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In discussions dealing with the beginning of modern science, *i.e.* of Galileo's physics, the question continues to be raised—especially since Pierre Duhem's far-fetched antedating of this beginning [1]—as to the part played in it by nominalism. Starting from the assumption, usually formulated none too precisely, that up to this very day modern physics is essentially nominalistic, an effort is being made to establish a link between the nominalism of late Scholastic times and modern physics. In the following, I shall attempt to show how such a connection, although very limited in scope, can indeed be observed.

To start with, here is a brief comment on the historical pattern of nominalism as far as this now concerns us. As a philosophical theory of language, nominalism contests the assertion of the "realists" that the order of *signum* and *res*, as applied in the use of proper names, is valid also in the case of what is called *universalia*; that is—in modern wording—that to predicates (or to concepts, if the phonemic realization of predicates may be ignored) there corresponds something still "distinguishable" from existing things. According to nominalistic interpretation these universals are (in a rather unfortunate terminology, dictated by the adverse party) nothing but "mere names," whose correlates in reality are again supposed to be nothing but existing

[1] Duhem started with an attempt to present Leonardo da Vinci as a decisive precursor of Galileo (*Les Origines de la Statique*, I—II, Paris 1905—1906). Afterwards he forwarded the claim that even before Galileo the Parisian Terminists headed by Nicole Oresme laid the foundation of modern physics in the 14th century (*Études sur Léonard de Vinci*, III, Paris 1913). While in volume 7 of his *Le Système du Monde* (1956) he again tries to substantiate the thesis of the authorship of the Parisian Terminists, volume 10 contains some remarks which reveal a more moderate opinion (*Le Système du Monde. Histoire des Doctrines Cosmologiques de Platon à Copernic*, X, Paris 1959, p. 45). For a presentation and a critical evaluation of this thesis see: E. Rosen, "Renaissance Science as Seen by Burckhardt and His Successors," in *The Renaissance: a Reconsideration of the Theories and Interpretations of the Age*, ed. by Tinsley Helton, Madison 1961, pp. 77—103; J. H. Randall Jr., *The Career of Philosophy. From the Middle Ages to the Enlightenment*, I, New York 1962, pp. 267—283.

things.[2] It seems that the earlier extreme nominalism, as interpreted by Roscelin de Compiègne (about 1050—1125), admits solely proper names—which is obviously absurd—while the later nominalism of William Ockham (d. 1349/50), more important in our context, persistently upholds the differentiation between proper names and predicates, already treating the latter, to some extent, as synsemantic expressions and calling them *universalia in praedicando*.[3] Ockham's further thesis, that of these universals taken by themselves an *esse in mente* holds[4] is—due to its obscure formulation—far from suitable to solve the real problem in this controversy on universals. The relevant question is, whether and how "abstract" objects can reasonably be discussed. Even so, Ockham's suggestion does prevent any naive assumption without, however—as falsely claimed by "realists"—renouncing a "knowledge of the general" and consequently of science. To be sure, general sentences—and nothing else is implied by the customary talk about the general—are allowed for in Ockham's theory.[5] In these or other sentences, any expressions, sounding like proper names yet not naming any object existing in this world, are to be eliminated. It is, however, left to the historical nominalism to prove that all these expressions can actually be eliminated without making the common world smaller. Ockham himself suggests to speak merely of "moving", or of "moving bodies," instead of using words like "motion", thereby attempting to avoid from the beginning the misleading "realistic" concept "motion exists."[6] In other words, to put it in a nutshell, Ockham's world

