4.2 *Motion*

"If motion . . . is something real," Leibniz wrote to Huygens in June of 1694, "it must have a *subject*" [Letter to Huygens, 12/22 June 1694, GM II 184: AG 308]. But, as Leibniz had explained to Arnauld some years earlier, this is precisely what motion as commonly understood lacks:

Motion, insofar as it is only a modification of extension and a change of neighborhood [i.e., as Descartes defined it] contains something imaginary,

so that one doesn't know how to determine to which among the subjects changing it belongs. [Letter to Arnauld, 30 April 1687, G II 98: AG 86]

The problem that Leibniz is pointing out here is twofold. One problem simply derives from the widely held view that motion, taken by itself, is just the change of spatial relations among various bodies.[*] If this is all that motion is, strictly speaking, then in the case where bodies *A* and *B* are in motion with respect to one another, we are free to consider *A* at rest and *B* in motion or *B* at rest and *A* in motion. "Motion, in all mathematical rigor, is nothing but a change in the positions of bodies with respect to one another," Leibniz wrote in an untitled essay in 1689, "and so, motion is not something absolute, but consists in a relation" [C 590: AG 91]. This observation is, of course, not unique to Leibniz, nor is it particularly deep. But Leibniz also holds a deeper and more characteristically Leibnizian view on the matter. Now, motion might be relative in this first, weak sense, and yet one might claim that it is possible to perform an experiment to determine whether it is really *A* or really *B* that is in motion. The most celebrated argument of this sort is Newton's bucket experiment. In his *Principia*, Newton argued that the way the water climbs the sides of a twirling bucket shows that it is the bucket that is moving in a universe at rest, and not the universe twirling around a resting bucket of water.[92] And so Newton distinguished between relative motion – motion with respect to an arbitrarily chosen rest point, and absolute motion – motion with respect to absolute space.[93] Leibniz knew of Newton's claim, and just as he rejected absolute space, he rejected Newton's absolute motion. Leibniz wrote to Huygens that:

> Mr. Newton recognized the equivalence of hypotheses in the case of rectilinear motions. But with respect to circular motions, he believes that the effort that circulating bodies make to recede from the center or from the axis of circulation allows us to know their absolute motion. But I have reasons that make me believe that nothing disrupts the general law of equivalence.[*] [GM II 184–85: AG 308][94]

Leibniz's arguments are difficult and obscure.[95] But the basic idea seems to have been this: everyone grants the equivalence of hypotheses for rectilinear motion, that is, we cannot perform any experiments that will allow us to tell whether we are in uniform rectilinear motion or at rest. But, Leibniz seems to have reasoned, in the billiard-ball world of the mechanical philosophy, all curvilinear and

accelerated motion is made up of (very short) segments of uniform rectilinear motion, the direction or speed of which is changed by collision with other bodies. And insofar as he thought that we cannot distinguish between a uniformly moving *A* colliding with a resting *B*, and a moving *B* colliding with a resting *A*, he seems to have thought that in the real, mechanical world, at least, the equivalence of hypotheses should hold for curvilinear and accelerated motions as much as it does for uniform rectilinear motions. And so he thought that he could give a demonstration that *no* experiments could allow one to distinguish any frame from any other and establish that the one is the true rest frame and the other isn't; this is what he calls the doctrine of the equivalence of hypotheses, stated (and proved) as proposition 19 of part II, section 3 of the *Dynamica* (GM VI 507–8).[96] And so, according to Leibniz's doctrine, not even an angel could discern whether Copernicus is right in holding that the Earth moves, or Ptolemy and Tycho are right in preferring a moving sun. In an interesting piece, written, significantly enough in 1689, during his year in Italy, where the memory of the condemnation of Galileo was still very much alive, Leibniz wrote:

> And whether the bodies are moving freely or colliding with one another, it is a wonderful law of nature that no eye, wherever in matter it might be placed, has a sure criterion for telling from the phenomena where there is motion, how much motion there is and of what sort it is, *or even whether God moves everything around it, or whether he moves that very eye itself.* (C 590: AG 91)[97]

