DESCARTES AND THE PROBLEM OF ACTION AT A DISTANCE

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1. Introduction.—My aim in this Note is to examine Descartes' position on the problem of action at a distance. Since the time of ancient Greece philosophers and physicists have puzzled over the phenomena which seem to show that one body can act upon another at a distance. Many have proposed to solve the problem by introducing sufficient kinds and quantities of unobservable matter to reduce every appearance of action at a distance to a series of contiguous actions; but they have been unable to silence the skepticism of those who could find no independent evidence for the existence of this new matter. On the other hand, those who have erected action at a distance itself as an ultimate principle have been unable to convince their fellow-investigators that it cannot be eventually explained away by more satisfactory modes of contact action. The result has been an interminable controversy still unsettled in our own time.¹

Descartes' handling of the problem is particularly interesting because of the enormous influence of his general ideas on the history of physics, particularly in the seventeenth century.² His most systematic statement on physics is his Principia Philosophiae,³ first published in 1644. Although the main outlines of this work are too familiar to require re-statement here, it is appropriate briefly to examine Descartes' attempt to reduce the whole of physics to kinematics. He thought that this reduction was effected by his reduction of the concept of body to that of geometrical solid and by his purely relational definition of motion. The clear and distinct notions of size, figure and motion are adequate for explaining everything concerning physical bodies, provided that the principles of mathematics and geometry are accepted.⁴ The quantity of motion is then defined as the product of the size (magnitudo) of a body and its velocity (as a scalar only).⁵ Within

¹ For example, in the area of electromagnetic phenomena, where contact-action theories have long held sway, action at a distance has recently been revived by J. A. Wheeler and R. P. Feynman, "Interaction with the Absorber as the Mechanism of Radiation," Reviews of Modern Physics, 17 (1945), 157–181.


³ Œuvres de Descartes, Adam & Tannery ed. (Paris, 1897), VIII.

⁴ Principia, IV, #203; see also II, #64, IV, #199. For comment on this point, see K. Lasswitz, Geschichte der Atomistik (Hamburg, 1890), II, 97.

⁵ It is sometimes held that Descartes defined what is ordinarily considered as momentum, but this is a definite error, for he had no proper notion of mass. That by "magnitudo" Descartes simply meant size or volume and not mass is supported by passages in the following articles: Ibid., II, #36, 40, 43, 47–52, IV, #199, 203. The quantity he does define is nearly useless. It does have two virtues: it is consistent with Descartes' kinematical viewpoint, and it pointed the way toward a correct definition of momentum.

this framework, a kinematical concept of force is defined. Force is simply the quantity of motion. This definition is not given explicitly and formally, but is easily deduced from repeated uses of the word in certain contexts.6

"After having examined the nature of motion, it is necessary that we consider the cause of it."7 At this point the kinematical program is abandoned and dynamics is introduced. It is to be noted in this connection that the concept of cause is not analyzed. Descartes explicitly requires that the particular causes of motion be clear and distinct, but he apparently tacitly assumes that the concept of cause itself has these two characteristics. This is also true of the more particular dynamical concepts of force and action. Particular forces must be clear and distinct, but the dynamical concept of force as the cause of motion is not formally considered. This second use of the word "force" may, however, like the kinematical use, be easily deduced from the contexts in which it occurs.8 In this sense, "force" is synonymous with "physical cause of motion." (Descartes' restriction of the physical causes of non-uniform motion to impact forces is discussed below.) Like "force," "action" is also used informally and with its ordinary, common-sense physical meaning.9

If the actual development of Descartes' theory had been limited to kinematics, the problem of action at a distance would have assumed a peculiar meaning. However, since he does use the dynamical concepts of force and action with their ordinary physical meaning, the problem assumes its traditional significance. His answer to the problem is well-known, but in order to see its full import we want to make clear the fundamental epistemological distinction between Parts II and III of the Principia.

