The force of dialectics

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Chapter 5. The physical outset: force and motion.

In this chapter I will expound Kant's early thoughts (1746-1758) which refer to force and motion in physical concepts.

section 1. The true estimation of living forces.

In 1746 Kant published a rather lengthy essay (with an equally lengthy title: Gedanken von der wahren Schätzung der lebendigen Kräfte und Beurteilung der Beweise, derer sich Herr von Leibniz und andere Mechaniker in dieser Streitsache bedienet haben, nebst einigen vorhergehenden Betrachtungen, welche die Kraft der Körper überhaupt betreffen) in which he tackles the question whether one should favour the Leibnizian concept of force or agree with the Cartesian concept of force (4). The question, as posed by Kant, mainly refers to the quantitative aspects of these concepts, viz. whether or not the concept of force involves the second power of the velocity (5). As a consequence, the essay deals with various physical experiments and demonstrations, most of which were common knowledge to natural philosophers and physicists or mathematicians in Kant's time, and which I will not deal with. Instead, I will look into the new contributions Kant makes to the basis of the theory of mechanics.

Preceding the actual discussion, Kant makes a number of observations concerning force and motion of physical bodies.

First, he distinguishes motion from force.

It is not correct, Kant says, to call motion a kind of action, and to ascribe a certain force to it on this ground. This is a confusion of concepts. Force is the effort to overcome opposition (WSdLK, s.1, p.26/A3). But a body which is confronted with the least opposition has the greatest amount of motion (id., s.3, p.27/A5). And a body which is in rest and which makes, therefore, no effort to move, can still possess a certain force, since it may for instance exert pressure by virtue of its weight. It is wrong, then, to associate force only with motion; one should associate it with activity in general, and denominate it **vis activa** instead of **vis motrix** (id., p.28/A5). Motion, therefore, is only an external phenomenon (id., p.27/A5). Force is something internal. It is, however, externally active; that is, its actual activity consists in the effort to change the internal state of a substance which is outside it (id., s.4, p.28/A5).

It is obvious that force, according to Kant, establishes relatedness. Below, it will become clear that this relatedness is the foundation of space, in Kant's opinion.

Force, inasfar as it brings about motion, is also closely related with time, says Kant. As he points out, if force cannot be actually active over a certain period of time, it cannot be actually active at all. Consider, he says, a substance. It possesses a force, which has to be actualized by acting upon another substance. Now either it will find a substance which can endure the entire activity of the force in one first moment, or it will find no such substance. If it does, there will be no motion, for in one moment no motion can

appear. We know there is motion. Therefore, the substance must find another substance which can only endure a limited part of the total activity of the force. The rest of the activity must also be exerted, since if the activity cannot be exerted, there is no reason to speak of force, and, as a consequence, the first situation would reappear; that is, there would be no force left, all of it would have been exerted in the first moment. But the rest of the activity must be exerted in a subsequent moment. Thus, force works successively, that is, in time (id., s.4, pp.28-29/A5-7).

In this way, force is posited in physical reality as inherent in substances and as external relation between substances. It does not, however, establish the existence ("Dasein") of substances, according to Kant, for relations are not necessary but contingent (6):

> "Weil ein jedwedes selbständiges Wesen die vollständige
> Quelle aller seiner Bestimmungen in sich enthällt, so ist es nicht notwendig zu seinem Dasein, dasz es mit andern Dingen in Verbindung stehe."
> (WSdLK, s.7, p.31/A10)
>
> (Since every independent being contains the complete source of all its determinations in itself, it is not necessary for its existence that it is related to other things.)

It is perfectly possible, then, that things which have actual existence (Kant speaks of "würklich existieren") nevertheless are nowhere in the world to be found. They simply have no place or situation, since they are not externally related to any other thing and since it is this external relatedness that establishes place or situation (WSdLK, s.7, p.31/A10). This paradox, which Kant claims as new and his own invention, entails that God may have created millions of worlds which have no connection with our world or with one another (id., s.8, p.32/A11). But it also implies that such independent worlds, or indeed all absolutely independent things whatsoever, are no part of the world we belong to, except in thought (id., p.32/A10). In Kant's view, a thing does not need to be active and, therefore, externally related to other things in order to exist, but it has to be active and, therefore, externally related to other things in order to exist and be part of the physical world as well. Physical existence, then, implies relatedness (7).

