

### 3.2 *Body and force*

The notion of force was important to Leibniz's mature thought from the time of its origins in the late 1670s. It is fair to say that in the early seventeenth century, the notion of force had no single definite meaning, nor did it in Leibniz's own earlier writings.<sup>53</sup> But throughout Leibniz's writings in the 1680s and 1690s, it is in the process of becoming a more precise technical term. The notion of force and the distinctions that Leibniz draws among the different kinds of force do not emerge all at once. But by 1695 everything seems to be in place, and Leibniz's ontology of force and its relation to the notions of body and substance receive a tidy and well-organized presentation in the SD.

In the SD and related writings, Leibniz presents a conception of force that involves two important distinctions, the distinction between primitive and derivative forces, and the distinction between active and passive forces. So in all, there are four principal varieties of force – primitive active and passive force, and derivative active and passive force. Leibniz writes:

*Active force* [which might not inappropriately be called *power* [*virtus*] as some do] is twofold, that is, either *primitive*, which is inherent in every corporeal substance *per se* . . . or *derivative*, which, resulting from a limitation of primitive force through the collision of bodies with one another, for example, is found in different degrees. Indeed, primitive force [which is nothing but the first entelechy] corresponds to the *soul* or *substantial form*. . . . Similarly, passive force is also twofold, either primitive or derivative. And indeed, the *primitive force of being acted upon* [*vis primitiva patiendi*] or of resisting constitutes that which is called *primary matter* in the schools, if correctly interpreted. This force is that by virtue of which it happens that a body cannot be penetrated by another body, but presents an obstacle to it, and at the same time is endowed with a certain laziness, so to speak, that is, an opposition to motion, nor, further, does it allow itself to be put into motion without somewhat diminishing the force of the body acting on it. As a result, the *derivative force of being acted upon* later shows itself to different degrees in *secondary matter*.

(SD, part I, par. 3, GM IV 236–7; AG 119–20)<sup>54</sup>

Let us begin by examining the notions of active and passive force. Leibniz writes in the SD:

[Active] force is . . . twofold. One force is elementary, which I also call *dead force*, since motion does not yet exist in it, but only a sollicitation<sup>\*)</sup> to motion,

as with the ball in the tube<sup>55</sup> or a stone in a sling being held in by a rope. The other is ordinary force, joined with actual motion, which I call *living force* [*vis viva*]. An example of dead force is centrifugal force itself, and also the force of heaviness [*vis gravitatis*] or centripetal force, and the force by which a stretched elastic body begins to restore itself. But when we are dealing with impact, which arises from a heavy body which has already been falling for some time, or from a bow that has already been restoring its shape for some time, or from a similar cause, the force in question is living force, which arises from an infinity of continual impressions of dead force.

(SD, part I, par. 6, GM VI 238: AG 121–22.)

This suggests that active force is to be connected with velocity and acceleration, more specifically, dead force with acceleration, and living force with actual motion. But though connected, active forces must not be *identified* with motion or acceleration; motion and change in motion (acceleration) are not forces themselves, as we shall later see in sec. 4.2, but the *effects* of forces. Furthermore, the BD argument shows that what is conserved in nature is not size times speed, but size times the square of speed. And so, if what is conserved in motion is force (living force), then force is not to be identified with motion *simpliciter*, since when the motion (velocity or speed) is doubled, the force is quadrupled.

Passive force is something quite different.<sup>56</sup> As the earlier passage quoted from the SD suggests, passive force is connected not with motion, but with the resistance to motion. This resistance is of two sorts.<sup>57</sup> First there is impenetrability, “that by virtue of which it happens that a body cannot be penetrated by another body.” But in addition to that there is a kind of passive force by virtue of which bodies actively oppose the motion other bodies try to impose on it in impact, what Leibniz calls “a certain laziness.” This resistance is something quite different from the mere tendency bodies have to remain in a given state, a notion basic to the thought of Descartes, Hobbes, and Spinoza. Leibniz writes to the Cartesian De Volder:

I admit that each and every thing remains in its state until there is a reason <sup>21</sup> for change; this is a principle of metaphysical necessity. But it is one thing to retain a state until something changes it, which even something intrinsically indifferent to both states does, and quite another thing, much more significant, for a thing not to be indifferent, but to have a force and, as it were, an inclination to retain its state, and so to resist changing.

(Letter to De Volder, 24 March/3 April 1699; G II 170: AG 172)<sup>58</sup>

It is this force of resistance that slows the body in motion colliding with the body at rest, allowing Leibniz to avoid the result that so tainted his own early physics. As with the active forces, Leibniz differentiates passive forces from the behavior in bodies that they cause. In the SD Leibniz is careful to characterize passive force as "that by virtue of which it happens" that bodies have impenetrability and resistance; the passive forces are the causes of this behavior in just the way that the active forces are the causes of motion. Passive force also seems to be the cause (in a somewhat extended sense) of a body's extension. Writing to Arnauld, Leibniz discusses the "primitive passive power [i.e., force]" of a substance as its matter, and claims that "in this sense matter would not be extended or divisible, although it would be the principle of divisibility or that which amounts to it in the substance" (letter to Arnauld, 9 October 1687, G II 120; see also G IV 394: AG 251). The view seems to be that the extension of a body is just the diffusion of resistance; extension is, properly speaking, a direct consequence of the property bodies have by virtue of which they resist penetration by other bodies.