2. The A Priori and the Hypothetical for Descartes. By contrasting the principles of Parts II and III, and their epistemological status, we are quickly led to a decision as to whether Descartes met the problem of action at a distance on a priori or a posteriori grounds. The general principles of material things, which comprise Part II, are all a priori, and the list of these principles is surprisingly large: they range from a denial of the existence of atoms to a statement of the law of inertia. For the validation of these many principles no appeal to experience is required. In fact, we must be careful not to be deceived by our senses, for our senses do not teach us the true nature of things but only that things are useful or hurtful. The procedure is to "rely upon the understanding alone, by reflecting carefully on the ideas implanted therein by nature."10 The results of Part II rest upon clear and distinct ideas and are therefore certain. No evidence of our senses could be used to disprove them; no experiments could be performed to refute them.11

6 Ibid., II, #47–52. Cf. Spinoza, The Principles of Descartes' Philosophy, trans. by H. Britan (LaSalle, Ill., 1943), 58: “It should be noted here, that by force (vis) we understand the quantity of motion.”
7 Principia, II, #36.
8 Ibid., II, #25, 26, 37, 43, 57–61, 63.
10 Ibid., II, #3.
11 Ibid., III, #4.
On the other hand, in Part III, when Descartes turns to consideration of the visible world, he admits that pure deduction from the certain, a priori principles developed in Part II is not sufficient to account for the actual phenomena of experience, in this case especially the motion of the heavens. The principles of Part II are necessary but not sufficient to account for these phenomena. The explicit consideration of phenomena or experiments, a switch from pure rationalism to at least a partial empiricism, is thus necessary to account for the details of the natural world. We are able to know by force of pure reason neither the size of the parts into which matter has been divided, the velocity of these parts, nor their paths. These things could have been ordained by God in an infinite number of different ways. In order to account for the world as it now appears to us, we are thus free to make hypotheses about how God originally ordered the various parts. We merely require of any such hypothesis that its consequences must be in accord with experience. We may in fact know that our hypotheses are false, because of some revealed truth of religion for example, but that does not prevent their being useful and functioning as if true to permit the arrangement of natural causes to produce desired effects. As the particular fundamental hypothesis to account for the phenomena of the visible world Descartes introduces his famous vortex theory. The fundamental assumptions of this theory are: 1) there is order rather than chaos at the beginning; 2) the parts of matter are all equal and moderate in size and velocity; 3) each part has two motions, rotation around its own center and movement with other parts around some fixed center. The motion around the fixed centers provides the only macroscopic inequality in an otherwise isotropic universe.

We may now ask: if Descartes' general theory of matter and motion is irrefutable by experience, and if, on the other hand, the vortex theory and its consequences are refutable, at what point is action at a distance re-

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12 Ibid., III, #4.
13 In other words, the system of a priori principles of Part II is non-categorical, in the sense that these principles may hold in two different worlds which are not isomorphic.
14 Ibid., III, #46.
15 Ibid., III, #44, 47.
16 Hyman Stock, The Method of Descartes in the Natural Sciences (New York, 1931), emphasizes the role of hypothesis in Descartes' physical thought. Lina Kahn, Metaphysics of the Supernatural as Illustrated by Descartes (New York, 1918), has a similar thesis. Kahn argues that Descartes began his work as a naturalist, demanding that we go to experience to get answers and that we examine empirical evidence rather than the dicta of authority as a basis for reaching conclusions. However, due to the religious conservatism of his time, Kahn argues, Descartes was forced by external pressure to introduce deductive, a priori methods and to integrate God into physics. Most commentators, such as Lasswitz, would question this thesis, I believe. Descartes' deductive procedures are too thoroughly a part of his method to have been completely put upon him by Church pressure; cf. Lasswitz, op. cit., II, 55-57. On the other hand, it is no doubt true that the strong rationalistic tendency of Descartes' thought has been traditionally overly emphasized.
17 Principia, III, #46, 47.
jectcd? The answer must be that the principle of contact action is part of the a priori knowledge that is independent of the evidence of the senses. The phrase "actio in distans" does not, I believe, occur anywhere in the *Principia*.

