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Philosophical Beliefs Underlying the Formulation of Physical Laws

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ON THE LAWS OF PHYSICS

A NUMBER OF POPULAR concepts of the essence of physics and its purposes are shared among most intellectuals and even among some of the people engaged in scientific research. The roots of these concepts are buried in schoolbooks, popular newspapers and scientific articles which describe the "ideal" world of physicists. In a nutshell, this popular outlook regards the laws and theories of physics as a unique product that no two could differ on. The premise underlying this outlook is that all disputes on scientific matters may be settled in the lab, and that the scientific experiment is the final arbitrator. In fact, however, this applies only to a single aspect of natural science, namely, that which is concerned with gathering a list of observations from a given experiment. Such observations, whether they are recorded by human beings or a machine, represent nothing more than a starting point. The true scientific work, however, is the result of the interaction between the human mind and the list of observations, and what the human mind adds to it by way of causality and logical unity. This human theorization is essential and represents the true spirit of scientific work. Hence, physics is just another human experience, and like all other human experiences, its meaning, purpose and use are subject to dispute and disagreement.

Take gravity,[1] for example. It would be possible to record lists upon lists of observations, which in due time would fill thousands of pages containing information on bodies falling to earth: on the shape of the body, its volume, its density, the kind of material it is made of, the height from which it fell, the time of flight, the type of soil it fell on, the depth of the hole it caused, etc. In other words, we would have lab books filled with facts, but no science. Science emerges only when the human mind comprehends such facts and views them from every conceivable angle, relating them to each other in such a way that the information can be compressed into a single statement (mathematical or verbal). After centuries of organized research, humankind finally taps into the science of gravity when it is announced that objects falling to earth do so at the same rate of acceleration. Decades later, the general law of gravitation is announced and a connection is made between bodies falling to earth, the moon orbiting the earth, and the planets orbiting the sun. Then centuries go by and the general theory of relativity is unveiled along with the role that gravity plays in shaping galaxies and nebulae. Yet, the science of gravity remains "open" and researchers in the field disagree on its underlying theories. This is due to the existence of more than one theory and philosophy to explain the lists of observations. The superiority of one philosophy over another cannot be tested by experiment or astronomical observations. In addition, we do not have any concrete idea of what gravity really is; hence, our endeavors are limited to finding a mathematical formula that gives an accurate description of how particles move under its influence. The methods currently available for scientific research fail to explain the nature of gravity, its essence and its source. In fact, it appears to be impossible to define such concepts in a way that would incorporate them into the realm of empirical research. This also applies to other known phenomena such as electric, magnetic and nuclear forces. In general, one can say that at the fundamental level, science does not seek to define the "reality of things," nor does it specify the essence of the forces that dictate things' behavior. Instead, the goal of science is to discover the most fundamental building blocks of which things are made as well as the laws which govern the forces that dictate their behavior. The foregoing discussion naturally leads us to the following question: What is a physical law and how does one discover it?

It is clear that empirical methods have greatly evolved over the centuries. The progress they have witnessed may be attributed not only to technological breakthroughs but also to the theorization and methods of scientific thought, which have proven to be effective in organizing and correlating the experimental facts. The aforementioned progress has allowed us to establish a methodology leading to the formulation of general laws from experimental observations. This applies at least to those studies that have reached a high level of maturity and precision like modern physics. The first step is to specify the state of the system under investigation by recording the experimental values for certain dynamic variables pertaining to the system. Experiments are then carried out to measure the values of these different variables while the system evolves. As it so happens, some of the system variables take on the same value throughout the course of the experiment, i.e., they are unchanged or constant. These constants lead to the "conservation laws" for the system. By scrutinizing the conservation laws for a set of identical systems one may be led to postulate a general law that conforms to the conservation laws. This law is then thoroughly tested against experiment and attempts are made to deduce them from more fundamental and comprehensive theories. These comprehensive theories are mathematical models for a large class of physical phenomena, which fall under the same type of fundamental interaction.