In this light, it is easily understood that the active forces establish space. For without internal force in every substance which is acting upon other substances, thereby bringing about their relatedness, there will be no relation. Without relation, no order. Without order, no space (id., s.9, p.33/A11) (8). Thus, space is established by the actual interaction of substances.

After the second chapter, which consists of about a hundred sections on Leibnizian and Cartesian concepts of motion and force, Kant expounds in the third chapter his

own estimation ("Schätzung") of living forces (9), which he claims to be the true one.

He begins by pointing out that mathematical laws and laws of nature are not identical. Kant says that mathematics defines the concept of body in such a way that it precludes a certain property which, however, natural bodies must have (WSdLK, s.114, p.169/A180-181). Mathematical bodies and natural bodies are, therefore, of an entirely different kind ("von ganz anderem Geschlechte") (id., s.115, p.170/A181). Mathematics, says Kant, precludes that a mathematical body possesses a force which does not entirely originate from the body which is the external cause of the motion of the former. This is a basic law of mechanics, and it only permits the Cartesian measure of force. With a natural body, however, it is a different matter:

> "Derselbe hat ein Vermögen in sich, die Kraft, welche von
> drauszen durch die Ursache seiner Bewegung in ihm erwecket worden, von selber in sich zu vergröszern, so, dasz in ihr Grade Kraft sein können, die von der aüszerlichen Ursache der Bewegung nicht entsprungen sein, und auch gröszer sein wie dieselbe, die folglich mit demselben Masze nicht können gemessen werden, womit die Kartesianische Kraft gemessen wird, und auch eine andere Schätzung haben."
> (WSdLK, s.115, p.170/A181-182)
>
> (It possesses a power to increase the force which has been generated in it by the cause of its motion, in such a way that there can be degrees of force in it which do not originate in the external cause of motion, and [which] are also greater than the same [viz. the force generated by the external cause], which [degrees] can, as a consequence, not be measured with the same measure as the Cartesian force is measured with, and [which degrees] also have a different estimation.)

This rather surprising concept of internal force (10) must be explained in further detail, of course, and Kant does so in the subsequent sections.

He repeats his initial remarks on motion and force, pointing out that motion as such is no action. But he adds that velocity is a determination of motion, that is, of the state of a body which does not exert the force which is in it, but remains inactive (WSdLK, s.116, pp.170-171/A182). So, according to Kant, motion is a state of a body, That is, of course, if its velocity is constant. And force is only exerted if something makes an effort to change this state:

> "Die Bewegung ist das aüszerliche Phaenomenon der Kraft,
> die Bestrebung aber, diese Bewegung zu erhalten, ist die Basis der Aktivität, und die Geschwindigkeit zeigt an, wie vielmal man dieselbe nehmen müsse,

> damit man die ganze Kraft habe. Jene wollen wir hinfüro die Intension nennen; also ist die Kraft dem Produkt aus der Geschwindigkeit in die Intension gleich."
>
> (WSdLK, s.117, p.171/A183)
>
> (Motion is the external phenomenon of force; the effort, however, to preserve this motion is the basis of the activity, and the velocity shows how many times one has to take it in order to get the total force. We shall call it [viz. the effort to preserve motion] henceforth intensity; the force, then, is equal to the product of velocity and intensity.)

The unit of activity, that is the unit of exerted force and therefore the unit of the measure of force (since force can be measured only if it is actually exerted), is the effort to preserve the motion. This intensity (effective force) is in fact a metaphysical concept. Kant explains that a force which is inactive, as for instance during an unchanging motion, is as inactive as it is in a body which is in rest. Now, when a body is resting, it has an infinitely small velocity. This is an assumption Kant makes in the 26th section:

> "[...] die Ruhe ist von einer sehr kleinen Bewegung nicht
> unterschieden."
>
> (WSdLK, s.26, p.48/A31)
>
> ([...] rest is not distinguished from a very small motion.)

It is based on Kant's reception of Leibniz's law of continuity (11) which Kant, in fact, transforms into the metaphysical principle that a very small inidentity is an identity.

