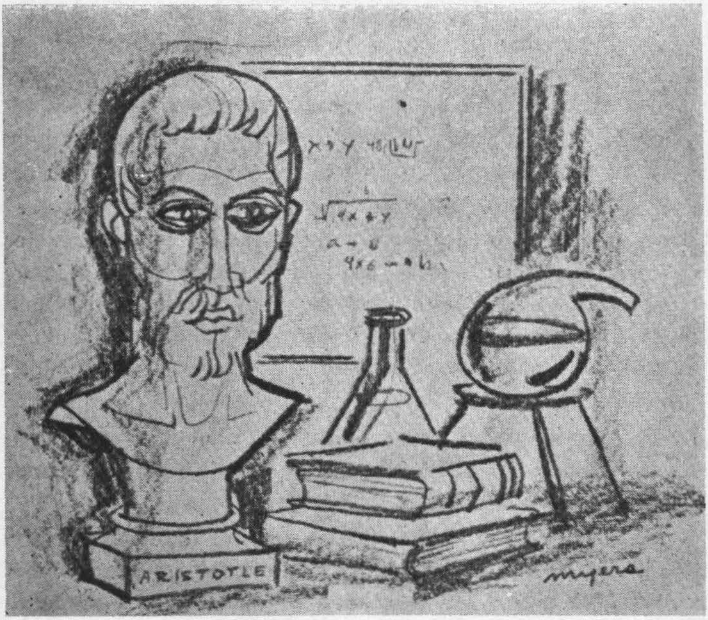

Truth in Modern Science

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"For the world as we know it is passing away." These words of St. Paul seem to lend theological verification to the conviction of contemporary physics. This conviction flows through the study of the most stable planetary systems down to the observations on the smallest of the fleeting sub-atomic particles. Everything seems to be in a state of flux. If indeed any permanence is to be found, it will consist simply in the permanence of the continual verification of the mutability of all material beings. The world of sub-atomic particles, the most basic ingredients of matter yet discovered, deepens our conviction of the 'always becoming' nature of the universe. For example, the omega-minus particle took six months of intensive bombardment to discover, and even then was found on only a few plates of the 50,000 photographs of the tracks produced by the bombardment. Another 'particle', the pi-zero meson, has an estimated life span of a mere 1 ten-trillionth of a second.

If our knowledge must ultimately spring from the endurable and permanent aspects woven in the changing things we study, then it seems that there is little hope for any certain knowledge in physics. However, we must not be deceived with what seems at first a hopeless case. In fact many modern scholars are willing to deny the real world if it does not fit what has been discovered through their mathematical formulae, which are held with the tenacity due something certain. Then too, a quick look at the two particles mentioned above, and at their brothers, shows that even in this nebulous realm of being there is some offering of certitude. The omega-minus was found, it should be noted, after being predicted by a theory or hypothesis, which in turn stemmed from a desire to unify and categorize all the sub-atomic entities in a system similar to that of the table of chemical elements. Obviously then, there must be some permanent law behind these particles if they admit of such a categorization. Furthermore, due to the extremely minute mass of these particles, we find by comparison with an automobile that they travel during their lifetime the same distance as a car would around the world. This fact alters on conviction of the fleetingness of the particles considerably! Hence, there does seem to be some relative permanence which can serve as the building block of knowledge.

The Three Levels of Nature

Since it is the construction of the realities we study which determines the nature of our method in studying them, as well as the type of certitude which will result from these studies, it will be best to examine them more closely. These 'now you see them, now you don't' realities comprise, to a large extent, the object of contemporary physics. But they are not the sole object, of course.

We might distinguish three levels of nature which fall under the watchful eye of contemporary physical considerations. The first level is that of the proper sensibles, or if one prefers, the level of gross experience, of direct qualitative confrontation with things. In this level the analogy of nature, first proposed by Aristotle, operates very well. This is the area in which imprecise qualitative comparisons can be made, such as 'This body is hotter than that one.'

Then there is the second layer of reality which falls under the aegis of physical study, and this is the level of the underlying measurable or quantitative changes which always accompany the qualitative ones. We could call this level of the common sensibles the mathmatical level. Here physics finds the static-atomistic or mechanical analogy most helpful and most profitable for knowledge. As we know, static atomism, similar to the insight of Democritus, is able to describe local motion in quite simple terms, provided of course that we forget any philosophical scruples we may have. Since local motions are the most proper study of physics, the atomistic conception of the universe served the purposes of the mechanistic and classical physicist perfectly. The world for them was analyzed into stresses and strains, lines of force, and mathematical point-particles. However, this fine, mathematically mechanical analysis breaks down at the sub-atomic level.