From the foregoing discussion of the strategy leading to useful scientific generalization, there appear to be three different levels of abstraction:

The conservation law level, which is a generalization akin to the experiment and is deduced directly from observation and measurement. The form of the conservation law is characterized by a specific function that depends on the measured variables and that retains the same value while the system evolves from one state to another. Because of the direct relationship between the conservation law and the experiment, it represents the frontline on the battleground for theory and experiment. The conservation laws are the foundations upon which theoretical constructs are built. The discovery of a physical process that does not abide by the conservation laws will therefore have a strong impact on the existing physical theories. This happened in 1957 when the law of parity conservation broke down and again in 1964 when the law of space inversion-charge conjugation was violated.[2] Physicists are currently engaged in a number of experiments to test the integrity of baryon[3] number conservation, which predicts the stability of protons against radioactive decay.

The general law level, which is a postulate formulated in such a way as to guarantee the validity of the known conservation laws. This level represents a mathematical foundation for discussing several phenomena that participate in the interactions affecting the phenomena that lead to the formulation of the conservation laws. The transition from the conservation law level to the general law level is not unique. There are often several mathematical postulates that lead to the same conservation laws but which differ outside the realm of experiment. The postulates that survive are only those which are not invalidated by experimentation.

The comprehensive theory level, which gives a unified mathematical formula for the fundamental interaction being studied in all the pertinent fields. The interaction is usually represented by a specific term in a Hamiltonian function that satisfies the required conservation laws. This level also provides the form of the general laws governing the set of phenomena it seeks to explain. The comprehensive theory contains a lot more than the bulk of experiments that instigated it. It is an artifact of the human mind constructed for the purpose of reproducing the various experimental results and possibly explaining the concepts emanating from it. Perhaps it is best to give an example from the field of electricity to illustrate the aforementioned levels of abstraction. At level (A), we find the law of conservation of charge: The net charge in a given process is constant. At level (B), we find several general laws, which describe reactions in which photons appear like photon-proton interaction or photon-electron or positron interaction. As for level (C), we find the theory of electromagnetism, which describes the behavior of material particles in an electromagnetic field and includes in a concise and precise mathematical formula all the known experimental properties of electric and magnetic phenomena.

Having demonstrated that human thought is a major factor involved in the generalization of experimental facts, we now move on to discuss the role of philosophical beliefs in the formulation of scientific laws and theories.

THE PHILOSOPHICAL BACKGROUND INVOLVED IN THE FORMULATION OF PHYSICAL LAW

There is a fundamental assumption upon which natural sciences are based, namely, that we live in a rational universe. In other words, the assumption that natural events are causally connected. Without it, science as we know it would be impossible. This assumption is natural and is perhaps even a part of human nature and its mental structure. In its extreme form, it is the belief in causal deterministic correlation, i.e. the belief that a specific state of a natural system necessarily leads to another specific state. The belief in causal deterministic correlation was prevalent till the beginning of the 20th Century and had such a strong hold on the scientific method that a great many scientists continued to believe that humankind's sense of freedom is nothing but an illusion. With the turn of the century, however, it was discovered that absolute determinism contradicts experiment. Causal correlation, in one way or another, remains an essential ingredient of the scientific method; however, the modifications which occurred in the postulate of determinism were tailored precisely to agree with the results of experimentation. So at the onset of the special theory of relativity, it was postulated that there is a causal connection between different events, i.e., that every event leads to a set of subsequent events independent of the existence of an observer. With the rise of the quantum theory of matter, it was postulated that systems evolve from one state to another in a deterministic fashion but that these states do not completely determine the values of the quantities being measured and only provide probabilities for obtaining specific values. The retreat from absolute determinism made room for some indeterminism and coincidence and allowed for a bit of "freedom of choice" for subatomic particles. The community of physicists, however, were left with a sense of discomfort since they had grown accustomed to the assumption that initial conditions along with the laws of dynamics precisely determine the evolutionary path of particles.

This view of the natural world necessarily entails the adoption of a philosophical standpoint, although is impossible to defend such a standpoint by means of a completely persuasive logic. At the same time, one cannot dismiss the possibility that we live in a chaotic universe with no rhyme or reason in the occurrence of events; however, a certain degree of implicit indeterminism need not prevent humankind from comprehending nature and reaping its fruits.

