Dynamics and the Reality of Force in Leibniz and Kant

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In this paper what I am going to focus on is the relationship between the articulation of the principles of dynamics and the prospects for metaphysics as assessed by Leibniz and, subsequently, by Kant. In order for the inquiry that Leibniz termed "dynamics" to be described two conditions had first to be met. The first was a displacement of the authority of Cartesian approaches to corporeal substances and the second was the articulation of a basis for the inquiry that would be dynamics in the metaphysics of Leibniz. I will describe the manner in which Leibniz met these conditions in order to then assess the difficulty of Kant's shifting responses to Leibniz, a difficulty that will be illustrated through comparison of two early texts of Kant, texts that illustrate both the continuing importance of the Leibnizian inquiries into both dynamics and metaphysics and yet which also make clear the grounds on Kant's part of the difficulties with accommodating these approaches whilst striving to make room for Newtonian conceptions.

1. The Cartesian view of corporeal substance

In the *Principles of Philosophy* Descartes defines substance in terms of the criteria of independence, a substance being that which depends on no other thing whilst other things depend upon it. Whilst he carefully describes the term "substance" as a term which does not apply univocally to God and created things the key point for my enquiry concerns the manner in which corporeal substance is described. Descartes determines that there is a principal attribute by which the substance in question can be des-

cribed and with regard to the corporeal he determines it to be extension stating:

> Everything else which can be attributed to body presupposes extension, and is merely a mode of an extended thing…For example, shape is unintelligible except in an extended thing; and motion is unintelligible except as motion in an extended space…By contrast, it is possible to understand extension without shape or movement…and this is quite clear to anyone who gives the matter his attention.[1]

To this pointed statement of the principal attribute of what is corporeal we need however to add another point that brings out its full significance for what kinds of claims can be made concerning body in any systematic manner. Descartes closes the third part of the *Principles* with precisely this statement:

> I freely acknowledge that I recognize no matter in corporeal things apart from that which the geometers call quantity, and take as the object of their demonstrations, i.e. that to which every kind of division, shape and motion is applicable. Moreover, my consideration of such matter involves absolutely nothing apart from these divisions, shapes and motions….And since all natural phenomena can be explained in this way…I do not think that any other principles are either admissible or desirable in physics.[2]

With these statements Descartes makes clear that if corporeality is reducible to pure extension then it follows that scientific inquiry is framed by quantity, shape and motion. The one question we might ask at this point would concern how motion is going to be accounted for if we take bodies to be constituted primarily through spatial quantifiable coordinates. Clearly matter is here conceived of

as homogeneous in nature and as describable in terms of the determinations of quantitative functions. Given this view the account of motion that will ensure will be entirely kinematic, it will, that is, present motion through a set of coordinates that will require no attention to elements of it that are productive or, as we might otherwise put it, that are the basis in the phenomena themselves of motion. There are two ways of conceiving of this result. On the one hand, we can thus view motion entirely through vectors that are understood on the model of computation. This would be something like a contemporary functionalist restatement of the Cartesian position which would pretend to do without metaphysics. On the other hand, we can resort to the words of Descartes himself who understands the production of motion to be an original act that is part of the constitution of the world by God who placed a certain quantity of motion in matter at the first instant which quantity is preserved by God.[3] Matter would, as it were, left to itself, remain at rest. But it is an original act of God's to impel movement of a certain quantity which he then conserves. Descartes elucidated this claim in a letter to Henry More where he stated that the claim that the same amount of motion remains in matter should be understood "as concerning the force [*vis*] impelling its parts, which attaches itself at one time to one part of matter, and at another time to another part" (AT V: 405).[4] This reference to impulsion suggests that when Descartes claims that the quantity of motion is conserved in the world what he is really meaning is not the actual effective motion that is produced but the *cause* that is conserved and with the conservation of this cause thus would come the effect.[5]

Whether this account of Descartes' conservation principle is adopted or not what is apparent is that there is no ground in Descartes' description of corporeal substance for a dynamical account of motion. It is only the nature of the effects of motion that is physically describable with the areas of causation ultimately removed to the level of metaphysics. This ensures however that force, inasmuch as it can be

conceived by Descartes at all, is viewed in terms of action by means of motion. However if force is viewed by means of motion then it has to be seen as something that is communicated to a body entirely externally. It also follows that force is not present in a body that is at rest and that body consists essentially in inert mass. These assumptions are what have to be overthrown for something like a dynamics to be described.