A body at rest, then, is actually moving very slowly, according to Kant. This infinitesimal motion must, he explains, be preserved by an infinitesimal intensity, which can be considered a point. The intensity is, therefore, the actual exertion of force in a moment. In this way, intensity is also the infinitesimal part of velocity. These infinitesimal parts form a finite sum, when a body has a finite velocity, that is, when it is in actual motion. This velocity is as a line compared to the point it is when it is infinitely small or zero. Since the force makes an effort to preserve the state of motion its body is in, the force is proportional to the velocity of the body. Now, force can preserve motion only in a moment, or continuously. If only in a moment, it would need to be renewed every other moment; that is, new force would need to come from outside the body. In this case, intensity would be a point, the velocity may have any finite value and be a line; their product, then, would be a line. This force, as a line, would be dead force, according to Kant, since it needs renewal and must, therefore, have an external cause. If, on the other hand, force preserves motion

continuously, then its intensity is not a point but a line (the sum of the points, i.e. of the moments or infinitesimal parts). Force, then, would be the product of velocity, which is a line, and intension, which is also a line, therefore it would be a plane. Hence the square; for, since the intensity is proportional to the velocity (its sum), one can simply take the force as the square of the velocity. This is living force, since it renews itself and has its own cause in itself (WSdLK, ss. 118-120, pp.172-174/A184-187).

Summing up: Dead force is the force of Descartes. It is the force exerted when one body collides with another and transfers (a part of) its motion in a moment. It is an external force. Living force is the force which establishes the conservation of the state of motion a body is in. Living force comes from within the body itself. This is, probably, the reason why Kant speaks of free conservation: the body is, in this respect, totally independent of other bodies (id., s.121, p.175/A187-188).

Kant subsequently tackles the question of how dead force is followed by living force, as must happen after a collision. The quantity of motion impressed in impact must be preserved.
Kant, again, makes use of his law of continuity.

It is clear, he argues, that living force cannot arise in the same moment dead force is exerted. For this would mean that dead force would be living force, which is a contradiction. It is, according to the law of continuity, the same thing for a body to be at the moment of its change of motion as to be at a moment which occurs an infinitely small period of time later. Therefore, neither can one say that the living force occurs directly after the moment dead force has been exerted. One must, Kant conludes, say that living force comes gradually into existence (12), i.e. that it is vivicated (WSdLK, s.122, pp.176-177/A189-190).

This means that a finite period of time is required for living force to reach a certain degree. Its infinitesimal parts, viz. the intensities, must form their sum, and this requires a number of infinitely small periods of time, says Kant. If, in the meantime, something should happen which frustrates the growth of this sum, for instance a collision with another body, the living force of the body will be diminished accordingly (id., s.123, pp.177-179/A190-192).

Summarizing, Kant claims that a body can preserve its free motion infinitely by virtue of its living force, which is proportional to the square of the velocity of its body. Therefore, the body has to have the ground ("Grund") of this continuous conservation of free, uniform motion in itself. It cannot receive its living force from outside. And this living force has to be produced in a finite period of time (WSdLK, s.124, p.179/A192-193).

Motion must be uniform in order to be preserved in this way, but it does not need to be rectilinear. Kant names the motion of the planets as an example to the contrary

(id., s.126, p.180/A194).

He also repeats that in mathematics there is no such thing as living force, and, as a consequence, no free motion (for free motion presupposes living force); mathematics only applies to dead force (id., p.181/A194-195).

The existence of living force follows from the existence of free motion, not from geometrical properties of the body, nor from essential properties ("wesentliche Eigenschaften"). Therefore, living forces are not necessary, but only hypothetical and contingent (id., s.129, pp.183-184/A198).

As a corollary, Kant points out that, since living force can only arise in combination with a finite velocity, it cannot arise in combination with an infinitely great or small velocity (id., ss.132ff., pp.186ff./A201ff.).

section 2. General history of nature and theory of the heavens.

In 1750 Thomas Wright of the county of Durham published a booklet with the title An original theory, or new hypothesis of the universe. In it, he explained that the white band of stars commonly called the Milky Way we see in clear nights, is not caused by the fact that stars in this region are more closely together than elsewhere, but is a consequence of our situation in a system of stars which has certain geometrical properties (viz. that it is less extended in one direction than it is in all directions perpendicular to this direction). He also assumed that there are other suns than our sun, and that there are more galaxies than our Milky Way. In 1751 Kant read an abstract of Wright’s essay in a journal edited in Hamburg (13), drew inspiration from it, and wrote his own original theory on the history of the universe which was published (anonymously, and dedicated to King Frederick of Prussia, probably to avoid religious attacks (14)) in 1755.

Kant’s treatise is both dynamical and evolutionary. He tried to explain the order of the universe which Wright had conjectured.