Sometimes it happens that a scientific theory is rejected on philosophical grounds despite its accordance with experimental results. For example, Newton's law of universal gravitation was criticized – even before the discovery that it disagreed with observations – because it allows for action at a distance, that is, particles separated by a distance are allowed to interact without a mediator. Also, researchers considered that one of the advantages of the general theory of relativity is that it somehow fulfills Mach's idea that remote bodies in the universe are responsible for giving massive particles their inertial properties. However, Mach's idea is nothing but a yearning to find a strong connection between that which is distant and that which is near – an idea meant to give meaning to the concept of mass and to make our perception of it more attractive.

This discussion leads us to conclude that at the level of fundamental interactions, scientific research has always been associated with philosophical premises or beliefs that do not emanate from experiment. This association is of paramount importance as it gives an intellectual and cultural dimension to the efforts put into research in the natural sciences. Furthermore, it could possibly contribute not only to the domain of technical applications, but also to the realm of human thought that aspires to a deeper understanding of life and its order. Consequently, we find that the formulation of many basic scientific laws leans toward sweeping generalizations, thereby giving the impression that certain philosophical standpoints are the fruit of empirical science and that any other standpoint must be false. This point can be illustrated by means of a few examples.

The first example is from the field of thermodynamics. The traditional forms of the second law of thermodynamics were sweeping and all-inclusive from the very beginning: "It is impossible to construct a device which converts all heat into useful work;" "The efficiency of the device which converts heat into useful work cannot in principle attain the maximum value of one which corresponds to the complete conversion of heat into work," or, "There is no natural process whose sole effect is the transfer of heat from one object to another at a higher temperature." To achieve this level of generality in a statement is no easy matter, especially when the statements are based on a limited number of experiments that were performed at a specific place and time on our planet earth. These are universal postulates about the nature of things. They fulfill the ambition of human beings to see their thoughts soar over the horizons of space and time. These universal statements are much preferred over the more humble statement that "a group of researchers performed certain experiments on specific materials under certain conditions in an attempt at achieving perfect efficiency in the conversion of heat into work but failed!"

The huge difference between this modest statement and the statements before cannot be attributed to experiment, but is the result of human thought and the adoption of a philosophical standpoint whose implicit claim is that, "What we failed to accomplish must be impossible." The assumptions that were "deduced" by such elaborate means allow us to apply them to the universe as a whole on the assumption that it represents an isolated thermodynamic system which abides by the laws of our labs, thus allowing us to predict the "heat death of the universe"!

The second example is from quantum theory. There is a corollary to the famous uncertainty principle which places an upper bound on the precision of a simultaneous measurement of a particle's position and momentum.[4] This corollary relates energy to time in the same way that the uncertainty principle relates momentum to position. This relationship between energy and time can be deduced from the first principles of quantum theory and does not require any additional postulates. The mathematical statement that relates the uncertainty in a measurement of time to the uncertainty in a measurement of energy is very simple and unanimously agreed upon as was the case for the laboratory experiments in our first example. If we restrict the interpretation to the mathematical statement, we find that it is just a statement of the degree of incompatibility of a simultaneous measurement of two incompatible observables, in this case energy and time. So whenever these two variables crop up (possibly among additional variables) in the description of the state of a system, they must appear in such a way as to satisfy the energy-time uncertainty principle. In particular, they must appear in the form of average values as opposed to exact values. Basically, this is one of the principles of quantum theory. If we assume that quantum theory is a representation of the reality of natural phenomena, then it must be considered an inherent property of the observed natural world. We then place a limitation on the precision of measuring the values of incompatible observables whenever they appear together in the description of the state of a system. However, the sweeping universal postulate which was founded on the aforementioned principle has far surpassed its strict meaning: "It is possible for a certain amount of energy to appear from nothing and disappear again within a given time interval provided that the amount of energy and its lifetime abide by the given mathematical relationship."