2. Leibniz's Challenge to the Cartesian View

The Cartesian conception of corporeal substance views it through mathematical qualities only with magnitude, position, figure and the changes of them being primary determinations and the description of "force", inasmuch as it is given a physical characterisation at all, allowed only at the moment when bodies come into contact with each other. The point of collision between two bodies thus involves transference of force from one to the other, a transference which is part of the general equilibrium sustained in the conservation of the total quantity of motion. Motion thus has to be viewed as continuous on this view whilst force, by contrast, is only present in the places in which motion is occurring. Leibniz's early piece of 1671, the *New Physical Hypothesis*, fails to articulate the principles of dynamics that come later but in confronting the Cartesian conception with the Hobbesian notion of *conatus* (or "endeavour") here he begins to elaborate some consequences of the Cartesian view that he will soon find problematic. Hobbes, like Descartes, was committed to the view that rest is a state in which nothing of any efficacy takes place but that motion is the basis of anything that can be thought as acting. Endeavour was however viewed by Hobbes as that motion which is made in an instant of time and is hence less than can be given to measurement in any space or time.[6] On the basis of the principles we have already elaborated Leibniz here looks at what the effect of them is on attempts to comprehend the *conatus* present in

interactions between bodies in collisions. This leads to the formulation:

> Hence *whatever moves*, no matter how feeble, and no matter how large may be the obstacle that it meets, *will propagate its conatus in full against all obstructions* into infinity, and furthermore it will impress its conatus on all that follows. For though it cannot be denied that a moving body does not proceed in its motion even when it has stopped, it at least strives to do so, and what is more, it strives, or what is the same thing, begins to move the obstructing bodies, however large, even though they may exceed it.[7]

This surprising result of the Cartesian position meeting the Hobbesian view of *conatus* produces the effect that any given body has to be viewed as including in itself many contrary endeavours that pull in different directions. Since the point of the Hobbesian thought is also to allow for the notion that some elements of the action of body occur at a level below that of sensory awareness Leibniz is also here led to the position that the conatus occurs in a time less than any that can be assigned and is in multiple locations with the result that "the body will fill a part of space greater than itself, or greater than it would fill at rest or if moving more slowly or if striving in one direction only". This leads to further paradoxes when Leibniz attempts to discuss the relationship between the differential *conatuses* and the time in which their actions take place. Each instant of time is viewed here as homogeneous with every other whilst the *conatuses* are seen to be heterogeneous. The way this is marked is however in quantitative terms with the instants stated to be *equal* to each other by contrast to the *un*equal *conatuses*. If time is measured by reference to uniform motion the problem emerges that the action that impels the motion cannot be uniformly distributed as Leibniz states when discussing acceleration. Acceleration, as he puts it,

presupposes an increase at each instant and hence at the beginning of the endeavour so one endeavour must be earlier than another even though they are in fact taking place at the same instant. This produces the obvious consequence that since the conatuses are unequal to each other so must be the instants in which they are given: "in one instant no conatus can pass through more than a point, or a part of space less than any given part, otherwise it would pass through an infinite line in time. Therefore one point is greater than another" (L 141).[8]

The early writing of Leibniz that produces these dramatic consequences by merely combining the Cartesian positions with the introduction of the notion of *conatus* and a concomitant description of the temporal possibilities of action produces paradoxes aplenty and was not long held by Leibniz. The fundamental difficulties that his early writing run into are based on a form of quantification of endeavour that lacks the basis of homogenous measurement being expressed in a medium that was set precisely for such homogeneous measurement. Hence the paradox of two conflicting frames of reference creates the difficulty that whilst dynamics is not yet given principled articulation that something is introduced in the shape of *conatus* that requires the alteration of the view of corporeal substance so that the description of it exceeds that of magnitude, figure and position. It requires something like the principles of dynamics to advance, the principles that is, as Leibniz was later to put it, of a "*science of power and action*".[9]

The mature Leibniz refers back to this early writing in his key text the *Specimen Dynamicum*. In this later work he rejects the positions of his early writing, not least the position that small bodies could move larger ones as easily as vice versa since, as he then puts it, anything could be accomplished by anything. In responding to his earlier position he here however also moves away from the Cartesian elements of it indicating that he now takes the view that corporeal substance needs a different description. The view of body as composed essentially of extension is

directly challenged in order that "an interpretation of forces may arise". The factor of force is now added to the notion of extension with the result that rules of motion, which Leibniz terms "systematic", are produced. These rules include the *law of continuity* which states that no change is produced by a leap or, as given positively, that all change emerges gradually from conditions given. Alongside the statement that every action involves a reaction is the claim that no new force is produced without diminishment of previous forces and that there can be neither more nor less power in an effect than is given in a cause. These laws are pointedly indicated to be derived not from mass but from an additional factor in bodies, the factor of force itself. Hence Leibniz replaces the Cartesian principle of conservation of the quantity of motion with the principle that what is conserved in the world is rather the quantity of force.[10] Whilst Leibniz makes clear claims at the level of physics for the conservation of force rather than motion he also argues that there is a key metaphysical reason for this move stating that without it the communication between bodies will have to be explicated by reference to God's conserving power. We have noted that this move is in fact directly authorized by Descartes and Leibniz's point here is that geometrical concepts such as we are given to describe the extension of body cannot generate the understanding of action.

