illustrates some moral lesson along the Bible's typical line. The lesson is conveyed in the form of a parable about the importance of observing the sabbath rest. The author of that chapter presents God as a role model for doing within six days a work, the making of *all*, a point which remains valid regardless of whether one proposes that *all* in terms of a cosmic bedouin tent or in terms of Copernican, Newtonian, or Einsteinian cosmology.[17]

So much about the coming from world views to science and from the merciless impact of science on them. What has been said should make it clear that science is particularly effective in demolishing world views. And this was a conspicuous feature of science as it came into its own, mostly through the work of Newton. Now something about the other question or whether it is possible to go from science to the world view which lay in the mind of the scientist as he began his scientific work.

Let us take Newton. He certainly did not begin with a mechanistic world view, let alone with a mechanistic philosophy. There is nothing of that philosophy in the third book of the *Principia*, which is about the 'System of the World', that is, of the system of planets. Newton does not say in the *Principia*, or elsewhere, that the system in question is a clockwork. Twenty or so years later, when he began to increase the number of Queries attached to his *Opticks*, Newton spoke of various fluids, some of them quasi-spiritual effluvia, that may explain electrical attraction and repulsion. He never tried to give a mechanistic explanation of gravitation. The first such effort, in terms of differential pressure, came twenty years after Newton, through the speculations of George Le Sage.[18] In sum, there is nothing in Newton to support what later became celebrated as a mechanistic philosophy, and was presented as Newton's thought and as demon-

[17] See my *Genesis 1 through the Ages*, pp. 274-79.

[18] See my *The Relevance of Physics* (Chicago: University of Chicago Press, 1966), p. 77.

strated by Newton. This philosophy was largely the work of such amateurs in physics as Voltaire and others. Newton's world view or philosophy had always been a strange mixture in which, in its early phase at least, the ideas of the Cambridge Neoplatonists were prominent. But one would try to do the impossible if one were to reconstruct Cambridge Neoplatonism from the *Principia*, or even from the *Opticks*, or reconstruct any consistent philosophy or world view from any or both of those works. The best parts of the *Opticks* were experimental and mathematical, and almost entirely mathematical was the *Principia*. This is why Newton called it *Philosophiae naturalis principia mathematica*, so that it may be distinguished from Descartes' *Principes de la philosophie*, which was a heap of bad philosophy to support an even worse Cartesian science.[19]

It can never be pondered long and hard enough that the title of the *Principia* was a misnomer. There was no philosophy, no epistemology, no metaphysics in the *Principia*. There was not even nature, and certainly not the kind of nature which, as a living entity, is born, grows, dies, and experiences a rebirth, if it does at all. Had Faraday known more than elementary algebra, he could have found this out by reading the *Principia*, which he never read, and could have also found out that his philosophy of nature, full of vitalism, was a far cry from Newtonianism. But for all his vitalism, Faraday longed for mechanical models, and begged Maxwell to give him such models, which Maxwell found more and more improper to do, because he himself had to give up mechanical models as he developed his electromagnetic theory. Yet he stuck with his chief mechanical model, the ether. He calculated the resistivity of the ether, its coefficient of tension and the like. All those numerical data are in the article he wrote on the ether for the ninth edition of the Encyclopedia Britannica.

Such were some of the presuppositions of Heinrich Hertz, when after demonstrating the existence of electromagnetic waves, he decided to find out *what*, please note the word *what*, electromagnetism was. He did not ask *how* electromagnetism worked. He wanted to know what it was. And after years of reflection he felt he had no choice but to write: 'Maxwell's theory is Maxwell's system of equations'.[20] This meant that to take just the case of Maxwell, it was not possible to go from Maxwell's equations, to Maxwell's world view of physical reality, which was very mechanical, let alone to his

[19] See ch. 2, 'The Spell of Vortices', in my *Planets and Planetarians: A History of Theories of the Origin of Planetary Systems* (New York: J. Wiley, 1978).

[20] H. Hertz, *Electric Waves*, tr. D.E. Jones (London: Macmillan, 1893), p. 21.

much broader world view, which was quite spiritual in the supernatural sense. Yet, if Maxwell had not been a devoutly believing Christian, but a materialist or a Comtean positivist, it would have been just as impossible to work one's way from Maxwell's electromagnetic theory to any materialistic or positivistic world view, or *Weltanschauung*.