[2] It is well known that the dispute over "universals" dates back to the futile discussion on *genera* and *species*, started by Porphyry in his preface to Aristotle's *Categories* ("Isagoge sive quinque voces," ed. A. Busse [*Comm. in Arist. Graeca*, IV, 1], Berlin 1887, p. 1; furthermore: Boethius, "In Porph. Comm." I [Migne, *Patrologia Latina* 64] 83A). Systematically, this dispute represents a variant of the argumentations, by which Plato, in the *Cratylus*, developed his programme of a philosophy of language in an antithetic form. The fact that the medieval dispute over universals does not follow this particular pattern but rather — on the part of the "realists" — follows Plato's supposed realism concerning Forms, is understandable in view of the way how Plato's writings have been transmitted; still, it is an unfortunate continuation of the dispute as introduced by Plato himself. Indeed, it can be shown, that Plato considered to be impossible a "reasonable" philosophy of language within such a type of antithesis, as that between nominalism and realism, and that for this reason he pointed out some acceptable "solution" of the problems under discussion; cf. K. Lorenz, J. Mittelstrass, "On Rational Philosophy of Language. The Programme in Plato's *Cratylus* Reconsidered," *Mind*, LXXVI (1967), pp. 1—20.

[3] *Summa Totius Logicae*, I, 15 (Franciscan Institute Publications, Text Series No. 2, ed. Ph. Boehner, St. Bonaventure 1951, pp. 45ff).

[4] Cf. *Summa Totius Logicae*, I, 14 (*ibid.* pp. 43ff) and I, 12 (*ibid.* pp. 38ff), with direct reference to the "psychological" theory of language in *De interpretatione* (1. 16a 3—4).

[5] Cf. W. Stegmüller, „Das Universalienproblem einst und jetzt", *Archiv für Philosophie*, 6 (1956), pp. 192—225 and 7 (1957), pp. 45—81; especially 6 (1956), pp. 202ff.

[6] "Summulae in Libros Physicorum", III, 7 (*Philosophia Naturalis*, Rome 1637, pp. 54f.); cf. *Tractatus de Successivis*, I (*Tractatus de Motu*) (Franciscan Institute Publications, Philosophy Series No. 1, ed. Ph. Boehner, St. Bonaventure 1944, p. 45).

consists, on the one hand, of "single things" whose behaviour, in the manner of moving bodies, is the object of a *scientia realis* and, on the other hand, of "linguistic symbols" by means of which this *scientia realis* operates "nominalistically"; these symbols, in turn, are the object of a further science, a *scientia rationalis,* which in itself establishes the rules for the use of these symbols.

Let us add here, that this *scientia rationalis* concentrates principally on problems of scientific methodology and, being itself an example of the *logica moderna,* still follows the preceding *logica nova* which, contrary to the *logica vetus,* also knew and discussed Aristotle's *Second Analytics.* [7] Considering this we may claim that this pattern of nominalism indeed drew very near to the tendencies of the new science in its evolution then. [8] After all, Galileo's mechanics rested on the very fact that the question as to the "essence" of motion was deliberately abandoned in favour of the study of moving bodies and that, for the first time, methodical means were granted by which exact descriptions of the behaviour of moving bodies became possible. The scholastic controversy whether motion is a *fluxus formae,* that is, an "independent" state still distinguishable from a moving body, or rather a *forma fluens,* meaning a form identical with the trajectory of the moving body, [9] is in no way of interest to Galileo, the author of the *Discorsi*—although it may be held that actually he is subscribing to the *forma-fluens*-theory which, significantly, had been championed by Ockham, too. [10] In conformity with Ockham's advice, Galileo thus

[7] Among Aristotle's writings, *logica vetus* comprised the *Categories* and *De interpretatione.* These are supplemented by the *Eisagoge* by Porphyry, the *Commentaries* by Boethius, as well as the book *De sex Principiis* ascribed to Gilbert de la Porrée. Upon publication of the remaining writings of the *Organon* in the middle of the 12th century, studies of the *Second Analytics,* the *Topics* and the *Sophistic Refutations* were, by contrast, distinguished as *logica nova.* Later on, both were covered by the common term *logica antiqua* (or *logica antiquorum*). This took place, after interests in a philosophy of language had been renewed under "nominalistic" leadership in the middle of the 13th century and brought about the evolution of a *logica moderna* (or *logica modernorum*), particularly as the result of a discussion on *proprietates terminorum.* These differentiations were never upheld very accurately: thus the difference between *antiqui* and *moderni* appears as early as the 10th century (C. S. Barach, *Zur Geschichte des Nominalismus vor Roscellin,* Wien 1866, p. 14); nor was this difference strictly upheld in later times. Cf. L. M. de Rijk, *Logica Modernorum. A Contribution to the History of Early Terminist Logic,* I, Assen 1962, pp. 14ff.