We are no longer talking about the properties of an explanatory theory for experimental observations or the limitations on measurements of variables used for specifying the state of a system. Rather, we are discussing emergence from emptiness, demise, and conservation. The subject, which originally was the limitation of humankind, has shifted to the extent of what is possible: the possibility of sudden creation and sudden annihilation.

Thus we can explain the emergence of energy from nothing since we have a physical law defined by a mathematical relation that makes this "emergence from nothing" possible. Moreover, a philosophical conclusion can be drawn about the basis of empirical science: Physical laws are not necessarily bound by "causality" as a mathematical relation relates the two variables of energy and time whenever they are. If we expand on this and say that energy can emerge from nothing, we can say that this can happen at any time and place without a cause-effect relationship between the event in question and events prior to it. Though a mathematical relation allows a tiny chance for arbitrariness or defiance of causality, and though the aforementioned postulate is apparently sweeping and undiscriminating concerning what humankind can observe and study, a number of researchers did propose theories based on this postulate. They intended to explain the emergence of the whole universe out of nonexistence with no cause or reason.

Our third and final example is from the field of cosmology, specifically, the "general principle of cosmology". Astronomical observations indicate that the galaxies and the faint background radiation reaching the Earth from every part of the sky are all regularly distributed up to the distance that astronomers managed to observe and record. This "fact" has been made the basis of a comprehensive postulate/assumption which is, in turn, a major principle in contemporary cosmology: "The universe seems regular and harmonious from any point in space and at any moment in time." This assumption is a sweeping generalization and an expansion based on limited observations carried out at a given spot of the universe. Yet, it is taken to be universally applicable and is the basis of every mathematical paradigm of the appearance and the evolution of the universe. The established philosophical point of departure is too obvious: perhaps we cannot see the entire universe, but what we cannot see must not be any different from what is already seen. This implies that the things and phenomena that draw our attention and set our minds working are those that have been proved to exist by our observatories and what is beyond that involves no mysteries or has nothing which is not known to us. This conviction makes it possible for researchers to propose theories about the whole universe and not just the world they can observe. These theories encompass the unique, huge universe from end to end rather than the limited observed world whose bounds taper off into an unseen and unknown realm that might be governed by factors that are not subject to human reasoning and experimentation.

The limits of experimentation and observation have obviously been overstepped in the three previous examples. This is consistent with an established philosophical proposition that gives the human mind full rein in the attempt to comprehend and explain natural phenomena. It is only natural that scientists tend to express their hypotheses in terms that give them the broadest possible applicability. These hypotheses are then tested by more experiments to adapt, alter or narrow down their scope. The intention here is not to criticize this method – for it may well be inherent in humankind. Rather, we simply wish to show that it is not really governed by the activities of observation and experimentation. We mean to show that the setting of laws and the formulation of propositions can take different forms that express different philosophical frames of reference, i.e. different presumptions that have nothing to do with scientific pursuit. The three examples cited here illustrate similar philosophical frames of reference revolving around the belief in the apparently endless capacities of the human mind: “What is humanly impossible is absolutely impossible” (the first example), “the human mind can comprehend everything including a natural law that governs the emergence of energy from non-existence” (the second example); “human knowledge encompasses the whole universe and there is very little that is beyond the cognition of man” (the third example).

These frames of reference share the belief that human reason, thought and work reign supreme in the entire universe and that there are no secrets or dark corners that human inventions and devices do not recognize. It is not surprising, then, that those who hold these beliefs should come out with generalizations and propositions shaped in a way that spontaneously echoes these beliefs. At this point, it is worth noting that a person who believes in the absolute superiority of human thought and actions and who believes that it was not humankind who set the rules and laws of the universe is not disturbed to find any aspect of irregularity or chaos in the course of nature.

However, to show that this philosophy is not dictated by science and that it has hardly any influence on its evolution and expansion, we propose to reconsider these same three examples in light of a philosophy that does not place human thought "above" existence.