Let us now turn to the distinction between primitive and derivative forces. In the passage from the SD quoted above, Leibniz characterizes the primitive active force as corresponding to "the soul or substantial form"; the primitive passive force, on the other hand, is characterized as constituting "that which is called *primary matter* in the schools, if correctly interpreted." Form and matter are, of course, terms of art from the Aristotelian account of substance; as noted earlier in characterizing the Aristotelian conception of substance in section 1, form and matter join together to constitute a substance for Aristotle and his followers. And so for Leibniz as well. Leibniz writes in his essay of May 1702:

Primitive active force, which Aristotle calls first entelechy and one commonly calls the form of a substance, is another natural principle which, together with matter or [primitive] passive force, completes a corporeal substance. This substance, of course, is one *per se*, and not a mere aggregate of many substances, for there is a great difference between an animal, for example, and a flock.<sup>\*2)</sup> (G IV 395: AG 252)

And so, it seems, the primitive forces, active and passive, come together to make up the corporeal substance, the genuine unity that, Leibniz claims, underlies the extended bodies of physics.

\*2) *Horde*

Derivative forces, in contrast, are the forces most of interest to the physicist. Leibniz writes in the SD:

Therefore, by derivative force, namely, that by which bodies actually act on one another or are acted upon by one another, I understand . . . only that which is connected to motion (local motion,<sup>24</sup> of course), and which, in turn, tends further to produce local motion. For we acknowledge that all other material phenomena can be explained by local motion.

(SD, pt. I, par. 4, GM VI 237: AG 120)

Derivative force is, furthermore, that in terms of which we can frame the laws of physics. Leibniz writes, again in the SD:

It is to these notions [i.e., the derivative forces] that the laws of action apply, laws which are understood not only through reason, but are also corroborated by sense itself through the phenomena.

(SD, part I, par. 3, GM VI 237: AG 120)

Leibniz uses a number of terms to describe the relation between primitive and derivative forces. In the SD he talks of derivative force as resulting from "a limitation of primitive force through the collision of bodies with one another" (SD, part I, par. 3, GM VI 236: AG 119). In the first draft of the "New System" (ca. 1694) he writes:

[I call form or entelechy] the primitive force in order to distinguish it from the secondary [i.e., derivative force], what one calls moving force, which is a limitation or accidental variation of the primitive force. (G IV 473)

Similarly, he writes to Bernoulli in 1698:

If we conceive of soul or form as the primary activity from whose modification secondary [i.e., derivative] forces arise as shapes arise from the modification of extension, then, I think, we take sufficient account of the intellect. Indeed there can be no active modifications of that which is merely passive in its essence, because modifications limit rather than increase or add.

(Letter to Bernoulli, 17 December 1698, GM III 552: AG 169)

And finally, Leibniz writes in the essay of May 1702 that "active force is twofold, primitive and derivative, that is, either substantial or accidental (G IV 395: AG 252). These passages suggest that derivative forces are to be understood as modes, accidents or the like, modifications of the primitive forces, which are understood as substances, or, better, as constituents of corporeal substances. Primitive active and passive forces, then, are the substantial ground of the

derivative active and passive forces, which are their accidents or modes, as shape is an accident or mode of an extended thing.

The picture of the physical world that emerges out of the SD and related writings is quite interesting for the way in which it joins scholasticism with mechanism. At the metaphysical ground are corporeal substances, unities of form and matter, primitive active and passive forces. These, in turn, ground derivative forces, the modes or accidents of these primitive forces, their momentary states that can change as do shapes in an extended substance. The derivative forces, active and passive, in turn, are the immediate cause of motion, resistance, impenetrability, and even extension in bodies, giving rise to the mechanist's world of extended bodies in motion, following certain laws. In this way Leibniz can say, as we have seen, that everything in the world happens mechanically, but that the world of the mechanical philosophers is grounded in something quite different than extended matter and motion, an Aristotelian metaphysics of substantial form and primary matter; it is the dynamics, the science of force that links the underlying Aristotelian metaphysics with the physics of the mechanists. The final form of this doctrine, with its careful distinction between form and matter, primitive and derivative forces, active and passive forces of different varieties may not appear until the mid 1690s, but the basic picture is integral to Leibniz's thought about the physical world from the 1680s on.<sup>59</sup>

In section 4 of this essay, we shall turn to the mechanist physics that Leibniz builds on the foundations of the dynamics, but we must first take a turn in the other direction, to the metaphysics, and examine the relation between the apparently Aristotelian metaphysics that seems to underlie the SD and the conception of substance that underlies Leibniz's more familiar metaphysical writings.