> We show, therefore, that there is in substance a force of action and that if it is created substance, there is also a force of suffering. We show too that the concept of extension is not complete in itself but requires a relation to something which is extended and whose diffusion or continuous repetition it implies, and therefore that it presupposes also a bodily substance which involves the power to act and resist, and which exists everywhere as corporeal mass, the diffusion of which is contained in extension. (L 445)

The first point to note here is that with the announcement of this position comes a claimed realism with regard to force that implies by contrast a demotion of the ontological status of motion along with those of space and time. Motion, viewed apart from force, is now seen purely as a relation and not as something absolute and this implies the relativity of motion and with this a stated equivalence between motion and rest. Leibniz is clear in claiming that if a number of bodies are in motion it is not possible, by observation of the phenomena alone, to state which bodies are to be claimed to be moving and which are at rest. Rest is hence now viewed, not as an absolute state, but rather as a minimal motion with the effect that motion is now seen in terms of quantities that approach zero without ever entirely reaching it whilst the nature of the differential relation between motions is relativized to frameworks of assessment. The metaphysical consequence of this however is that it ceases to be necessary to view relations between bodies as ones in which the effect in one is produced by the cause in another. If a particular body is viewed in terms of two capacities, the capacity to act and the capacity to suffer, then any apparent contact of one body with another can be viewed simply in terms of the internal states of either one. As Leibniz puts this:

> For since the percussion is the same regardless of what body the true motion belongs to, it follows that the effect of percussion will be equally distributed between both, and that *both act equally in the collision*, so that half of the effect comes from the action of one, the other half from the action of the other. And since half of the effect or passion is also in one and half in the other, it suffices to derive the passion which is in one from the action which is in it, so that we need no influence of one upon the other; even though the action of one provides an occasion for the other to produce a change within itself. (L 448)

Whilst this claim is apt to appear as paradoxical at first sight as some of the consequences of the positions adopted in the *New Physical Hypothesis* it is grounded in a claim concerning the nature of corporeal substance that is well worth further elaboration. If a contact between two bodies results in impact the first phenomena that can be noted as resulting from such impact is the disentanglement of the bodies from each other. This is what Leibniz understands as repulsion and his argument is that such repulsion arises from within the bodies themselves and this repulsion can be expressed in one of two ways. We can either view it as a result of the fact that bodies are internally elastic, that is, such substances as expand and contract on their own volition or as a result of the matter that constitutes body with such matter being viewed as an ethereal fluid which permeates the body. Leibniz sometimes speaks in one vocabulary, sometimes in the other but as with his claim concerning the relativity of hypotheses concerning motion so he is also here implicitly viewing these hypotheses as relative to explanatory framework. Either way we see the action of the body as arising from an internal force that exists within it.

This appeal to internal force is however understood by Leibniz on about four levels. The basic claim he wishes to make concerns what he calls "primitive force". The rationale for ruling out any substantial reality in "rest" is the claim that all bodies possess primitive force and Leibniz relates it to general causes which metaphysically supplement the laws of the physical, a supplement that enables him to offer a partial reinstatement of the Aristotelian conception of substantial forms. Primitive force is seen as active *and* passive with active force being the basis of the movement of the body and the passive force being that which enables repulsion and impenetrability. However the primitive forces are introduced for metaphysical completeness, not for accounting of nature. This function is rather performed by the derivative forces which result as limitations of primitive force arising from the collision of bodies. The derivative forces are what are

appealed to in accounting for motion. Bodies, when moving, possess a degree of velocity and if we add to this the direction of movement we arrive at Leibniz's mature notion of *conatus*. Impetus is then viewed as the product of mass of the body by its velocity and whilst this can be seen as having existence in time through each moment the relation of the moments of movement "is an integral of the impetuses…existing in the moving body multiplied by the corresponding intervals of time" (L 437). Whilst the impetus itself is thus a momentaneous quantity it arises from a succession of an infinite number of impacts on the same moving body. Thus *conatus* is now effectively duplicated being seen on the one hand as something elementary or infinitely small, and at this level it is effectively a solicitation of the body to movement and then at another level we have the continuation or repetition of these impulsions which latter is what we might term "impetus itself".

> Hence force is also of two kinds: the one elementary, which I also call *dead* force, because motion does not yet exist in it but only a solicitation to motion, such as that of the ball in the tube or a stone in a sling even while it is still held by the string; the other is ordinary force combined with actual motion, which I call *living* force [*vis viva*]. An example of dead force is centrifugal force, and likewise the force of gravity or centripetal force; also the force with which a stretched elastic body begins to restore itself. But in impact, whether this arises from a heavy body which has been falling for some time, or from a bow which has been restoring itself for some time, or from some similar cause, the force is living and arises from an infinite number of continuous impressions of dead force. [L 438]