[8] Of recent literature cf. O. Fleckenstein, *Naturwissenschaft und Politik. Von Galilei bis Einstein,* München 1965, p. 17.

[9] A detailed account of this terminologically at times rather obscure discussion (this explains the numerous contradictions in its modern recapitulations!) is given by A. Maier, *Zwischen Philosophie und Mechanik. Studien zur Naturphilosophie der Spätscholastik,* Rome 1958, pp. 59ff.

[10] "Ideo dicendum est, quod motus non est talis res distincta secundum se totam a re permanente, quia frustra fit per plura, quod potest fieri per pauciora ... Ponendo enim, quod corpus sit in uno loco et postea in alio loco, sic procedendo sine omni quiete et omni re media alia ab ipso corpore et ipso agente, quod movet, vere habemus motum localem; igitur frustra ponitur talis res alia" (*Tractatus de Successivis* I, Boehner, p. 45). Cf. "Summulae in Libros Physicorum", III, 6—7 (*Philosophia Naturalis* pp. 53ff). A. Maier, *op. cit.,* pp. 100ff.

ceased reasoning about "motion"; instead, he establishes rules about bodies in so far as they are in motion. To be sure, in his methodical reflexions Galileo makes use of a clearly nominalistic vocabulary, as seen particularly well in the famous quotation from the *Dialogo*: he claims that "gravity", which Simplicio, the representative of a scholastic Aristotelianism, suggests to be the cause of the motion of falling bodies, is but a "name" for certain observed regularities.[11] In his works, *e.g.* in connection with the problem of secondary qualities,[12] Galileo repeatedly protests that references to causative substances, as commonly used in scholastic discourses, constitute nothing but "pure names" (*puri nomi*) and represent by no means well-founded and justifiable explanations. This may be considered to be evidence of Galileo's deliberately accepting the nominalistic parlance of argumentation. Ockham's nominalism had reached Northern Italy as early as about 1400, by way of the Parisian Ockhamism; among other places it was in Padua that Averroistic circles ardently discussed it ever since. There is little doubt, therefore, that Galileo must have been well acquainted with nominalistic reasoning. He may also have known such works as those written by Albert of Saxony (d. 1390) and Marsilius of Inghen (d. 1396)—because in the *Juvenilia*, considered to be lecture-notes from his time at Pisa, mention is made of Ockham, Albert of Saxony, as well as of Paulus Venetus (d. 1429), a man of great importance in this line of tradition, and of the Doctores Parisienses.

Galileo's aversion to the assumption that there are any substances to be substituted for phenomena, combined with his mechanics which obviously made such substances superfluous, had an extraordinary effect upon future thinking. There seemed to be—as was still the case with Leibniz in his youth[13]—a necessity of choosing between the acceptance of "substantial forms" and the "mechanical theory"—a decision which was made almost unanimously in favour of the "mechanical theory" and which, at the same time, adopted its nominalistic pathos. The nominalism of the new science was rightfully looked upon as an attempt of vindicating one's own scientific theory philosophically; and at the rate at which this new science, starting from Galileo's mechanics, progressed successfully, nominalism itself was being accepted as a "philosophical" theory of now established value. This connection is probably most distinctly discernible in Hobbes' works. On the one hand, Hobbes, like Descartes, intended to write a Meta-

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[11] "Dialogo sopra i due massimi sistemi del mondo," II, in *Le Opere di Galileo Galilei*, Edizione Nazionale, VII, pp. 260f.