The third level, then, is that of the sub-atom. It is this plane of nature which is far and away the most intensively studied area of contemporary physics. Here it is found that local motion is not nearly enough to explain the changes taking place, especially the local motions of minute bodies. Some resolution into an ultimate foundation of matter becomes necessary. By so doing, contemporary physics affirms the indeterminate, unindividuated, and 'becoming' nature of reality. Moreover, since discussion of local motions in terms of substantial change (e.g., the movement of a particle as an energy knot waving in a field, coming from the field and returning to it in a flash of energy) was not exactly tasteful to the mentality of the physicist, he devised a new way of solving some of his difficulties. This new way was a study of relationships between motions and between particles. Although these relationships are universals and can be scientifically explored, they also give rise to probability physics in its present mode.

How Much Can We Know?

With these brief considerations of the three levels which comprise the object of contemporary physics, we are now able to consider the fallibility and certitude of knowledge on these respective levels. Truth is found properly in judgment, an act of the mind. But we are also concerned with coloration and distortion of the truth and reasoning, and this distortion can occur either when there is a composed object or when there is any composing and combining done on our part. We will therefore examine first the part of the object in the certitude of physics, and then examine the reasoning process itself.

In discussing the object of physics, we find that any sensory thing is an imperfect, composed, and complex entity capable of great variation. For this reason alone we can be deceived. We are not able to determine in most cases the essential definition of such things, and hence we have only a limited and disparate understanding of them in terms of an enumeration of events and properties.

Because of these difficulties, we find that there is no one wholly satisfactory way of studying changeable beings. We can approach them using the analogy of natures. Or we may consider the whole of which they are parts, as is the case with probabilities. Further, we can study some things from what they come to be outside of their usual context, as the cathode ray particles are studied as 'free' electrons no longer on a pilgrimage of being. Finally we might use a composition mentality, dividing up the entities into their parts, whether these be their basic elements or their principles. But all these methods are in some way 'abstractions'; that is, by leaving aside some of the properties they do violence to the realities.

However, in each of these methods there are operative, certain and evident principles which can serve as the major premises of demonstrations. Most generally, there are the principles discovered in the investigations of the science of criteriology, for example, the principle of contradiction. But these principles, because of the particular nature of physics, are too general to enter directly into any systematized method of thought. Then there are the more proximate principles of natural philosophy, such as that nothing comes from nothing, and that whatever already is cannot come to be. Some philosophers such as Parmenides considered these principles so evident and certain that they were willing to deny the data of ordinary sense experience rather than alter them in any way. Finally there are the proper principles of each of the areas of contemporary physics—e.g., that charge is always found with mass, that every particle has a field (in the context of the field theory), and so on. Thus even with vague and complex objects, some demonstration is possible.

There is a particular difficulty with the two lower levels of nature we have mentioned, the mathematical and the sub-atomic. The entities on these levels are not directly sensed. As may be readily guessed, whenever a medium is interjected between the reality and sense perception of this reality, our chances of error are greatly increased. The error can arise either from the machines used (though often as not, machines are more trustworthy detectors than our own sense powers) or from the step by step transition between the object of study and a sensible manifestation of it. For example, the common way of studying sub-atomic particles is by means of the cloud chamber. Cloud trails are observed which offer us the fundamental foundation necessary for all knowledge—a sensible object. But notice the chances for error! What is observed is a photographic plate of the cloud trails. Here some distortion or interference can occasion an incorrect interpretation. The cloud trail itself is actually condensed water vapor and this in turn was caused by ionized elements of a gas. The ions were caused by the charge, which itself is associated but not identical with the particle itself. Finally, by a step of intellectual speculation (usually mathematical) we are able to postulate something of the nature of the particle which, through this long process, indirectly produced the cloud trails.

How We Can Make Mistakes

The intellectual consideration of the nature of the particles forces us now to examine the fallibility and infallibility of reasoning in physics. In general, excluding the errors induced by other knowing powers or by inattention and prejudice, reasoning participates in the reliability of all our natural powers. In more complex cases than everyday reasoning can handle, a formal logic is needed to strengthen this natural drive towards the truth. But because of the uncertain and complex nature of our object, in addition to the logical requirements we must also have premises which are necessary truths and proportioned to our object. We have already noted these general principles.

Again a difficulty arises. In the proper subject matter of physics we cannot always be sure we have strictly necessary principles, since the material beings concerned are contingent. For this reason, the principles we formulate may not be proportioned to the matter at hand. We should also note that the word 'necessity' here indicates only a conditioned necessity. To illustrate the conditioned or 'ifness' of physical demonstrations, let us look at one proposed by a philosopher of science; although it is taken from chemistry, an analogous case could also be found in physics:[1]

An inert gas	is	an element with a neutral valence (most stable electronic structure)	is	chemically inactive.