Kant begins by pointing out a paradox. On the one hand, all planets rotate in almost one plane and in the same direction as the Sun’s rotation. This gives reason to believe that in the space occupied by our solar system there must have been or still is a common cause which brought about this motion. On the other hand, however, the rest of the space (surrounding the Sun and between the planets in our solar system) is empty. This means that there is no matter which could have any influence whatsoever, and, therefore, there seems to be nothing which could act as a common cause (ANTH, pp.273-274/A23-25). It is clear, however, says Kant:

> "[...] dasz ein Begriff sein müsse, in welchem diese dem
> Scheine nach wider einander streitende Gründe verei-

> niget werden können und sollen, und dasz in diesem Begriff das wahre System zu suchen sei."
> (ANTH, p.274/A25)
>
> ([...] that there must be a concept in which these seemingly conflicting grounds can and should be unified, and that in this concept the true system is to be found.)

The only satisfactory concept, says Kant, is a historical one. At one time there must have been the same space, occupied by a completely dispersed matter which could exert forces that brought about the present motion in the system and which transformed into great lumps in the act (ANTH, p.274/A26).

Thus, Kant assumes that in the beginning of all things all kinds of matter of which the sun, the planets, and the comets consist were dissolved in their constitutive elements, which filled the entire space of the world system. This initial state of things is the most simple state that can follow the state before it, viz. nothingness, says Kant (ANTH, p.175/A27).

The initial state of being of the universe, according to this theory, is chaos. But even in this chaos its elements possess properties which concur with the perfect order God had in His mind and which has yet to come into being (loc.cit.). The elements are of different kinds, as is only natural in chaos; and as they all are material, they possess the force of attraction and the force of repulsion. If the elements were all alike, the initial state of chaos and rest would never change, for they would all attract each other to the same degree. But they are not, therefore the heavier elements act instantly as centres of gravity and matter begins to draw together around them. The repulsive force, however, causes the aberration of the perpendicular line along which matter tries to draw together. In this way, a spiralling, circular motion arises. The force of repulsion is weaker than the force of attraction, which means that the former needs more time to be effective than the latter. As a consequence, heavy elements can attract a great quantity of other elements nearby, forming a centre of gravity which increases in strength and attracts elements from a greater distance. But these elements which are farther away take more time to reach the centre, therefore the force of repulsion can affect the direction of their motion, cause them to aberrate from the perpendicular line towards the centre of gravity, and make them rotate around this centre. Thus, great whirling constellations of matter arise, which intersect each other’s motions (which is possible on account of the high degree of dispersion of matter). The conflict between these motions brings about that gradually all motion is in one direction and in one plane, because in this way the whirling constellations suffer the least obstruction from each other’s motions. The final state of motion is, of course, rotation around the gravitational centres, in one plane: free circular motion (ANTH, pp.276-280/A28-34).

Matter now rotates in concentric circles, in one plane, around centres of gravity, that is, around suns. In these circles matter is drawn to relatively smaller centres of gravity, thus forming planets which, of course, still rotate around their suns. After this, the circles are not perfect anymore, since the constitutive elements of the planets differ as concerns their distance to the sun; ellipses arise. Also the plane is not perfect, planets may diverge slightly from it (id., pp.281-282/A35-37).

These small defects are only natural, says Kant:

> "[...] weil überhaupt die Vielheit der Umstände, die an jeglicher Naturbeschaffenheit Anteil nehmen, eine abgemessene Regelmäszigkeit nicht verstattet.
> (ANTH, p.282/A37)
>
> ([...] since the multitude of circumstances which take part in every natural situation does not allow a m e a s u r e d r e g u l a r i t y a t a l l .)

All is now in a state of least interaction (" in dem Zustande der kleinsten Wechselwirkung", ANTH, p.279/A32).

Kant reasons, that this process is not typical for our galaxy and solar system only. All fixed stars are suns and, probably, have planetary systems as in our solar system; by way of analogy we may conclude, therefore, that they have been formed in the same way as our system, and that, if they are not part of our galaxy, they are part of other galaxies (id., p.326/A101). It seems reasonable then, Kant says, to assume that, since attraction and repulsion are effective throughout all space, and since space is infinite, the galaxies themselves form a system which is similar to our solar system, and that this system is part of an even greater system, as our solar system is part of the Milky Way; and so forth **ad infinitum** (id., pp.326-327/A101-102). Then, of course, there should be in the centre of a supergalaxy a heavy, gravitating body, heavier and gravitating more strongly than the body in the centre of our galaxy which is, in turn, heavier and more powerful than our sun. In a super-supergalaxy the central body must be even heavier and more powerful than in a supergalaxy, and so forth **ad infinitum.** These centres of gravity unite the bodies which encircle it in a system, a system of systems, etc. (id., p.328/A103-104).