Before describing however the relative importance of living and dead force and their respective ways of being developed in physical demonstrations it is first necessary to

relate the description of these forces to Leibniz's infinite analysis of the composition of corporeal substances. At times this claim concerning the composition of corporeal substances is simply drawn out of the Cartesian view of extension as when Leibniz claims in the draft of a letter to Arnauld from late 1686 that every extended mass can be viewed as a composite of a thousand others with the only true extension being given in contact. On these grounds no body would really qualify *as* a substance however as it would then be the case that each would be merely an aggregate. This quasi-mathematical argument is however not Leibniz's real case since he rather wishes to derive from his consideration that each effect can be seen to be a product of the internal action of the individual corporeal substance the conclusion that within each body there is an infinity of interactions. As he puts this: "Every living thing contains a world of diversity in a real unity"[11]. The relation between the diversity *in* each corporeal substance and that which makes it united so that we can indeed distinguish *between* individual substances is a thorny problem in Leibniz though he indicates his general solution to the difficulty in a letter of 1703 to De Volder when he writes:

> If you think of mass as an aggregate containing many substances, you can still conceive of a single pre-eminent substance or primary entelechy in it. For the rest, I arrange in the monad or the simple substance, complete with an entelechy, only one primitive passive force which is related to the whole mass of the organic body. The other subordinate monads placed in the organs do not make up a part of it, though they are immediately required by it, and they combine with the primary monad to make the organic corporeal substance. (L 530)

Here Leibniz indicates the need for the body to be governed by an entelechy that is primarily and decisively its own in connection with a primitive passive force that

combines with this active element. The other monads that are within the organs of the rest of the body are distinguished from the body itself, as, whilst they reside in the organs, they are still not *part* of the body. In denying that these subordinate monads are part of the body Leibniz is not departing from the positions advanced earlier since to assimilate the subordinate monads to the parts of the body would be to render them as purely elements of extension rather than placing them within the substantial infinity. The primitive entelechy and the primary passive element are what together are now said to form the complete monad. By contrast the subordinate monads concur in the secondary matter of the body, the element that is the basis of derivative forces. Since these derivative forces are in turn governed by the action that is produced in the unity of primitive entelechy and primary matter they can be metaphysically reduced to this unity. The change that belongs to the body itself is thus grounded in the complete primary monad and it is this that marks the corporeal substance as an *individual*. But the body that is thus reducible to the individuated corporeal substance is not only itself infinitely divisible but all other extensive quantities are likewise so divisible ensuring that the world is *full* of matter and there is not a space in which there are not parts thereof.[12]

However a final point worth drawing out from Leibniz's dynamical account of matter is that whilst it presents a realism of force in connection with a phenomenal analysis of motion it is not merely the case that motion is the phenomenal ground of force but also true that force is viewed only through the prism of the internal articulation of bodies. The effect of these points is to rule out the notion of attraction in accounting for either physical cohesion or as part of the story concerning impact and phenomenal interaction. This principled rejection of interaction is effectively part of Leibniz's refusal of Neo-Platonic principles in matter as expressed in his virulent rejection of the views of Henry More but which is extended in his late works to a rejection of the account of action at a distance

given in Newton. This rejection is particularly pointedly expressed in his late piece *Against Barbaric Physics* where Leibniz argues against the view of attraction on the grounds that it is akin to imputing principles of mutual love to the elements of matter or, as he also puts it, it is as if "a certain intelligence were given to each part of matter by whose means each part could perceive and desire even the most remote thing" contrasting this view unfavourably with a mechanical conception that is based rather on "the motion of smaller pervading bodies".[13] In making this attack and contrasting the view that upholds attraction in this way with a mechanical picture of nature Leibniz self-consciously aligns his later dynamics with his early renovation of the Cartesian conception indicating that the appeal to principles of extension is one that he wishes to supplement, not supplant. The nature of this supplementation requires the statement however that what is uniform and homogeneous in appearance is not so in itself as rather diversity is what is displayed in corporeal substances, albeit a diversity that is ordered through principles of continuity. The attempt to capture the principles of this order through the rectification of the Cartesian conceptions of conservation and the rewriting of the rules of impact is curtailed by the continued adherence to the primacy in physical accounts of principles that build on the geometrical description of corporeality, always drawing on it as a basis for the divergent treatment of forces. This resolution indicates a twofold basis to the resistance to the postulation of attraction on Leibniz's part since on the one hand such an appeal requires reference to a principle beyond the substances themselves, an appeal that introduces an element that is heteronomous to his internal rule of explanation and on the other such a reference to attraction does not supplement mechanical appeals to extensible qualities, it rather supersedes it. On both these grounds Leibniz's picture of dynamics requires resistance to a postulation of an active force that not only countenances interaction between bodies but also views this interaction in terms of a force that is extrinsically external to them. By

contrast to this conception, Leibniz, the thinker who more than any other, views substance through the prism of activity, is constrained to present the basic case for repulsion as the key force that bodies exert.[14]

Kant's Early View of Living Force

Now that the ramifications and dimensions of Leibniz's notion of dynamics have been set out it is possible to move to detailing some key elements of Kant's early responses to it. Kant's very first publication, *Thoughts on the True Estimation of Living Forces*, was written with the prime purpose of mediating in the dispute between Leibnizians and Cartesians over the right form of conservation principle. Whilst this is the explicit purpose of the work however the nature of Kant's response to the question introduces some important qualifications of Leibniz's dynamics that suggest an argument that complicates the ontological status of force and disarticulates it from motion. Hence, in the key third section of this piece, a short paragraph composed of a mere seven sentences; the young Kant undertakes a demonstration of some significance. What he gives here are three examples meant to show that a body's motion is not commensurate to its action and, connected to these examples, are two arguments that aim to convince us that the understanding of force as something that essentially involves movement is an incoherent conception. I want to look at this paragraph in order to unravel a few questions from this early writing. Kant's first example is given in the following way:

> A body to which an infinitely small opposition is made, and one which therefore hardly acts at all, has motion in an especial degree. The motion is only the external phenomenon of the state of the body; for the body is not here acting, and yet is striving to act. (Ak. 1: 18)

Prior to introducing these examples Kant opened this work by indicating that the view, that a body that is in motion has a force, implies that a body acts by overcoming hindrances and displacing masses. Since the body in this first example faces almost no opposition, it would, on these grounds, be right to think that it is hardly acting at all, which is the consequence drawn. Kant also employs here the Neo-Hobbesian vocabulary of *conatus* in implying that the body is really "striving" to act. This does not imply that the body in question is hardly moving as the very fact that there is scant opposition to the movement of the body in question ensures that its movement is particularly pronounced. The nature of the movement in question is close to that of inertial motion which Kant describes in paragraph 15 of the work as having "the characteristic of maintaining itself indefinitely in the body in which it was imparted, if no obstacle is set against it" (Ak. 1: 28).[15] The peculiarity of the passage is that Kant, in the first sentence of our citation, suggests that in this case there is hardly any action whilst in the second sentence, he hardens his position to saying that there is *no* action here at all, merely a striving to act. The reason for the movement between the two sentences is that the definition of pressure in the second paragraph of the work was in terms of an exertion that strives towards motion if we think of force in terms of movement. Since this example in fact shows, on Kant's view, the distinction between force and movement we are led thereby to the position of thinking that movement is only an "external phenomenon" of the body's state.[16]

The second example follows from the first one but is a development on from it. In this case we consider that the motion of the body stops due to the body having come into contact with another one. It has hence reached the obstacle indicated in Kant's account of inertia. In this case there is a moment of being brought to rest in which movement halts but action does not. The thought here is clearly that the second body with which the first has come into contact is sufficiently dense to prevent our first body from moving

further which does not however prevent our first body from still exerting force on the second but this force is not one that is not accompanied further by external manifestation in movement. Since however the hindrance that is preventing the external manifestation of movement does so precisely due to the *degree* of its hindrance so the force that is being exerted in this case would be *proportionate* to the hindrance and thus, despite the absence of movement, the force would be being exerted to a great degree. The first two examples are hence mutual counterparts. The first example shows movement being exercised without corresponding force, the second force being exercised without corresponding movement.

The next point in this section is however particularly surprising. Firstly, Kant draws a general conclusion from the two examples, secondly he introduces a third example that appears less clear than the first two and thirdly he appears to make a statement about all three examples.

> We should not, therefore, take our title for the force of a substance from that which is not an action; and still less should we say of the bodies which act while they are at rest (e.g., a sphere which through its weight presses upon the table on which it lies) that they strive to move. For since in moving they would not be active, we should have to maintain that in so far as a body is active it strives to fall into the state in which it does not act. (Ak 1: 18)

The general argument that we should distinguish force from movement is in accord with the argument of the section thus far. The reference to the example of the sphere is clearly patterned after the second example of a body being brought to rest and the reference to striving indicates that the sphere is exerting pressure on the surface it is placed but that this pressure is a product of the force of the sphere itself so that striving is disconnected from movement. This example is distinct from the second one as in that case it was the

moment of being brought to rest which was being seen as a moment of great force and hence paralleled the first example where a point of significant movement was aligned with a description where no force was acting. The third example by contrast is of a stationary body. There is a parallel to this example in the *Critique* where Kant refers to a ball being laid on a cushion and producing a hollow in the latter (A203/B248). Whilst the point of introducing this example in the *Critique* concerns the understanding of causal action as based on an *order* of time that need not be correlated to *lapses* in time and is hence not of a piece with the example of the sphere in *Living Forces* it is nonetheless possible to interpret the example used in the *Critique* in accordance with the point in *Living Forces*. After the ball has been left on the cushion it is stationary and this does not prevent it from acting on the cushion in the sense that the cushion, whilst the ball is placed upon it, continues to have a hollow and thus there is here "pressure" being exerted and the question of the nature of the pressure is answered by the argument from *Living Forces*, it is a pressure that indicates that the ball is acting by means of a force but this is clearly not a force that requires movement as the ball is stationary. So the ball and the sphere on the table are acting in the same way.