FROM A DIFFERENT FRAME OF REFERENCE

Suppose that a researcher believes that there is an all wise Creator for this universe: Almighty God. He/she also believes that He created all creatures and sent them messengers and by means of revelation, via His messengers, He taught humans many facts of existence. He taught them that God is one; that His creatures are far more than people's eyes and observatories can see; that human beings are distinguished from other beings by their free will, freedom, and knowledge, and that consequently, they are required by God to worship and obey Him. They are also aware that it is possible to acquire knowledge by experimentation and calculations, because these teachings state that God has made the conduct of beings regular and disciplined. By study and research, human beings can discover the laws that govern this conduct. When they do, life on earth is made easier and human beings are better informed about God's Greatness and Might and the beauty of His creation. Accordingly, our empirical science and theories are nothing in comparison to God's knowledge, and are not enough to recognize the secrets of existence and its Creator. The room available for human beings to live, experiment, and reflect is limited, and so are human mental capacities. Indeed, human beings' earthly lifespan is fleeting, and human beings' knowledge is not meant to unveil what has been concealed from them by God.

Such a researcher – who may be termed the believer-researcher – believes that human beings' free will is a reality and not a psychological illusion. Therefore, unlike other physicists who hold that the behavior of particles is predetermined, he/she believes that this determinism must stop at a certain degree of complexity, such as the degree of complexity of a mature human mind.

At present it seems that the choices that individual particles make are always arbitrary and accidental, but statistically they tend to agree with the expected frequency of occurrence. The faith-based position of the believer-researcher rejects the very notion of accident as incompatible with the laws of God. The notion of accident rather reflects humankind's blindness to the causes and reasons beyond the phenomena in question. This ignorance relates either to the finiteness of human knowledge in general, or to lack of knowledge at this particular stage. This faith does not rule out the possibility of particles having their own sense of determinism and their own volition with which the individual "choices" of these particles are accordingly made. This has to do with the belief in the existence of a special relation between these beings and their Creator to which we are impervious. Perhaps the behavior of these beings is too subtle and profound for our minds and experiments to unravel. In social studies we normally accept statistical predictability concerning human collective conduct, standardizing "general tendencies" and possible patterns of development for groups of people. At the same time, we admit that these norms cannot help predict the behavior of a certain member of society in the very general circumstances shared by his/her fellow citizens. However, we do not describe the behavior of individuals as haphazard or accidental. Ironically, the same phenomenon is found in the behavior of electrons; their collective behavior is fairly disciplined and their individual behavior is almost chaotic, which leads to the description of the individual electrons as accidental. A believer-researcher has an explanation for the disparity between collective and individual behavior: he/she believes that, unlike electrons, humankind has volition, will, and responsibility to God. Nevertheless, this researcher might see in the existence of electrons a significance that no labs can find.

This line of thought is rejected by many researchers as a self-contradictory scientific method. This very rejection implies a belief in the uniqueness of human mentality and the superiority of human reason to everything else in the universe. A believer-researcher sees nothing in his/her belief contradicting the scientific method. On the contrary, he/she finds that the success of the scientific method proves the permanence of God's universal laws. Such a faith-based outlook by no means prevented believers from contributing to scientific research even within the context of absolute determinism when that was prevalent, or the probabilistic interpretation of quantum behavior when it was dominant. Such a researcher believes that all human knowledge is limited, temporal and approximate, and that it is based on the most infinitesimal part of existence as a whole. This summarizes the position of the believer-researcher concerning the three above examples and others.

In the first example we find that the second law of thermodynamics expresses an observed property of thermodynamics systems examined in labs: these systems do not convert all heat into useful work. It would be scientifically profitable to develop such a property into a general principle that would regulate the conduct of these systems. If we could further apply this principle on a wider scale, provided that it did not contradict empirical observations or better established principles, then this would be an undisputed success and would provide material evidence of the validity of the theory used. This method of theorizing is undoubtedly better than stating that the researchers could not realize their ends. However, this principle should not be made into a universal postulate eliminating the mere possibility that something different might occur. To be more specific, it cannot be thought of as applicable to the entire universe and made into a premise from which we can jump to conclusions about how human existence will come to an end. Humankind's environment, which includes everything that the human-made devices can detect, is not the whole universe. It is not a closed thermodynamic system. It is no more than a negligible part in a creation that only Almighty God fully understands. This limited (human) environment might interact with the rest of the universe in ways that are beyond humankind's recognition and means. The believer-researcher, backed by the solidly established teachings of a God-revealed religion, places this conviction on a much higher scale than empirical and uncertain methods. By means of it, he/she holds his or her imagination in check.