The result is that the explicit rejection of action at a distance must be constructed as an inference by the reader. However, this inference is not a difficult one, and I imagine no serious reader has ever misunderstood Descartes' position on this matter. In stating the three "laws of nature," which are a priori, Descartes commits himself entirely to impact forces and thus to a clear, although tacit, rejection of action at a distance. The first law asserts that every body continues in the same state as long as possible and that it is changed only by colliding with other bodies. Any kind of effective action at a distance is rejected by the use of "only." This law is known a priori because God is immutable and always acts in the same way. The second law of nature is that all bodies which are moved tend to continue their movements in a straight line. This is only violated when they meet other bodies. This law, like the first, is deduced from the immutability of God and the fact that He conserves the motion of matter in the simplest possible way. It also entails the a priori rejection of all attractive or repulsive forces acting at a distance and causing a body to deviate from a state of uniform motion, for such forces are not a case of collision as required by the law. The third law asserts that if a body meets another which has a greater quantity of motion, it loses none of its motion, but if it encounters one having less quantity of motion, it loses as much motion as it transmits to the latter. Descartes goes on to say that all the particular corporeal causes changing the state of a body are comprised in this rule, and thus again any action at a distance is ruled out, for such action would not be a case of bodies colliding and could not, therefore, be subsumed under this rule.

Moreover, after the proof of the third law Descartes declares that the force of each body simply consists in the inertia of each body to remain in the same state of motion. Through this force of inertia a body may act on...
another by impact, and may in turn resist the impact of another body. Descartes emphasizes that the force of a body consists only in this inertial property; it has no active attractive or repulsive powers of any kind. Thus we see that to his a priori kinematics, Descartes added but one kind of dynamical force, that of impact. Every change in the state of motion of a body is to be accounted for by the impact of other bodies upon it, or, what amounts to the same thing, by its impact on them. The contact action of impact is the only mode of action between material things which is clear and distinct. Descartes' a priori mechanics is nearly faithful to his program, for this single dynamical cause of motion is conceived in terms of the figure, size and motion of bodies. Descartes emphasizes this by asserting that the quantity of inertial force of a body is a function of the size of the body, the surface which separates it from other bodies, and the speed of its motion.

Other a priori arguments of Descartes which logically entail the rejection of action at a distance can easily be given, but these centering around the three laws of motion are sufficient to show how completely he accepted the principle of contact action on a priori grounds. The consequence is that the explanation of every phenomenon must, without exception, be given in terms of a mechanism of contact action. As E. T. Whittaker has remarked, this places a heavy burden upon Descartes' system. The explanation of gravitation, light, heat, fire, magnetism and the motion of the planets must in each case involve a mechanism of impact or pressure. Every hypothesis which is made to account for any of these phenomena must use contact action, and the often disastrous results of adopting such a priori principles of natural knowledge are nowhere better illustrated than in Descartes' detailed explanations in Parts III and IV of the physical phenomena mentioned above.

3. Critical Remarks. This analysis of Descartes' position on action at a distance leads to at least three major criticisms of his physical theory as expounded in the Principia.

I. A mechanics based on a priori principles seems doomed to failure, for principles which are above experience, unalterable and irrefutable, can never be abandoned for principles more in conformity with empirical observations. Historically, there is an interesting parallel between Descartes and Kant. Kant's solution of the problem of action at a distance was dif-

23 It should be noted that Descartes has traditionally been severely criticized for his inadequate account of how a body possessing only the property of extension could have resistance to impact. In the Principia this is an untouched mystery. In correspondence with Henry More, Descartes states the following view: "It cannot be understood that one part of an extended thing penetrate another equal to it without the middle part of that extension being, by that fact, destroyed, or annihilated; but what is destroyed does not penetrate the other; and, so, in my judgment, it is demonstrated that impenetrability belongs to the essence of extension, and not of any other thing." Oeuvres, Adam & Tannery ed., V, 378:

Different from Descartes', for he made both a principle of contact action and a principle of action at a distance a priori synthetic. Methodologically, however, the two philosophers stand together, for they both offered a solution of this fundamental physical puzzle on a priori grounds. Kant's analysis is, of course, more sophisticated than Descartes', but it suffered the same fate: incompatibility with the later development of physics.