Positivism can, of course, be of two very different kinds. One is better known, the other is hardly known. And here I consider positivism only insofar as was it professed by prominent physicists, and only with respect to their science. Kirchhoff was a positivist physicist who claimed that only the positive data of physics constituted valid knowledge. And to his credit, he spoke of nothing else, at least in science. Of course, as a cavalry officer in the Franco-Prussian war, he had to admit that there was valid knowledge even outside science. Certainly in Kirchoff's collected works one would look in vain for Nature, for philosophy, for a world view. Quite different was the case in the positivism of Oswald and of Mach. They built a general sensationist philosophy on their positivist concept of science. To speak only of Mach, he finally espoused Buddhism as the only philosophy in tune with science.[21]

There was at that time only one notable physicist who, while strictly positivist in his science, warned against drawing metaphysical and/or countermetaphysical conclusions from science. He was Pierre Duhem, the founder of chemical thermodynamics.[22] But for the most part his warnings were almost completely ignored or even misconstrued. His book, *La théorie physique, son objet et sa structure*, or its English translation, *The Aim and Structure of Physical Theory*, is still the most penetrating study on this problem. But he also warned that nothing in physics, however effective, can be used against reasoning in that much wider field which is nowadays called the humanities. These, including philosophy, must stand on their own ground, or they become games in sheer equivocations. In that case they prove totally ineffective in coping with extravagant claims coming from the scientific side, such as the grand conclusion of Heisenberg's paper of March 1927, in which he first presented what he called the principle of indeterminism. In the conclusion of his paper he stated that because all experiments are subject to the laws of quantum

[21] See my *The Road of Science and the Ways to God* (Chicago: University of Chicago Press, 1978), pp.159-60.

[22] For details, see my *Uneasy Genius: The Life and Work of Pierre Duhem* (Dordrecht; Martinus Nijhoff, 1984).

mechanics and therefore to its uncertainty relation, which he had just derived, 'invalidity of the law of causality is definitively established (die Ungültigkeit des Kausalgesetzes [ist] definitiv festgestellt'). Few are aware of the fact that by then Heisenberg had rejected causality on entirely different grounds. He did so as a spirited supporter of the romantic ideology of the Jugendbewegung.[23] Should we therefore try to reconstruct that romanticism from the principle of indeterminacy? Should we see any rhyme and reason in expressions, such as 'passion-at-a-distance', of which more and more appear in writings about arcane interactions among fundamental particles?

Heisenberg would have been entitled only to conclude that as long as one used Planck's quantum and a non-commutative algebra, one had to conclude that it was not possible to make fully accurate measurements of physical interactions implying conjugate variables. He could not even prove that fully accurate measurements were absolutely impossible. And he certainly did not prove that the principle of causality did not exist. For even if causality was reduced to mechanistic causality, there was more to it than the idea of fully accurate measurements. And when causality was taken in its ontological sense, in relation to being and not being, then Heisenberg's conclusion amounted to a plain irresponsibility.

One could quote a number of prominent twentieth-century physicists who recognized that science in its most exact form was a mere set of calculations. Such a physicist was Feynman. Another was, and this may surprise many, Niels Bohr, the father, with Heisenberg, of the Copenhagen interpretation of quantum theory. All quantum physics, Bohr said, is a set of rules and nothing more.[24] In other words, insofar as quantum mechanics is science, it is not a world view, a philosophy of nature. And if quantum mechanics is turned into a world view, the sole support for this lies in the philosophy of the physicist who performs that turnover. The performance is all too often very shabby, in proof of a famous dictum of Einstein: 'The man of science is a poor philosopher'.[25] This does not mean that the scien-

[23] As well documented in P. Forman, 'Weimar Culture, Causality and Quantum Theory 1918-1927. Adaptation by German Physicists and Mathematicians to Hostile Intellectual Environment', *Historical Studies in Physical Science*, 3 (1971), pp. 1-115.

[24] N. Bohr, *Atomic Theory and the Description of Nature* (Cambridge: Cambridge University Press, 1934), p. 60.

[25] A. Einstein, 'Physics and Reality' (1936), in *Out of My Later Years* (New York: Philosophical Library, 1950), p. 59.

tist cannot be a very good philosopher, but if he is, the grounds for this must be philosophical.

Einstein was surely a poor philosopher when in the name of his science he denied the existence of free will.[26] It did not even dawn on him that unless his denial of free will was done freely, it could not constitute an argument. Nor did he, who spoke so much of human responsibility, realize the measure of his responsibility in that particular case. He denied free will in reply to a student who turned to him, as the greatest authority on earth, for advice on whether to believe in free will or not. Einstein failed to ponder that he constructed freely a four-dimensional cosmological manifold from which he could proceed only to the notion of a physical world in which there was no randomness, but no room either for any free act, including that of writing a letter.