Nothing in the world of physics taken strictly, that is, nothing in the mechanist world of size, shape, and motion can determine whether a given body is in motion or at rest, *mathematico rigore*. And so, Leibniz argues, motion so understood lacks a determinate subject, and lacking a subject, cannot itself really be a constituent of the world. Behind this view, of course, is a metaphysical assumption or two. Leibniz finds it absolutely unintelligible that there could be a property that is not really a property of some one thing, a property that is *irreducibly* relational. What exactly this means is not altogether clear.[98] But, Leibniz inferred, if motion is to be real, it must be grounded in something that is not mere relation, something that is a real property of real things.

Though Leibniz tried a number of solutions,[99] the one he finally

settled on was *force:* "One cannot really . . . say to which subject motion belongs, and thus there is nothing real in motion except force and the power [*potentia*] things are endowed with," Leibniz wrote in a characteristic passage from 1683 (VE II 294; cf. *Discourse*, par. 18, G IV 444: AG 51; SD, part II, par. 2, GM VI 247–48: AG 130–1; G IV 369: L 393; G IV 400: AG 256; G IV 523: L 496; VE III 481, 488, 495). The ontology of force we discussed in section 3 gives Leibniz a way of grounding the reality of motion. Though motion or rest taken narrowly, the change of position or the lack thereof, cannot be attributed to individual bodies in a nonarbitrary way, Leibniz claims that there is a real fact of the matter about the force that is the cause of the motion we see, which really can be said to pertain to one body or another. As Leibniz wrote in the *Discourse on Metaphysics* (1686):

> Motion . . . is not a thing entirely real. . . . But force or the proximate cause of these changes is something more real, and there are sufficient grounds to attribute it to one body rather than to another. Furthermore, it is only in this way that we can know to which body the motion belongs.
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> (*Discourse*, par. 18, G IV 444: AG 51)

Though motion understood as change of place is relative, strictly speaking, the appeal beyond the world of extension and its changes to force can break that relativity, Leibniz seems to think, and allow us to talk intelligibly about the *cause* of motion as pertaining to one body rather than another. Motion so grounded can enter the world of physics.

Leibniz's view on motion raises an interesting question, though. Motion is completely relative, and by the doctrine of the equivalence of hypotheses, there are no physical marks to distinguish real motion from apparent; every frame of reference is as good as every other, at least from the point of view of physics proper, that is, if we limit ourselves to the consideration of extended bodies in motion.[100] But, Leibniz argues, underlying motion there must be force, the cause of motion, something that goes beyond the mechanist's world of extension and its modes, something that really pertains to one body rather than another. There is, in this sense, a correct frame for determining motion, the frame in which the motions observed are the effects of real underlying forces which are their causes. *But such a frame could never be identified.* Motion has a foundation, in a sense, but one that makes no real (or apparent) difference in the

world of physics; in this way the theory of motion would seem to float free of its foundations in the notion of force.[101]

The fact that we cannot link observed motions to some particular underlying forces should not, by itself, undermine Leibniz's project; Leibniz hadn't intended that force should ground physics in that crude and direct way, I think. What force explains is that the attribution of motion to the world makes sense *at all*. For Leibniz, all real properties of things in the world ultimately reside in genuine individuals. If that is the case, it is evident why mere motion, the mere change of place, just won't do; for it to be intelligible that there is motion at all, there must be something nonrelativistic, something that is an absolute and nonarbitrary property of some individual thing, that is the cause and ground of motion. This is where force comes in. The present state of the world must have a ground in reality, in *some* configuration of forces; *something* must be there, though Leibniz cannot say *what specifically*. Nor does it matter *which* of the infinity of possible configurations of force there are in the world from the point of view of physics; it is only important that there is some one such configuration.

But the appeal to force grounds more than just the reality of motion: it grounds its laws as well. Despite the fact that we cannot determine where the real causes of motion lie in nature, these forces have a crucial role to play in the derivation of Leibniz's laws of motion. This is what we shall see in the following section.