We can now move to an interpretation of the obscure sentence that follows the introduction of the third example. Kant now indicates that we should not view bodies that act whilst at rest as involved in a "striving" to move. In neither of the cases of the second or the third examples would this be correct. If the body in the second example was to move this would be due to the obstacle that has been met being removed and thus would appear to be an effect merely of what is external to it. If the sphere were to move then it would also be due to external conditions as its presence on the table is one in which its state of being stationary is an adequate expression of its force so that the alteration of place would be one in which force was lessened, not increased. In either case, therefore, if we understood the bodies in

question to be striving, we would be seeing them as having an active orientation *not* to act. The suggestion of the argument is thus in accord with the spirit of Leibniz's view, if not its letter. If the essential force of bodies can be measured in its movement then it would follow that bodies at rest possessed no force, precisely a conclusion Leibniz would have protested against.

In section 4 of the work Kant moves on to discussing the way in which movement, whilst not to be understood as equivalent to force, is nonetheless derivative from it. The argument analyses the action of substances through the effect they have on each other. The nature of the relationship between substances is thus assessed in a non-Leibnizian way as an example of transeunt causation. The action of one substance is viewed as occurring in a force that is determined to act outside itself and thus to change the internal state of another substance. The manner of the transmission of this force is however here assessed as occurring under one of two conditions. Either the first substance finds a second that is capable of instantaneously receiving its whole power or it does not find such a second substance so capable. Kant then adds that if every substance in acting found another substance that was capable of absorbing the whole of its force in acting then there would be no movement in bodies. The connection between substances and bodies now begins to emerge as Kant describes the reasons for thinking this. Our first point however is that if there is a problem with instantaneous reception of the force of substances this must be due to something within the substances that prevents such reception. Not only is this so but the observation of phenomenal movement must have a ground within substances. If substances cannot instantaneously transfer their force however then they must only be exerting at a particular point part of their force. What is happening then to the rest of the force?

Kant's reply to this question is to assert that the force is expressed in the case where instantaneous reception is not

possible in a gradual manner. However not only is this the case but, since the force that the substance is expressing could not be received instantaneously by the first substance it comes into contact with, then this first affected substance will be unable to receive the force in question over time as well. The ground for this assertion is that if the first substance that has been affected were capable of receiving the whole force being expressed then they could have received it at the first point of expression. Since they could not they must be intrinsically incapable of receiving the whole force in question at all. Hence the active substance must, as it gradually exerts its force, be acting continuously on other substances. Kant adds that if the first acting substance could not exert the whole force on the first one it affects then the next one that it affects must have a different location from the first one it came into contact with. The reason for this is that otherwise the first acting substance could have instantaneously affected the second substance it came into contact with. Hence not merely must there be a condition of temporality for at least some of the substantial force that is being exerted but the nature of this force must also be something that is spread through distinct locations with the result emerging from this analysis that the conditions for the expression of the action of substances beyond the limit case of instantaneous reception must be given in space and time.

Movement hence occurs due to an inability of substances to instantaneously receive each other's force. Movement is thus an effect of the deferment of force's action. In sections 5 and 6 Kant turns back to the level of the phenomenal and in doing so addresses the relationship between soul and body. Kant points out that the basis of the problem with mind-body interaction is how the body, which can only be assessed through mass and motion, can have an effect on the mind, which is the seat of ideas and representations? In assessing this Kant draws on the account that has emerged from section 4 concerning the nature of position. He writes: "The concept of that which we entitle position, as we find

upon analysing it, itself refers us to the mutual action of substances." (Ak. 1: 21) Since substances act on each other by reference not to movement but through temporal succession the nature of this action presents space as a possibility. Hence space is not transcendentally real but is rather the external phenomena of action. Since this is so the relation between mind and body has to be seen as patterned after the mutual interaction of substances. Both mind and body would be phenomenal correlates of distinct substances which entails that mind is *not* intrinsically distinct from body. On this basis what we can say is that the internal states of minds and bodies are related to each other whilst the external phenomena are distinct. The inner relation between mind and body can furthermore be pictured through the way in which the mind presents to itself in the generality of its conceptions (such as figures) the inward articulation of outward matter.[17] Furthermore, we have also noted that the absence of movement between two phenomena is not itself a signal of the absence of force but quite the opposite. Hence the substantial analysis of force provides us with a basic ground for assuming that not only is there interaction between mind and body but that this interaction can be understood firstly on the grounds of substantial interaction and secondly through the analysis of the states of bodies at rest.

Whilst this ingenious extrapolation from the account of the relation of movement and force to the mind-body problem marks *Living Forces* as an innovative work the key questions in its response to Leibniz for me are elsewhere. In section 15 of the work Kant contrasts two types of motion. The first kind of motion has the characteristic of maintaining itself indefinitely in the body in which it is imparted so long as it encounters no obstacle. The second kind of motion, by contrast, is a perpetual effect of a continually driving force but the cessation of this movement does not require the meeting of an external resistance. The second kind of motion is based on external force and ceases when the force in question ceases to operate. This second kind of motion is

equated by Kant with dead pressure and is finite in duration whilst the first sort contains in it something that is infinite in his view. The distinction between them is starkly expressed when Kant argues that the motion that is finite is one that can be viewed as if it appeared and disappeared in the same moment, that it can, in other words, be viewed as approximating to zero. This description of dead pressure, equivalent to derivative passive force on Leibniz's view, is what we can see as an account of the basis of repulsive movement.[18] The parallel type of movement is subsequently assessed however primarily through the question of the nature of what resistance could possibly overcome it rather than through a description of its movement that would produce a discussion of its internal active element. As with Leibniz, on whom the author of *Living Forces* wishes to improve, so also here we lack anything like an account of attraction.

