

2. THE MATURE PHYSICS: AN OVERVIEW

Leibniz's notes and correspondence in the late 1670s and early 1680s show considerable interest in questions of motion, physics, and, more generally, natural philosophy.³² But the foundations of Leibniz's new physics were not publicly revealed until 1686, when Leibniz published his brief but important "Brevis Demonstratio Erroris memorabilis Cartesii et aliorum circa Legem Naturalem" (BD) in the *Acta Eruditorum*.³³ In this work, Leibniz presented for the first time in public what he had been telling friends and correspondents in private for some years – that the Cartesian law of the conservation of quantity of motion (size times speed) is false and leads to paradox. We shall discuss this argument in more detail in section 4.3. An enormous controversy followed among the many who still followed Descartes in holding the conservation principle, a controversy that continued well into the 1690s.³⁴

While the BD emphasized what is wrong with Descartes' physics, it gave only a hint of what Leibniz intended to replace it with. But shortly after the appearance of that essay, perhaps goaded³² by the appearance of Isaac Newton's *Principia Mathematica* in 1687, Leibniz began to work out the details of his own positive program in physics.³⁵ Most important from the point of view of the foundations of the new science that Leibniz dubbed "dynamics" is the massive *Dynamica de Potentia et Legibus Naturae corporeae*, written during Leibniz's trip to Italy in 1689–90 with the intention of publication, but unpublished during his lifetime.³⁶ This work is a systematic

treatise on motion and its laws, presenting in a systematic and rigorous fashion the conclusions of the new science. While Leibniz never published the *Dynamica*, he did publish an essay that presents what he takes to be the foundations of the dynamics. This essay was entitled "Specimen Dynamicum" (SD), and was published in the *Acta Eruditorum* in 1695.³⁷ Though its title suggests a summary of, or selection from, the earlier work and Leibniz's opening words suggest that the new work will present some hint of what the *Dynamica* contained, little of the highly technical material from the *Dynamica* is found in the SD; instead, what we have is a careful exposition of the metaphysical foundations of the new science, something that is hard to find in the old *Dynamica*, and no less valuable than the more technical physics of the *Dynamica*.

Also important in the writings of this period is the "Tentamen de Motuum Coelestium causis," published in the *Acta Eruditorum* in 1689. In this essay Leibniz offers an account of the motion of the planets, using a complex scheme of vortices, a more explicitly mechanist alternative to the account in terms of the theory of universal gravitation that Newton presented in his *Principia*.³⁸ While Newton does not deny that there may be an underlying mechanical explanation of the force of gravity he discovered and the motion of the planets that follows from that force on his theory, his *Principia* offers no such account. Leibniz's essay, on the other hand, is intended specifically to offer such an account; it is a most visible tribute to the depths of Leibniz's continuing commitment to the mechanist program of a physics grounded in size, shape, and motion.

These by no means exhaust Leibniz's scientific interests in this period, from which numerous other notes and publications date.³⁹ But what is especially interesting is the way in which Leibniz's new program for physics penetrates the more philosophical writings, particularly in the 1680s and 1690s. In Leibniz's mind, as we shall later see in more detail, the new program for physics is intimately linked with his more philosophical programs, and so Leibniz's enthusiasm for his new physics spills over into works like the *Discourse on Metaphysics*, his philosophical correspondence, particularly the letters with Arnauld in the late 1680s, essays like the "Correction of Metaphysics . . ." of 1694, and the "New System" of 1695. Most interesting here is an essay Leibniz published in 1698, "On Nature Itself," which, Leibniz announces in the subtitle, is "on the inherent

force and actions of created things, toward confirming and illustrating their dynamics."

It is in the 1680s and 1690s that Leibniz is most actively interested in working out his physics and the metaphysical questions connected with it. His interest in physics by no means disappears in later writings; he continues to discuss his ideas in physics and its foundations with his correspondents, as is shown, for example, by his correspondence with DeVolder, Des Bosses, and, especially, the correspondence he conducted at the very end of his life with Samuel Clarke, who acted as a stand-in for the great Sir Isaac Newton.⁴⁰ But by the late 1690s, it is fair to say that Leibniz's basic views on physics and its foundations are well settled. Without ignoring those later writings, I shall try to give an overview of Leibniz's thought on matters of physics in these two crucial decades. Before turning to the details, though, it will be helpful to introduce a distinction implicit in Leibniz's writings about the natural world, a distinction that will help to organize the discussion to follow.

Throughout his mature writings, Leibniz sides with the mechanists against both the philosophy of the schools and against the Newtonian attempt to extend the mechanical philosophy through the introduction of gravity, a force that some Newtonians, if not Newton himself, thought was inexplicable in mechanical terms. But, Leibniz held, the mechanical physics is not fundamental in a very important sense. Leibniz writes in a characteristic passage from the *Discourse on Metaphysics of 1686*:

Although all the particular phenomena of nature can be explained mathematically or mechanically by those who understand them, nevertheless the general principles of corporeal nature and of mechanics itself are more metaphysical than geometrical, and belong to some indivisible forms or natures as the causes of appearances, rather than to corporeal mass or extension.

(*Discourse*, par. 18, G IV 444: AG 51-52)⁴¹

These "indivisible forms or natures" ^{*)} pertain to corporeal substances, which, as we shall see below, are characterized in the physical writings in terms of the notion of force. This suggests that there are at least two levels in Leibniz's natural philosophy. At the surface, as it were, is the mechanical philosophy, in which everything is explained in terms of the notions of size, shape, and motion, assuming that motion satisfies certain laws. This, I think, is what Leibniz

often thought of as physics proper.^{x2)} But below physics proper stands the science that treats force and the metaphysical entities, the corporeal substances to which force, properly speaking, pertains and from which motion and its laws derive. This science is what Leibniz called dynamics.⁴² Leibniz clearly thinks that dynamics is closely connected to metaphysics, but the relation between the corporeal substances, characterized in terms of force, and the individual substances, later monads, that dominate his more directly metaphysical writings is obscure, as we shall later see.⁴³ In the remainder of this essay, I would like to focus on the more straightforward categories of physics and dynamics. The two levels are difficult to separate completely and treat entirely independently. I will begin by discussing the dynamical level in Leibniz's natural philosophy, the notion of force, before turning to the notions of space, shape, and motion that constitute Leibniz's notion of physics proper.