So much for the hazards inherent in discussions of the cultural values of science as such values cannot make sense without a world view. A chief of such hazards is to run the risk of saying something equivalent to what Bohr once said, though in great confidence: 'One day the principle of complementarity will be taught as the only true religion'.[27] Anyone sharing that view has to explain how such religion can do what that word means to do as an act of *re-ligare*, or re-tie. But to what or to whom?

Philosophers can say even more startling things than some physicists. They seem to forget that when they say something which is about things and not about mere ideas, they all too often say something which is measurable. Then the scientist barges in, and rightly so. Hegel tried to escape this prospect by claiming that qualities control quantities. In reverse, this also meant – and both the Hegelian right and the Hegelian left kept saying this – that if one piles quantities upon quantities one ends up with qualities. In both cases the results for science were disastrous, to say nothing of other cultural disasters.

Contrary to Hegel, quantities remain in their splendid conceptual isolation. To a human mind which aims so desperately at a synthesis, this status of quantities may be a painful fact to consider. It may be a tiresome prospect to play always with two balls at the same time. In a higher world,

[26] Letter of April 11, 1946, to O. Juliusburger, in *Albert Einstein: The Human Side: New Glimpses from his Archives*, ed. H. Dukas and B. Hoffman (Princeton: Princeton University Press, 1979), p. 81.

[27] See *Niels Bohr: A Centenary Volume*, ed. A.P. French and P.J. Kennedy (Harvard University Press, 1985), p. 323.

such as the world of angels, let alone of God, it will be different. But here below, there is no way of reducing quantities to qualities and qualities to quantities. They form two sides of a coin, which cannot exist without having two sides. They form one reality, but the two sides cannot be integrated into one another if this means the fusing of the two into one. This is just another application of the memorable dictum about the tax coin.

Those for whom that dictum smacks of the supernatural world, may do well to ponder something about the natural world, in its totality, which is the universe. The universe is the greatest idea next to the idea of God, so Newman said in his *Idea of a University*,[28] easily the finest book ever written on higher education. I wish he had spoken not of idea but of reality, and in the interest of science. Science surely works with ideas, including the idea of the world, the universe, but the truth of any scientific conclusion must rest with empirical operation on the physically real. Now there is no scientific method that could assure an experimental, or observational proof of the physical universe, because there is no way of getting outside the universe in order to observe it. To have a rational certainty about the reality of the universe as the totality of consistently interacting things, one has to rely on a set of reasonings that are partly physical, partly metaphysical. I tried to work out that reasoning in my Liverpool University Lectures, under the title: *Is There a Universe?* In sum, one is driven back on the purely natural level too, to the image of a coin with two sides to it. Whereas the two sides are indispensable to one another, neither can be reduced to the other. Herein lies the source of all problems of any effort to go from world views to science and back and ascertain the cultural values of science.

On a much lower level it is the problem of a fish caught in a net which consists of ever smaller loops. Once the fish boldly swims into that net at its broad end, the farther it swims toward the narrow end, the less chance it has to retrace its steps to freedom. Let the wide left end of the net represent world views taken in a broad sense. The small right end of the net represents science in its quantitative exactness as well as narrowness. Just as the fish cannot move from the narrow end of the net back to the wide end, so it is with the man who goes from a world view to science and then in vain tries to retrace his track to that world view.

There is, however, a big difference. Although he must start with a world view, at the narrow end he can find science, but he cannot find there the

[28] J.H. Newman, *The Idea of a University* (8th ed.; London: Longmans, Green and Co., 1888), p. 462.

world or the universe. He finds at that narrow end only a set of quantities void of views taken in a broader sense. This is to be kept in mind in any discourse about the cultural values of science. In science there are no values in any cultural and ethical sense. Einstein himself recognized something of this when he said that he had not succeeded in deriving a drop of ethical value from his science.[29] There is no way of escaping the difference between quantities and qualities, or science and the humanities. They can come into conflict only when humanists state something which is quantitatively verifiable, and when scientists make statements that can have no quantitative verification. This conflict will fail to give uneasiness only to those who, while on this earth, try to play the angel.

[29] In an interview with P. Michelmore, *Einstein, Profile of the Man* (New York: Dodd. 1962), p. 251.