[12] Cf. "Il Saggiatore," *ibid.*, VI, p. 348.

[13] Cf. the autobiographical note in Leibniz's letter to Remond, dated Jan. 10, 1714, *Die philosophischen Schriften von G. W. Leibniz*, ed. C. J. Gerhardt, III, p. 606.

physics corresponding to the new science and, on the other, he holds a strictly nominalistic view on language which strongly relies on Ockhamism.[14] In Hobbes' works and, more clearly, in the so—called British Empiricism, it once more becomes apparent how much nominalism and the new science are in agreement with each other. Even so, it must be stressed that neither nominalism, turning psychological at a steadily increasing rate, nor the new science which more and more abandoned its "synthetic" character, represent theories which are soundly based by themselves.

If one bears in mind that Hobbes and the British Empiricism testified to the compatibility — however problematical in this historical form—of nominalism and the new science, and if one adds the fact that even in Galileo's times the new science made use of a nominalistic language for its "philosophical" justification, one might be tempted to assume, that the new science could not possibly come into existence without the historical nominalism of Ockham's version. In consequence, it might then be claimed that only with the new concept of "reality", as advanced by Ockham, the creation of a new type of physics was made possible. And one might continue in this vein and argue that this new type of physics had merely to supply a better "theory" about a world with which the metaphysicians had long ago come to terms. However, this allegation would vastly exaggerate the part played generally by philosophy in the history of science; in particular, it is manifestly false as far as the origin of modern physics is concerned.

The version given so far, *i.e.* that Galileo himself sought to find in nominalism a "philosophical" justification of his own physical theory, does by no means imply that nominalism is in any way already presupposed in the actual system of Galileo's physics. This system should rather be imagined to follow Euclid's geometry in so far as Galileo's mechanics is also based on axioms. The validity of these axioms, however, is not to be considered self-evident as those in geometry are, but it is subject to an experimental examination of their logical implications. This "geometric" or, as previously labelled, "synthetic" character makes Galileo's mechanics appear indifferent to the historical alternative between nominalism and realism, because at that time neither realism nor nominalism could have supplied a satisfactory explanation of "Euclidic" connections of sentences and the concepts used within these connections. Thus the tradition, which Galileo follows in the "Euclidic" build-up of his mechanics, had from the very beginning not been affected in any way by the realism-nominalism controversy. As a rule, deductive procedures had been freely applied by

[14] Cf. "De corpore," I, 2 (*Opera philosophica quae latine scripsit omnia*, ed. G. Molesworth, I, pp. 11ff.).

both realists and nominalists, while then one was facing a matter of methodology, manifestly quite irrelevant to one's own controversial problems. As far as it may be asserted that the greatness of Galileo's historical achievement lies in the field of methodological reasoning—he being the first to develop within the framework of his Euclidic model a methodically fully convincing approach to the explanation of physical phenomena—the allegation mentioned above seems inappropriate. In fact, Galileo did not have to depend on historical nominalism, even if this philosophical theory proved convenient for his scientific purpose, by reason of its opposition to the Aristotelian-Scholastic "substances" and because of its persistence in pointing out a world of "single things".

Now, the objection might be raised that, while Galileo's mechanics does not, in its theoretical core (i.e. in its "Euclidic" structure), contain anything specifically nominalistic, it still envisages from the very beginning a world that can only be comprehended by a nominalistic mind. Undoubtedly this assumption fits very well what previously has been said about comparable intentions of both Ockham's nominalism and the new science; but even here some reservations are to the point. This assumption is acceptable if it is meant to say that, to some extent, the domain of physics had become smaller than it had been before, when "substantial forms" had been part of it; again, this assumption is erroneous, if it should be used to chain the new physics to a definite philosophical doctrine. Because once more Galileo surpasses his nominalistic predecessors in methodological sagacity. His remark—previously mentioned as evidence of a nominalistic influence—that "gravity" is but a name, not an acceptable explanation of certain observable regularities, is undoubtedly proof of his acquaintance with the nominalistic vocabulary. But, at the same time, this remark must be understood on the background of a differentiation which methodologically had become of great importance for his mechanics. We refer to his differentiation between a kinematic and a dynamic approach. It is well known, that Galileo pays no attention to the dependence of the motions, as dealt with in his mechanics, on the forces causing these motions; and it is his clear-cut distinction between the cause of motion and the form of motion, which for the first time made it possible to formulate precise statements on the phenomenon of motion. This means, however, that henceforth the dynamic approach does not become superfluous, but that it is now, in a methodically convincing order, even required by the mechanics which has been carefully limited to a kinematic approach. [15]