The point of departure for the believer-researcher in the second example is the limitedness of human experience in time and space. His/her basic position is that our lab experiments can tell us nothing about "absolute nonexistence," for it does not exist in our environment. It is logically impossible to realize how this world – this bubble of time, space, and energy – could have emerged out of no time, no space, and no energy. Human beings are imprisoned in this bubble by their body and mind. It is thus absurd that they should think themselves able, by means of experimentation and theorization, to transcend this status, look at existence from the outside, and get to know how things were shaped out of absolute nonexistence. However, there is no philosophical problematic concerning the explanation of the relation between the uncertainty in energy and the uncertainty in time. Energy and time are, according to the quantum theory, two incompatible variables. If we accept this theory's account of physical reality, it follows that when we have to describe the state of a physical system using variables including energy and time, we must allow for a degree of uncertainty in their values so as not to contradict the quantum theory that describes them as incompatible. This allows no room for the use of the expression "absolute nonexistence" or the possibility of the emergence or the disappearance of energy. A believer-researcher rejects the notion of arbitrariness which allows the emergence and disappearance of energy for no reason for any amount of time, however short it might be. Causality is the basis of empirical science, and this mathematical relation casts no doubt on the validity of this postulate.

The cosmological principle in the third example is in itself an embodiment of a philosophy that rejects the possibility that anything of significance might be beyond the grasp of human recognition. To think that unobserved aspects of existence might not be a mere extension of the observed world and that, instead, they might have decidedly different properties, is to shake the established certainty that the knowledge acquired by experimentation is final and adequate as far as the human pursuit of knowledge is concerned. It is, of course, of great importance to know that the observed part of the universe is harmonious and regular. It is a basic step for building mathematical paradigms that explain the evolution of the universe from its very early phases. However, these cannot be built without detaching the observer from the observed in accordance with the strategy followed in natural sciences. The study of a hydrogen atom, for instance, is based on the assumption that there is nothing in the world beyond the interaction of an electron and a proton. This makes the properties of the hydrogen atom a type of microcosm of the wider universe. This is true in relation to cosmology just as it is in relation to all natural sciences. The properties of the cosmic paradigms, which are inferred from the cosmic principle, pertain to the observed part of the universe. The cosmological principle is that this part could, to some extent, be isolated. Part of the assumption is that the cosmic paradigms do not indefinitely expand in existence. This makes it possible to induce the properties of the universe from a single part thereof.

However, many contemporary cosmologists have realized how naïve it is to think that the observed part of existence is the whole existence; they no longer look at their field as confined to the established properties of observed existence, i.e. the three spatial dimensions. The observed dimensions do not exclude the possibility of the existence of other spatial dimensions that our experiment–based devices cannot see. Apart from the implications of these theoretical paradigms, which are still in their primary phases and have no distinct physical content, the belief that the basic properties of the observed world are essentially local agrees with the accumulated experiences of the natural sciences, and especially astronomy. In this discipline we move from the Earth to the Solar System, to the galaxy, to the constellation of galaxies and then to the regular distribution of galaxies within view of our observatories. Each of these levels of observed existence possesses local properties that do not apply to other levels. It is thus only natural to believe that differences among the various levels might vanish at the point where human astronomy cannot see further. A believer-researcher sees the origin of this belief as humankind's fear that existence might be too vast for human beings to see for themselves. In the approximate harmony of observed existence, a believer-researcher finds support for the study of his/her local environment by the use of mathematical paradigms. This study deepens his/her appreciation of God's Creation, of which his/her own environment is only a tiny part.