# DISCUSSION ON THE PAPER BY JAKI

ZICHICHI: You've given a complete review of what mankind has thought from the beginning of civilisation up to now. Let me make a few comments. If we project into the real world all human thought before Galilei, the number of ideas that you've mentioned have zero projection on the real world. In other words, what was thought to be correct for ten thousand years about the logic of the world was all wrong. For example, you mentioned the atomic ideas of the Greeks. The basic atomic idea of Democritus has been proved by us to be incorrect for the following reason: up to 1975 it was imagined that if an object has a structure it must be broken, and this has been going on since the birth of civilisation up to 1975 when it was proved that the proton you and me are made of, and everything is made of protons, does not break, in spite of the fact that it has an innumerable number of objects (quarks, gluons, real and virtual) inside. Why? Because the forces acting inside the proton – no one had ever imagined this – are non-Abelian forces. This, in the history of human thought, had never been realised, and it's just an example of the projection of thought into the real world. You cited Maxwell, and Faraday who preceded Maxwell, and Einstein, but you did not cite Lorentz. The greatest conceptual consequence of the Maxwell equation is the complexity of space and time. As I mentioned yesterday, if space is real, time has to be imaginary and vice versa. This has tremendous consequences, which had never been imagined by any human being in the history of thinking. From this we are now at the point of formulating the theoretical structure of the super-world using mathematics. In other words, after Euclid we thought that space had three dimensions, three for space and one for time: total four. We are now convinced, following the development of science and therefore of the real world, that we have 43 dimensions, and this had never been imagined by anyone. So, I would like to convince you that progress in scientific thought started drastically with Galilei not because Galilei was thinking: 'This is how I imagine the world', but because he

imparted to us the lesson that if you want to know the logic of nature you must perform experiments and interpret them in a rigorous mathematical form. This is how in four hundred years we could demonstrate that previous ideas were all wrong.

JAKI: First of all about the atomists, I did not talk about them at any length, but I never thought that the ancient atomists had anticipated modern atomic physics, partly because it radically differs from Democritus who claimed that atoms of all sizes must exist, even atoms of infinite size. You find this in Diels' *Pre-Socratic Fragments*. The other thing: you yourself said that with regard to space and time, first of all, long before Lorentz, Lobacevski, Gauss and Boyarin spoke of a four-dimensional manifold. You yourself said that whatever you think after that epoch-making discovery, of which man did not have thought before, you have to express it in mathematics, so you are saying exactly what I am saying. Ultimately it boils down to quantities, and that from quantities you do not get anything else, and this was your major dispute yesterday, the essence of your major dispute with Professor De Duve who spoke endlessly about philosophy, about purpose and some somersault in logic, namely chance that doesn't exhume to exclude inevitability: in Princeton any sophomore would be thrown out from the logic class if he came up with this idea. So, ultimately we have to live with quantities and with everything else, and this is the problem: we have to play with two balls all the time, and man is unwilling to live with this condition, man always wants to synthesise and to reduce everything to one single dimension, and this is the curse of reductionism, whether you call it scientific reductionism or any other kind of reductionism. It is a world view, a reductionist world view.

SHEA: Stanley, I want to thank you very much for demonstrating that wild speculation can be very stimulating. I'll make a very brief comment and ask a precise question. From the vantage point of an historian of science, one has to confess that the ideas that were thrown out were subsequently very influential, even if they were not modern science. The Atomists, for instance, deeply influenced Newton and his thinking, and Dalton also. Copernicus found the idea of the centrality of the sun in Hermes Trismegistus, so we cannot exclude that wild conjectures can be useful. This is my comment. My question is, since you insisted on the centrality of the notion of creation as being very important, could you say a few words about that precise point?

JAKI: Concerning your first comment, for which you did not ask a question, but I want to say something about it by way of a comment. All those wild ideas could be useful or utterly useless until somehow the core of those ideas was put in quantitative terms. Now, the second thing is this: the idea of creation. I have already lambasted the modern abuse of the word 'creation'. Too bad I did not bring here some clippings from *The New York Times* in which a most prominent cosmologist at MIT, Professor Guth and many others, claims that modern quantum cosmology enables him to create entire universes at least in theory, and he also said that for all we know our actual universe may have been created in a basement laboratory in another galaxy. Now, the only illuminating part of this statement is that he referred to a basement laboratory, which are usually very dark places.

Now, the idea of creation is absolutely fundamental because it allows us, assures us, that we must do *a posteriori* research. We cannot approach things on an *a priori* basis, and apriorism has been throughout the whole history of science the curse of the scientific enterprise. And also, that only in the Christian or Biblical or Catholic theological traditions you find this notion of the Creator who when He creates doesn't diminish. In all other forms of philosophic and religious traditions the first principle diminishes by producing something else out of itself. You see it in Plotinus and elsewhere, or in Spinoza. And if in this post-Christian or de-Christianising world we Christians or Catholics do not appreciate profoundly the importance of this greatest contribution of ours to world culture, then we can only blame ourselves.

SINGER: Thank you, Professor Jaki. I think we have reached our time, and it will remain difficult to know whether concepts precede theory or beliefs precede concepts or vice versa.