[15] A detailed account of the methodological aspect of Galileo's physics, which in the context of this article could be sketched merely in its general outline, may

Accordingly, Galileo, in the passage quoted above, does not attempt to banish the discussion on "gravity" from physics, as any ardent nominalist would have done; he rather prefers to postpone such a discussion and makes it quite clear that at this point nothing could be gained by introducing some sort of mysterious "substance". Here he is, of course, in full agreement with historical nominalism, the terminology of which he adopts.

Thus, in every attempt of linking late Scholastic nominalism with the rise of the new science, one must, with regard to Galileo, carefully distinguish primary methodological insights from his interpretative means of expression. When Galileo discusses his own physics, either for combating adverse notions or for the purpose of promoting his own opinion, he does so mostly in order to emphasize the reliability of mathematical demonstration and the liability to error of metaphysical allegations within the domain of his science. In doing this he prefers to use the nominalistic parlance, because it seems to be least involved with metaphysics. It should be added, that in fact Galileo had no interest whatsoever in philosophical problems as traditionally discussed. In favour of fragmentary research he dispenses with any "philosophy" of his own which, most certainly, would have overreached this type of research. And it is characteristic that a metaphysicist like Descartes promptly called this attitude of Galileo a philosophical deficiency. [16] There was in Galileo's mind no room for anything like the question, how to explain the fact that the theorems of his mechanics hold true for the world — a question that occupied modern philosophy up to Kant's provoking formulation how experience is possible at all. In this context a remark like Galileo's famed comment on the Book of Nature, as written in mathematical wording, [17] must be looked upon rather as the resumption and successful continuation of a well-known metaphor. [18] This remark also shows how easily even some Christian platonism in Galileo's reasoning could agree with the nominalistic beliefs which he explicitly professed elsewhere.

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be found in E. J. Dijksterhuis, *Die Mechanisierung des Weltbildes* (in German by H. Habicht), Berlin—Göttingen—Heidelberg 1956, pp. 371ff.

[16] Letter dated Oct. 11, 1638 to Mersenne, in *Oeuvres de Descartes*, ed. Ch. Adam and P. Tannery, II, p. 380. Here Descartes refers to his perusal of the recently published *Discorsi*. With regard to this "philosophical" protest against the "unphilosophical" character of the new science, compare the present author's work: *Die Rettung der Phänomene. Ursprung und Geschichte eines antiken Forschungsprinzips*, Berlin 1962, pp. 255ff.

[17] "Il Saggiatore," *loc. cit.*, VI, p. 232; letter dated January 1641 to Liceti, Ed. Naz. XVIII, pp. 293ff.

[18] On the history of the so-called "book metaphor" cf. E. R. Curtius, *Europäische Literatur und lateinisches Mittelalter*, 3rd ed., Bern 1961, pp. 323ff.

In conclusion one might comment on the interrelation between nominalism and the new science as follows: occasionally the new science tries to find its philosophical justification in nominalism. In spite of this, science in its actual structure is by no means dependent upon historical nominalism. However, it is the use of nominalism that, in line with Galileo's attitude, the new science could afford to do without any "philosophical" justification of its own. There is yet no definite explanation on hand as to how such a justification can be established.