A Hasidic boy wears phylacteries for his morning prayers. (©Richard T. Nowitz/CORBIS)

for keeping the Law). Jewish men, when they say their morning prayers on weekdays (but not on Sabbaths or feasts), are to tie (literally ''lay'') one of the phylacteries on the forehead and one on the left arm. The custom of thus wearing phylacteries is still observed by Orthodox Jews, but not by Reform Jews.

The institution of the phylacteries is based on a literal interpretation of the injunctions in Ex 13.9 (''It shall be as a sign on your hand and as a reminder on your forehead'') and Dt 6.8, 11.18 (''Bind them at your wrist as a sign and let them be as a pendant on your forehead''); hence the choice of the four passages for the phylacteries. Originally, however, these injunctions were no doubt intended to be understood in a figurative sense, like the modern expression, ''Tie a string on your finger that you don't forget''; the Israelites were never to forget Yahweh's laws or His mighty deeds in rescuing them from bondage in Egypt. There is no evidence for the custom of wearing phylacteries before the last few pre-Christian centuries. But several phylacteries have been found at Qumran and further south in the Desert of Judah, e.g., at Murabba'āt, that come from about the time of Christ. The words of Jesus in Mt 23.5 show that the wearing of phylacteries was a common custom at His time; He did not condemn the custom as such, but only the hypocritical display of ''wide phylacteries.'' Among ignorant people phylacteries might have been regarded primarily as amulets; hence their name in Greek. It is possible that the wearing of phylacteries had certain affinities with the apotropaic practices of the ancient Near East; E. A. Speiser seeks to establish this connection by means of the words used to describe phylacteries in Dt 6.8, 11.18: '*ôt* (sign) and *ṭôṭāpōt* (pendants).

See Also: MEZUZAH.

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[S. M. POLAN]

PHYSICAL LAWS, PHILOSOPHICAL ASPECTS

In considering physical laws, this article presents a historical survey of humanity's understanding of the nature and existence of these laws and a critique of various philosophical positions concerning them.

The conception that nature is regulated by physical laws in its properties and activities has received explicit formulation only in modern science, but it is rooted in notions that have been gradually formed through human experience. The animistic view of nature held by primitive peoples, through reflection and observation, have given place to a rational and philosophical concept of physical reality, and of natural events, as a regular concatenation of causes and effects. This rationalization of the concept of nature has been furthered by astronomical observations of the movements of the stars and by the development of technical arts—involving the construction of instruments and machines—that embody basic applications of mathematics. In these advances one can already detect a foreshadowing of physical laws in the modern sense.

Historical Survey. The mathematical conception of nature came into philosophy with PYTHAGORAS and the Pythagoreans, and with PLATO, who taught that God acts as the geometrician in the world. For ARISTOTLE, the existence of physical laws has a more solid basis in his conception of NATURE as the active principle of MOTION and rest in bodies. Moreover, Aristotle distinguishes events in the heavens from those on earth, the former being regu-

lated by absolutely necessary laws admitting of no exception, the latter—while subject to determinate laws of nature and not merely to CHANCE—admitting of exception and thereby leaving room for chance events (*Phys.* 192b 20–23, 195b 31–198a 13).

After Aristotle, philosophy—and scholastic philosophy in particular—preserved and developed the Aristotelian concept of nature, while corroborating its philosophical analysis with the conception of the world proposed in the Bible. Sacred Scripture describes the universe as a work of the wisdom and omnipotence of God the Creator, by whom all things are disposed ''by measure and number and weight'' (Wis 11.20). According to St. THOMAS AQUINAS, ''since all things subject to divine province are ruled and measured . . . it is evident that all things partake the eternal law in some way, namely, inasmuch as, from its being impressed upon them, they have inclinations to their own acts and ends. . . . And this participation of the eternal law in the rational creature is called the natural law. . . . In the irrational creature, however, [the eternal law] is not shared in a rational way; so it cannot be called a law except by way of similitude'' (*Summa theologiae* 1a2ae, 91.2 and ad 3). All creatures, then, have from their Creator those determined natural inclinations to their own respective ends ''which we say are natural laws'' (*In Dion de div. nom.,* 10.1).

Thus, already in ancient and medieval thought, the lawfulness of physical nature is clearly stated, and the founders of modern science, especially GALILEO and Isaac Newton, were clearly conscious of the continuity of their thought with the foregoing philosophical tradition.

Ontological Value of Laws. Not only in Aristotelian and scholastic philosophy, therefore, but also for the founders of modern science, physical law has an ontological value. The regular and constant relation in the succession of physical phenomena, expressed by a mathematical function relating experimental variables in a determinate way, is, in its turn, and expression of an ontological necessity based upon the very nature of physical agents, which results from the directive will and divine wisdom of the Creator. Moreover, this conception, even when purified of its metaphysical and theological connotations, remained dominant in modern physical science until the 19th century. The classical POSITIVISM of A. Comte expressly acknowledged the realism of physical laws, which were deemed by him to be dogmatically universal facts, no less positively verifiable than singular facts [*Cours de philosophie positive* (Paris 1930) Lesson 1]. A similar realistic conception is defended by contemporary dialectical materialism, which, according to the teaching of K. MARX and F. ENGELS, holds that scientific knowledge is assimilated as a passive representation and faithful mirror of reality (*see* MATERIALISM, DIALECTICAL AND HISTORICAL).

