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GREEK PHYSICS AND DYNAMICS.

Le Système du Monde: Histoire des Doctrines Cosmologiques de Platon à Copernic. By Prof. Pierre Duhem. Tome Premier. Pp. 512. (Paris: A. Hermann et Fils, 1913.) Price 18.50 francs.

THIS book contains a good deal more than one might expect from the title. It not only gives an account of the cosmical systems of the Greeks from Pythagoras to Ptolemy, but discusses in considerable detail the views of the different schools of the same period as to the constitution of matter, and their principles of dynamics. As was to be expected from the author's previous publications on the history of natural philosophy, he shows himself well acquainted with ancient literature, and also (with a few exceptions) with the very extensive modern literature of monographs on Greek science. The most recent editions of the classical writers are always quoted, but with one notable exception, Diels's edition of the *Doxographi Græci* not having been made use of.

The astronomical chapters, which fill less than half the book, do not call for any extended notice, as the subject treated in them has been dealt with in more than one book accessible to English readers, the last being Sir Thomas Heath's book on Aristarchus, published only a year ago. As to the origin of the heliocentric idea, the author follows in the main the theory of Schiaparelli, that it was really due to Herakleides, fifty years before the time of Aristarchus, and he seems unconvinced by the weighty arguments brought forward against it by subsequent writers.

The most valuable part of M. Duhem's book is undoubtedly that dealing with the physics and dynamics of the Greeks, especially of Aristotle, and it gives a very clear and thorough account of this difficult subject. While Plato's views on nature were characterised by doubts as to facts learned by perception, as the immutability which is regarded as the essence of things is not revealed thereby, Aristotle rehabilitated experience and observation, though often led astray by preconceived notions. In his dynamics the idea of mass does not enter; every moving body is necessarily subject to two forces, a power and a resistance; without a power it would not move at all, without resistance the motion would be accomplished in an instant. The velocity with which the body moves depends both on the magnitude of the power and on that of the resistance;

if both are constant the resulting motion is supposed to be uniform; if the resistance decreases the velocity will increase, if the same power be employed to move resisting bodies, the velocities which it communicates to them are inversely proportional to the resisting weights.

Velocity is therefore proportional to the ratio of power to resistance, and yet, how can motion cease when they become equal? Aristotle sees this difficulty and tries to get over it by remarking that because a certain power moves a body through a certain length it does not follow that any fraction of the power will move the body through the same fraction of the length. A body falling through air or water represents to Aristotle the simplest motion we can conceive; the power is here the weight of the body, while the resistance is caused by the medium it traverses, and the velocity of the fall is proportional to the weight. On the other hand, by the fundamental principle of Aristotelian dynamics, the velocity is inversely proportional to the resistance, and Aristotle seems to admit that this resistance is proportional to the density of the medium. But he maintained that if a fall in empty space were possible (which he denies), bodies of different weight would not fall with the same velocity. "This," he says (*Physics.* iv. 8, p. 216a), "is impossible, for what should then cause one body to move faster? This is necessarily the case in a medium because the body which has the greater power divides the medium more quickly, but in the void all bodies would have the same velocity, which is impossible."

The author also discusses very fully the theories prevalent after Aristotle so far as John Philoponus in the sixth century. In opposition to Aristotle, Philoponus taught that weight is something which belongs to a body and represents the downward motion it would have in empty space; the resisting medium prolongs the time of the fall, but if the resistance is diminished to zero the fall does not become instantaneous, the limit of the velocity being that with which it would fall through empty space. This doctrine, so different from that of Aristotle, was not accepted in the Middle Ages, though it was not without some influence on the views of Simplicius, who otherwise was a severe critic of Philoponus. We shall look forward with interest to M. Duhem's second volume, in which he will doubtless discuss the views of Thomas Aquinas and other philosophers of the Middle Ages, which did not always coincide completely with those of Aristotle.

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