If we were deceived into thinking that physical demonstration represented eternal verities we ought to be distressed by this demonstration, for we have since discovered that inert gases are not chemically inactive! What is wrong here? New evidence has been discovered which must alter our principle (the major). Hence the conditional nature of physical reasoning not only applies to the contingency of the entity which is its subject (allowed for in 'if-then' propositions such as, 'If a composed body exists, then it will' etc.), but also to the experimental facts. It is for this reason that all definitions and universals about material things, even essential ones, are open on all possibilities and upon any new evidence.

In contemporary physics, certitude is strengthened by the use of mathematics. For another example, let us look at the demonstration proposed for the atomic theory:[2]

The relative mass of a chemical compound	is	the sum of the relative masses combined in fixed proportions by weight	is	caused by bodies or elements of unit masses (called atoms).

The major of this demonstration is a particular expression of the general mathematical axiom that the unit is the cause of all numbers. As such, this major participates in absolute mathematical certitude (not conditioned by contingency or chance). This raises a special problem: what is the place of mathematics in physics? Mathematics might seem the wrong way to approach nature, for the reason Aristotle mentioned: "The minute accuracy of mathematics is not to be demanded in all cases, but only in the case of things which have no matter. Hence its method is not that of natural science; for presumably the whole of nature has matter." [3]

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1 W. Wallace, O.P., "Some Demonstrations in Physical Science," *The Thomist Reader* (Washington, Thomist Press, 1957), p. 110.

2 Wallace, *op. cit.,* p. 104.

3 Aristotle, *Metaphysics,* XI, 2, 995a15-18.

It would be inane to attempt a resoultion to this problem in so brief a discussion. However, if we remember that there are three concerns in physics—principles, causes, and elements—the problem is partially solved. To say that nature has mathematical principles is erroneous, and this is what Aristotle was cautioning against. There is only a physical, conditioned certitude in nature. On the other hand, to explain and predict the elements or units of physical things by using mathematics opens new spheres of knowledge. The modern physicist, we may submit, is attempting to explain the elements of things and not their principles. Often this does entail the further discovery of some formal causes (e.g., spin, mass, charge), and can even elicit expressions of a thing in terms of its active and passive aspects (e.g. the 'energy knot') or its bond with its grounds. But these are not the primary purpose of physics in the modern sense.

The conditional nature of physical argumentation is preserved in our example by the minor of the demonstration proposed for the atomic theory. What is the condition? It is that experimental evidence has shown that the sum of the relative masses combined in fixed proportions by weight is the relative mass of compounds. If some new evidence were introduced which contradicted this, the demonstration would fail.

This last point exemplifies the two criteria whereby conclusions of reasoning in physics can be verified to see if they are physically certain: first, the conclusion should explain all the known facts, and secondly, it should be able to predict other events. In this way the permanent law of structure underlying phenomena is touched. Both of these methods of certainty-verification consist in continual checking or testing of the conclusion with the *facts* of the natural world. Thus the only criterion in physics, in the ultimate analysis, is what is offered to our experience. This is the only way to tell if we have erred in reasoning or not.

Error, let us remember, is both negative and positive. In negative error we miss something that is there in the object of study. This type of error is rampant in contemporary physics. We are often forced to postulate (a fancy word for guess) with insufficient evidence. Poor laboratory techniques, incomplete development of data, and inattention to the canons of induction—combined with that removal from the immediate object mentioned earlier—all lead to mistakes. But this type of error is part of the human condition and it never can be completely eradicated. Positive error, on the other hand, can be corrected and erased by logical and careful consideration of the facts. We find this error especially in the tendency to consider hypotheses as proven facts, or more generally, in the tendency to attribute more certitude to our conclusions than they warrant. Futhermore, the interpretation of mathematical formulae leads to disparate accounts of the natures of things. The error most prevalent here is that of attributing mathematical properties to real things, such as thinking that there are really existing mathematical points in the world which in turn make up matter.

Nevertheless, allowing for so many possibilities of error, we must still conclude that the object of physics can be known and is known. The act of reasoning through sensible effects (the *sine qua non* of knowledge) is conditioned in its certitude and necessity. As we have seen, the strength of the certitude of mathematics is often lent to the physical proofs by using physico-mathematical argumentation. The result obtained is the greatest certitude possible in view of the changing complexities of the material realms under study. Even if we could eliminate all the chances for error we would still be left with the residue of conditioned necessity, for this is the nature of the world we study in contemporary physics.

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