In conclusion I want to state in abbreviated form the basis on which the account of attraction is subsequently stated by Kant, not in the essay on *Living Forces* but instead in the *Physical Monadology*. In this paper, written a number of years after *Living Forces*, Kant focuses mainly not on the question of force directly[19] but instead on the relationship between the Newtonian claim that space is infinitely divisible with the Leibnizian claim that there are simple substances that are not divided. Whilst on one level there need be no antinomy between these claims if the Leibnizian view is seen to be a statement of a purely metaphysical sort the young Kant views the monadological claim as a statement that affects the substantial reality of bodies. The monad is here viewed, in accordance with the statement made by Leibniz to De Volder, as what gives body its reality and hence if it does so and yet body occupies space and this latter is infinitely divisible it follows that body is also so divisible with the question emerging as to how then there can exist an indivisible substance as the ground of physical reality? In responding to this question Kant distinguishes the space that is occupied by the body from the monad which is

the ground of the filling of the space in terms firstly of distinct properties that the monad possesses. The monad has relational determinations which we can determine as external but also non-relational determinations which are internal. In filling space the monad possesses a extensive quantity and in dividing space it is this extensive quantity of the monad that is divided. But the internal determinations are not in space and hence are not divided when the external presence of the monad is. However what I want to bring out of the discussion is that the possibility of space being filled depends still on the action of substances so that the external quantity is the orbit of activity of the substance. The means by which this filling of space occurs however is twofold with the repulsive element presented first as that by means of which each monad exercises a force on each other monad to prevent the space filled by one becoming occupied by the other. To the consideration of this however there now occurs precisely the parallel argument missing in the *Living Forces* distinction between two kinds of motion, which is here however an account of distinct forms of space-filling.

> The force of impenetrability is a repulsive force, which prevents anything external from approaching more closely. Since this force is innate in all elements whatever, one can, it is true, understand from its nature why the intensity of its action diminishes as the distance over which its influence extends increases. But why, at any given distance, it should cease altogether – that is something which cannot be understood from its nature at all. Thus, if it were this force alone which existed, bodies would have no cohesive structure at all, for the particles would only repel each other, and no body would have a volume which was circumscribed by a determinate limit. It is, therefore, necessary that there be opposed to this striving another striving which is opposed to it and which is equal to it at a given distance, and which, by occupying a space, determines its limit. But that

> which works in the opposite direction to repulsion is attraction. (Ak. 1: 483-4.)

Here, in accordance with the Leibnizian thought concerning the relation between forces requiring that any force that can be produced must be so at the cost of diminishment of another and that any action involves a reaction Kant finally provides a basis for attraction. The ground for resistance to this thought however in Leibniz himself clearly concerned the problem of describing forces that would be distinct from the operation of internal properties of bodies and thus be given, according to him, in a form that was neither mechanical nor substantial. In response Kant here derives attraction not from consideration of the external effect on substances[20] but rather from consideration of the action of the substances themselves. Just as the action that constitutes space can be seen as the external manifestation of action which prescribes limits of occupation so the substance also possesses an intensity that diminishes in proportion to the increase of space in which it is extended and this provides a quantitative basis for the assessment of repulsive action so also the attractive force will be that which brings within the orbit of the action of the substance the relation it has both to its own external quantity and also provide a positive relation to other substances.

The conclusion of Kant's demonstration is that the bodies or media which are elastic, which includes aether or the matter of fire, is grounded on the primitive impossibility of any force penetrating a basic element in its inmost part. This impossibility demonstrates the impenetrability of each force with regard to every other in terms of its infinite proportion at the central diameter of its presence. However two points are worth making about the picture Kant presents in conclusion. Firstly, the distinction between the density of bodies is defended on the basis of a primitive distinction between simple elements and this effectively requires the postulation of distinct inertial powers in different bodies. Secondly, whilst the introduction of this solution to the

filling of space is presented by Kant in the context of the postulation of a vacuum, a notion that depends on the mathematical relation to space as concepts of "full" and "empty" are quantitative characterisations and hence mechanical rather than dynamical, the resolution offered by Kant does not involve the rejection of this vacuum. Hence, unlike in his later Critical philosophy, Kant is not here committed to the rejection of "empty" space but is giving a dynamical undercurrent to this conception through the variant estimate of the manners in which inertial force keeps monads distinct from each other to varying degrees which would still provide a dynamical account for the appearance of the relational property of "emptiness".