From this, it follows that attraction forms space:

> "Die Anziehung ist ohne Zweifel eine eben so weit ausgedehnte Eigenschaft der Materie, als die Koexistenz, welche den Raum macht, indem sie die Substanzen durch gegenseitige Abhängigkeiten verbindet, oder, eigentlicher zu reden, die Anziehung ist eben diese allgemeine Beziehung, welche die Teile der Natur in einem Raume vereinigt: sie erstrecket sich also auf die ganze Ausdehnung desselben, bis in alle Weiten ihrer Unendlichkeit."
> (ANTH, p.328/A104)

> (Attraction is without doubt a property of matter which is as widely extended as is the coexistence which establishes space, since it connects the substances by mutual dependencies, or, speaking more properly, attraction is indeed this general relation which unites the parts of nature in one space: it stretches, therefore, away over the total extension of it [viz. of nature], into the distances of its infinity.)

According to Kant, space is truly (potentially) infinite; it has no limits or boundaries, for this would mean that God, who is infinite and must, therefore, possess limitless power or force, would only be active with a part of his power, which is obviously absurd (ANTH, p.329/A105-106). In his opinion, even if space at this moment is not yet infinite, it is potentially so, because it is infinite **qua** matter which has to assume a form, that is, which has to be organized in spatial structures as described above (id., p.331/A108). Attraction, he says, has to be active in all matter, for, if not, part of nature would collapse sooner or later (or never be organized), which means that the universe would not exist as a whole except by a miracle (which had to compensate for the absence of active attraction); but such an imperfect world would hardly be a divine creation (id., p.329/A108-109). Therefore, he concludes, there must be one ultimate general body which acts as the centre of attraction or gravity for the entire universe, and upon the existence and activity of which nature as a system (or system of systems, etc., ad infinitum; with each system having its own centre) rests. Naturally, he reasons, this general centre must be the heaviest of all bodies. It must, therefore, have been formed out of the heaviest elements closest together in the beginning of the evolution of nature. It then began to affect matter around it, which was organized as described above, reaching out farther and ever farther organizing matter (id., pp.332-333/A110-112). This means that the history of the universe has an actual direction, viz. the universe is older in the direction of its centre and younger in the opposite direction. In fact, since the universe is potentially infinite, there must be parts of it which are not yet born:

> "Ein jeder endlicher Periodus, dessen Länge zu der Grösze
> des zu vollbringenden Werks ein Verhältnis hat, wird immer nur eine endliche Sphäre, von diesem Mittelpunkte an, zur Ausbildung bringen; der übrige unendliche Teil wird indessen noch mit der Verwirrung und dem Chaos streiten, und um so viel weiter von dem Zustande der vollendeten Bildung entfernet sein, je weiter dessen Abstand von der Sphäre der schon ausgebildeten Natur entfernet ist."
> (ANTH, pp.333-334/A112)
>
> (In every period, of which the length is proportional to the work that must be completed, only a finite

> sphere is organized, starting from this centre; the remaining infinite part, however, is still struggling with disorder and chaos, as far from its state of complete organization as it is distant from the sphere of already organized nature.)

Furthermore, the organization of matter takes more time when it is at a greater distance of the general centre, since the degree of dispersion of matter increases with the distance to the general centre (where density is greatest) (ANTH, p.338/A118).

The organization of matter is not everlasting. Everything which is finite must come to an end (id., p.339/A119). Rotation will falter, overcome by attraction. This will happen first in the original centre, and then the destruction spreads as formerly the organization (id., p.341/A122-123). But in the dense centres of gravity (viz. the suns which have devoured their planets, and the centres of galaxies and super-galaxies which have devoured their galaxies, etc.), the force of repulsion gains strength. As a natural consequence, the centres will spit out what they had devoured, and the original state of chaos will have returned. Then, the same process of organization will start all over again. Nature is as a Phoenix, arising again and again from its ashes (id., pp.342-343/A124-126).