It has been argued that if it had not been for the historical accident of Newton and the relative weakness of contemporary Cartesian physicists, the Cartesian physics might have been corrected and further developed. This is a defensible speculation if only the results of the Cartesian physics are considered. If, however, the methods by which these results were validated are also considered, it does not seem defensible. It is true that the hypothetical, refutable vortex theory could have been changed without violating basic Cartesian tenets, and thereby some of the detailed explanations of particular phenomena could have been considerably improved. However, the same kind of tampering with the fundamental mechanical principles set forth in Part II of the Principia could not have been tolerated. From Descartes' standpoint, to deny seriously the truth of any principle stated in Part II would have been as absurd as to deny the truth of a theorem of Euclid, for every one of these principles belongs to the domain of mathematics and geometry. Since the principles of Part II are non-categorical, that is, do not uniquely determine the complete structure of the physical world, there exists the logical possibility of supplementing them by new hypotheses replacing the vortex theory. Nevertheless, it is unlikely that a set of hypotheses could have been found which would have been both empirically adequate and logically consistent with the a priori principles.

II. Although in a general sense the hypothetical methods of Parts III and IV of the Principia are acceptable, the actual analyses of particular physical phenomena are almost completely unsatisfactory. What is the main reason why the developments in these parts of the treatise now seem so ridiculous, particularly when compared with the physical treatises of Galileo and Newton? The central weakness, it seems to me, is the wholesale postulation of unobservable particles which are assigned complicated, yet purely qualitative, imprecisely defined structures. The various microscopic particles introduced by Descartes are all slavishly modeled after the macroscopic bodies observed and encountered in ordinary experience. This obviously inadequate method of analogy is the main technique employed in passing from the general vortex theory to particular phenomena.

A second, closely related weakness of Parts III and IV is that the logical consequences of the many subsidiary hypotheses are not pursued in any detail. This failing led to the early downfall of Descartes' system in the most important and precise branch of seventeenth-century science, namely, the mechanics of the solar system. The vertical explanation of the motion of

25 Metaphysische Anfangsgründe der Naturwissenschaft (Riga, 1786), Zweites Hauptstück.
26 Many, op. cit., 321-322. 27 Principia, II, #64.
III. Descartes' use of an ideal fluid on the one hand, and of shaped particles on the other, to constitute the plenum is one of his most serious and fundamental confusions. There seems to be a clear reason why this or some other comparable inconsistency was inevitable in his system. The hydrodynamics of an ideal, non-viscous fluid seems to be the natural physics of contact action, and this is the physics dominating Part II. A particle of such a fluid is essentially a point without figure or size; it cannot have definite shape, size or rigidity. Consonant with this physics of fluids, Descartes denied on a priori grounds the existence of atoms and the existence of attractive and repulsive forces acting at a distance. In thus limiting his physics so severely, he effectively eliminated any device for explaining the specific variety of bodies encountered in experience. The result was that when he turned from the general theory to the explanation of particular phenomena, he was forced to introduce surreptitiously either shaped particles, i.e., atoms, or dynamical forces of attraction and repulsion. The course that he does adopt is the one least inconsistent with his position on action at a distance. The shaped particles are made to explain observed phenomena by their actual motions, which can only be changed by impact with other particles. Dynamical forces of attraction and repulsion, existing independently of the actual motions of the particles, are rejected as thoroughly in Parts III and IV as in Part II.

This general mechanical ideal of reducing the particular causes of all changes in nature to simple cases of contiguous forces of impact has exercised an enormous hold on the development of physics even until recent years. Yet from a systematic philosophical standpoint, Cartesian physical theory is an example of reductionism at its worst. This reductionism is probably the source of the paradoxical historical position of Descartes' physics: his simplifying general ideas had great influence, yet his positive technical contributions were slight. A physics based on a very few clear ideas is perennially appealing, but it can be empirically sound and technically interesting only if provided with a powerful mathematical framework, which is precisely what Descartes did not provide for his theory. Indeed, from the standpoint of physics, we may say of Descartes what Locke said of himself: that he served "as an under-labourer in clearing the ground a little, and removing some of the rubbish that lies in the way to knowledge."

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28 Newton simply pursued the logical consequences of Descartes' hypotheses far enough to show that they were inconsistent with Kepler's second and third laws, and could not account for the observed motions of comets or planetary satellites. *Philosophiae Naturalis Principia Mathematica*, Cajori translation (Berkeley, Calif., 1940), 285, 286, 343.

29 *Principia*, II, #34, 39.

30 It is interesting to note that Boscovich and Kant took the opposite course: they denied the existence of atoms and affirmed the existence of dynamical forces. In the working out of details, neither was as inconsistent as Descartes.