The movement from the Cartesian conception of corporeal substances in terms of extension to the articulation of a dynamics takes thus at least three stages though the story is here incomplete. The first stage would be Leibniz's reformulation of the Cartesian position which elaborates Neo-Hobbesian elements, the second would be the expansion of his correction of the Cartesian position and the move beyond kinematics to dynamics. The third movement would be Kant's initial recovery of the Leibnizian move within however a discussion that requires the partial disarticulation of movement from force. The subsequent fourth movement however would be the attempt to reconcile the Leibnizian description of substance with the Newtonian conception of attractive power. That this reconciliation requires a synthesis of mathematical and dynamical qualities is the key to the Kantian project though the question of which stage of reconciliation is ultimately the one that encompasses the greatest metaphysical depth may not coincide with that which has the best physical range.

Endnotes

[1] Descartes *Principles of Philosophy* AT VIII A: 25.
[2] *Ibid* AT VIII A: 78-9.

[3] This is the formulation of *The World*. In the *Principles* Descartes writes that: "God moved the parts of matter in different ways when he created them, and now conserves the whole of that matter in the same way and with the same laws with which he created them earlier, he also always conserves it with the same amount of motion" (Pr II 36).
[4] The translation of *vis* by "force" is somewhat problematic given the instability of terminology with regard to descriptions of force. See here R.S. Westfall (1971) *Force in Newton's Physics: The Science of Dynamics in the Seventeenth Century* (Macdonald: London and American Elsevier: New York), Appendix B.
[5] This is suggested as the right way to interpret the statement in the letter to Henry More by Daniel Garber. See Daniel Garber (1992) *Descartes' Metaphysical Physics* (The University of Chicago Press: Chicago and London), p. 283. See also however his extended discussion of the ontology of force: pp. 293-9.
[6] This does entail an important departure from the Cartesian position as Hobbes clearly thinks of endeavour as something distinct from motion *per se* as motion is something given to the senses whilst *conatus* is rather the action that the motion has regardless of its presence to the senses. This whole discussion is set out in his *De Corpore*.
[7] Loemker, p. 140.
[8] The account of the basis of rest here is also intriguing as Leibniz indicates that something must act simultaneously on everything else and be the cause of everything equally as otherwise no action would happen and then deduces from this that the cause of rest is given also by this simultaneous action.
[9] This statement occurs in the preliminary specimen of the *Dynamics* of 1691, one of the sharper formulations of Leibniz's rejection of Descartes' conservation principle. The history of this rejection is given in a particularly sophisticated manner in Pierre Costabel (1960) *Leibniz and Dynamics: The Texts of 1692* (1973 trans. by R.E.W. Maddison, Hermann: Paris, Methuen: London & Cornell University Press: Itacha).
[10] For some cautious considerations concerning the relationship between Leibniz's claim about the conservation of force with Huygens' earlier claim concerning the conservation of the square of the velocity of bodies see Westfall *op. cit.* pp. 157-8, 289-303.
[11] Leibniz Open Court volume: p. 194 (letter of April 30th 1687 to Arnauld).

[12] For a classic statement of this view see section 3 of the *Principles of Nature and Grace*.
[13] Ariew and Garber pp. 313-14.
[14] Westfall nicely states the irony of this adding that the importance of passivity in mechanics is in a sense the result of the Leibnizian view of dynamics despite the latter's thinking of activity as what needed to be accounted for.
[15] This characterisation bears comparison with those given by Descartes and Newton. Descartes' first law of nature, as stated in the *Principles of Philosophy*, is that each thing "as far as in its power, always remains in the same state; and that consequently, when it is once moved, it always continues to move" (Pr II 37) whilst Newton states in his first law that "Every body preserves in its state of being at rest or of moving uniformly straight forward, except insofar as it is compelled to change its state by forces impressed" (*Principia,* p. 416). Notable contrasts between the three formulas: Kant's merely describes motion without reference to force whilst Descartes brings in a reference to power and Newton to force (although in the latter case force is seen purely externally). Whilst Newton's law brings in a reference to straightness this involves an incorporation of characteristics of Descartes' second law of nature into his first law of motion (although Newton's second law also has a relation to Descartes' second law).
[16] The point that motion is not a process but a state is generally recognized to be the point of Galileo's innovations in physics and it clearly underlies the formulations of inertial motion given in the previous note. Here we find a phenomenalist interpretation of the view that motion is a state: namely that it is an outward manifestation of force but cannot be seen as the same as force. This is clearly the basis for Kant's subsequent distinction between mathematical and physical bodies (#115).
[17] This is a slightly stronger formulation than is directly given in *Living Forces* but a form of this argument is implied in section 6.
[18] Intriguingly however Kant's account of this dead pressure appears to lapse into a kinematics, something Leibniz would have been unhappy with.
[19] In fact, the position of the *Physical Monadology* with regard to the relationship between force and movement marks a complete reversal of the position adopted in *Living Forces* as in the latter work Kant explicitly adopts the Wolffian conception

of *vis motrix* which the arguments of the opening section of *Living Forces* sought to refute.

[20] It should be noted however that Kant explicitly invokes here the Newtonian inverse-square law of attraction (Ak. 1: 484), something that corrects his argument concerning the inverse square of speed in *Living Forces*.