CONCLUSION

What is normally called the empirical method is only a more developed and regulated form of the method used by ordinary people to acquire information about their surroundings. The profound knowledge which has been attained by the natural sciences of the behavior of particles and the forces affecting them has not come about by waving a magic wand called "the empirical." When a physicist phrases physical laws in a way which is incomprehensible to the ordinary man or woman, he/she, in fact, oversteps the bounds of the scientific method. This method is rather too narrow – neither broad nor sublime enough – for human ambition. No researcher can approach his/her work with his/her personal feelings and psychological make-up completely neutralized. He/she approaches his/her work with ambitions, views and expectations that have been formed in relation to a certain philosophy or frame of reference.

The failure to accurately observe the limits of the scientific method in the formation of discovered laws is perhaps inherent in man, be it a deliberate or an unintentional act. Many distinguished researchers over ages of scientific evolution have been moved by the desire to introduce "daring" propositions. Such exciting propositions, which do not observe methodical restraints, have been of prime importance to the evolution of all sciences. It is these daring propositions which have attained the status of established laws, and which are encountered in scientific journals and specialized publications. Thus it can be seen that the human aspect of scientific pursuit is what enriches and energizes it. However, we must not lose sight of the fact that scientific writings do reflect their writer's philosophies and beliefs and that they are not completely governed by the findings of their experimental work. With this in mind, it should not be hard to follow what is written and said cautiously and critically. In so doing, it should not take long to acquire the experience necessary to distinguish between purely scientific content and the writer's philosophy and beliefs.

At this point we have to distinguish between philosophical-social and moral speculation based on or inspired by the findings of natural sciences on the one hand, and on the other, a comprehensive belief system espoused by researchers before they engage in the process of scientific research, since such beliefs tend to dominate research and influence the formulation of scientific laws. In this article, we are concerned only with the latter aspect. Some philosophical positions can undoubtedly change as a result of experimental work and the facts it reveals. Some philosophical issues have thus been resolved by experimental facts. Examples of these are mechanical determinism and the timelessness of the universe. However, the resolution of such issues has led in most cases to a slight modification that would ensure that the researchers' philosophical convictions would not be invalidated by the new facts. This casts doubt on the alleged objectivity of natural scientists. The professional objectivity of scientific research requires that we do nothing but record facts and observations as they occur. However, it is not necessary for researchers to confine their speculations, conclusions, and statements to the body of facts they possess. Indeed, as we mentioned earlier, this would in no way benefit science. Nevertheless, if it is taken to extremes we might be presented with an exciting philosophical view which is devoid of real science. In such cases, the scientists make use of their scientific reputation to convey a message that has nothing to do with their field of expertise, though perfectly disguised in it. A case in point is a series of articles published recently by a contemporary cosmologist in specialized journals. He introduces what he calls the "chaotic universe." Briefly, he argues that the initial state of the Creation allowed several values for certain variables that were randomly distributed. The result was a great number of universes, the evolution of each of which was determined by the specific initial value from which it evolved. Our share is the universe we now live in.

These ideas were presented in the context of an answer to a question that demanded an explanation of the values of the known fundamental constants. The author said that the question was pointless, as there were universes with all possible sets of values. My argument in reply to this is that this kind of statement echoes a belief-based philosophy devoid of scientific content. It reflects an essentially "non-experimental" position which rejects causal thought. If other sets of values exist in the unobserved world, it is of no use to wonder about the specific values of the fundamental constants actualized in the observed world. The author's response is similar to the popular quantum mechanical interpretation of the multiplicity of universes which claims that we observe an electron to "choose" a certain path from an infinite number of possible paths because of our inability to observe the many unseen worlds. These philosophies are beliefs devoid of intellectual content. They add nothing to real science; they are, in essence, a type of preaching that distracts people lest they raise certain taboo questions.

To recapitulate, every effort exerted in the natural sciences, from outlining lab experiments to the wording of general laws and basic theories, is a human pursuit that bears the features of those engaged therein. It reflects ideological, intellectual, and philosophical positions which are by no means essential to the relevant field of scientific work. This should be borne in mind when we read scientific writings and when we train young scholars and scientists in all fields of the natural sciences.