Empiricism and Criticism. To this objective and rationalistic conception of physical laws is opposed EMPIRICISM, notably in the extreme form proposed by D. HUME. According to Hume, the necessity of phenomena expressed in physical law is something purely subjective, a mere psychological expectancy resulting from series of constant connections observed in the past (*Treatise of Human Nature,* 1.3.6). Wishing to save the necessity of physical laws thus compromised by Hume's skeptical empiricism, I. KANT had recourse to synthetic a priori judgments. For him, law is the application of a mental category to PHENOMENA, already ordered in representation through the subjective forms of space and time. In Kant's view, law is valid for the phenomenal world but cannot be acknowledged as valid for reality itself (*Critique of Pure Reason,* Analysis of Principles).

The motives prompting the criticisms by Hume and Kant coalesce, near the end of the 19th century, in the empiriocriticism of E. Mach. This resolves the world of perception into pure sensations and, therefore, the natural sciences into a mere analysis of sensation. For Mach, physical laws are not necessarily operative in reality, since this presupposes the inverifiable postulate of regularity in nature. They are merely a restriction that the subject imposes upon himself in anticipating future sensations, for the sake of economy and as a means of functional adaptation in the struggle for life (*Analyse der Empfindungen,* Jena 1900).

Conventionalism. Very close to this conception is the conventionalism of J. H. Poincaré, for whom general principles—both of mathematics and of physics—are free conventions or masked definitions, adopted as criteria of scientific convenience, i.e., for their simplicity and logical coherence (*La Science et l'hypothèse,* Paris 1902). Poincaré's conventionalism was inspired not so much by philosophical preconceptions as by the evolution of mathematics and physics during the 19th century, which had shown that many laws and principles, held to be necessary and eternal by classical science and by positivism, had to be revised and replaced by other principles and laws that were more in accord with experimental facts. From this is was easy to conclude that principles and physical laws are not absolutely imposed by experience and do not express objective relations or the causes of phenomena, but are posited by the scientist as apt conventions and as approximate and provisional expressions. Hence physical laws become mere algebraic relations connecting the numbers that result from experimental measurement; such relations can be approximated in an

infinite number of ways by mathematical functions, from which the simplest relations are selected only for the sake of convenience and economy.

Neopositivism. The neopositivism of the *Wiener Kreis,* of Rudolf CARNAP and Otto Neurath, took up the teaching of Hume and Mach, eliminating its psychological elements and reducing empiricism to mere nominalism. For LOGICAL POSITIVISM the only meaningful propositions are ''protocol statements,'' which state an experimentally verifiable fact; physical laws, when enunciated as universals, cannot be verified. Rather, in their abstractness, they are not even complete propositions, but only propositional functions containing indeterminate variables in which determinate and concrete values can be substituted. Thus, for logical positivists, universal law is transformed into a protocol statement [J. Joergensen, *The Development of Logical Empiricism* (Chicago 1951) 30].

Critical Realism. The subjectivistic conception of physical laws is widely diffused in contemporary thought, being accepted even by neoscholastic philosophers such as J. MARITAIN and F. Renoirte, who deem it a legitimate purification of sciences from philosophical and metaphysical elements. Yet many scientists and philosophers defend the ontological value of physical laws by a kind of critical realism that steers a middle road between opposing extremes. Among these, the first to be cited are the founders of contemporary physics, namely, Max Planck and Albert EINSTEIN. Critical realism accords to empiricist and subjectivistic views the merit of having combated the exaggerated realism of a Platonic or mechanistic type that was dominant in classical physics. Thus it recognizes the essential activity of the mind in formulating scientific laws, which necessarily contain subjective, approximate, and provisory elements. At the same time, however, it admits the capacity of human thought to know material reality in itself and to penetrate into its essence through observed phenomena and by scientific reasoning.

Uniformity. The ontological value of physical laws can be justified by a critical theory of KNOWLEDGE in general, and then reinforced by a consideration of the practical value of science itself. If, in fact, physical laws lack all ontological value, the ability to predict phenomena from physical laws and the practical value of science in technical applications would be only casual and fortuitous coincidences, as even Poincaré noted in opposing the extremist interpretation given by E. Le Roy to his teaching [H. Poincaré, *La Valeur de la science* (Paris 1905) 220]. One must therefore admit that the constant and uniform regularity observed in experience, and stated in physical laws, has an ontological basis in the nature of physical agents. This nature is independent of human knowledge and is antecedent to action itself. Physical law thus objectively, *in actu primo,* as a causal antecedent of the activity regulated by it, even before being discovered and formulated by scientists, even before man appeared on the earth. The principles of UNIFORMITY in nature or of ontological determinism in physical agents offer, then, the ontological basis and rational explanation of physical laws.

Determinism. The ontological determinism of physical agents, or the principle of determinate causality, is a necessary presupposition for the formulation of physical laws and is also the ontological basis for scientific INDUCTION. As such, it cannot result from this type of induction, but must be seen as an application of the self-evident principle of SUFFICIENT REASON, according to which everything existing or happening has a reason for exiting or happening. If the physical agent, deprived of knowledge and choice, were not determined by its nature to one action rather than another, it would be indifferent to any action whatever and would therefore not act (St. Thomas, *C. gent.* 3.2). Even as regards physical determinism, however, contemporary physics has moderated the rigidity claimed by classical physics. This determinism is no longer absolute, but relative. Thus, from a metaphysical point of view, one can reject the illicit extrapolation of determinism from the physical world to the human will and, even more so, to the divine will. From a physical point of view, the discovery of statistical laws and of quantum indeterminism has shown the value of a conception of nature like that of Aristotle. While seeing determinism and necessity as arising from FORM, this recognizes the existence of indetermination and potentiality arising from MATTER and admits the existence of chance events as exceptions to natural law.

See Also: LAW; NATURAL LAW; INDETERMINISM; MECHANISM.

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PHYSIOLOGUS

Physiologus, composed in or near Egypt in the 2d century A.D., was the most widely known animal book