As concerns the foundation of the unity of the universe, viz. the ultimate general centre of gravity, there is a problem.
Space is, according to Kant, infinite. But the infinite cannot have a centre, that is, it cannot actually have a middle point. Kant acknowledges this fact, but tries to escape from its implications:

> "Es ist zwar an dem, dasz in einem unendlichen Raume kein
> Punkt eigentlich das Vorrecht haben kann, der Mittelpunkt zu heiszen; aber, vermittelst einer gewissen Verhältnis, die sich auf die wesentliche Grade der Dichtigkeit des Urstoffes gründet, nach welcher dieser zugleich mit seiner Schöpfung (15) an einem gewissen Orte vorzüglich dichter gehäufet, und mit den Weiten von demselben in der Zerstreuung zunimmt, kann ein solcher Punkt das Vorrecht haben, der Mittelpunkt zu heiszen, und er wird es auch wirklich, durch die Bildung der Zentralmasse von der kräftigsten Anziehung in demselben, zu dem sich alle übrige, in Partikularbildungen begriffene elementarische Materie senket, und dadurch, so weit sich auch die Auswickelung der Natur erstrecken mag, in der unendlichen Sphäre der Schöpfung, aus dem ganzen All nur ein einziges System macht."
>
> (ANTH, pp.332-333/A110-111)
>
> (Although this brings the problem with it that in an infinite space no point can have the privilege to be called the middle point, yet, by virtue of a certain

> relation which is based on the essential degree of density of primitive matter, according to which this [matter], when it was created, was given a greater primary density at a certain point and increases in dispersion proportional to its distance to this point, such a point can have the privilege to be called the middle point. And it actually is, through the organization of the central mass by the most powerful attraction in it, to which [central mass] all remaining elementary matter which is included in particular forms of organization descends, thus, as far as the development of nature may extend, in the infinite sphere of creation, making the entire universe into one single system.)

It is true, Kant seems to argue here, that geometrically there cannot be a middle point. Yet there is a virtual middle point, viz. the centre of organizing force of the universe. This point may not be the middle point of space, but it is the centre of activity, and since this activity establishes space, it is, in this sense, its middle point.

This is questionable. It is true that the centre is active in finite spheres. This has been made clear above. A finite sphere can have a middle point. However, Kant claims that this middle point is the basis on which the entire universe rests. The centre is ultimately the cause of the organization of the entire universe as one single system. But as such, the universe is infinite. It transcends, so to speak, the finity of the successively organized spheres. And the infinite cannot have a middle point. Kant tries to escape from the consequences of infinity by turning to the finite parts which constitute it. In his view, the universe consists of an infinite number of finite spheres; every sphere has its own centre, a set of spheres has its own centre (which is of a higher order), a set of a set of spheres again has a centre, and so on. But the essence of infinity is that it is more than the sum of finite parts. He has to face, therefore, the dilemma: either he can claim that the universe is an infinite but single system, but then he cannot locate its central basis, or he can locate a central basis, but then he cannot claim that the universe is an infinite single system.

Kant, strictly speaking, does not succeed in locating the ground of the infinite unity in one (or all) of its finite parts. Therefore, although he pretends he does, he ultimately has no physical means which could mediate between the totality he seems to want (the universe as a single infinite system) and its elements (the finite parts of the universe).

Kant definitely seems to be aware of this problem and offers a solution which is, of course, no physical solution, but a metaphysical one.

Confronted with the obvious harmony of the universe, one has to choose between two positions, he says. Either one claims that the constitutive parts of this harmonious system are incapable of forming relations with each other

and, therefore, need alien assistance in order to establish such a system. Or one claims that:

> "[...] der Entwurf der Einrichtung des **Universi** von dem
> höchsten Verstande schon in die wesentlichen Bestimmungen der ewigen Naturen gelegt, und in die allgemeine Bewegungsgesetze gepflanzet sei, um sich aus ihnen, auf eine der vollkommensten Ordnung anständige Art, ungezwungen zu entwickeln; [...]."
> (ANTH, p.355/A144)
>
> ([...] the design of the organization of the universe has already been included in the essential determinations of the eternal natures by the highest Intellect, and has been planted into the general laws of motion, to flow from them freely, in a way which is in agreement with the most perfect order; [...].)

Kant, of course, chooses the latter, which is much more in agreement with the attributes God must possess. It is unworthy to assume that God could deliver an imperfect creation, which needed miraculous assistance (ANTH, p.357/A147). Therefore, if everything is in harmony, one must conclude that the essential properties do not have an independent necessity, that there is no blind fate, but that they all originate in the one divine Intellect which is the ultimate ground and source of all beings and which has included all of them in His divine scheme of the universe.

> "Alles, was sich aufeinander, zu einer gewechselten
> Harmonie, beziehet, musz in einem einzigen Wesen, von welchem es insgesamt abhänget, unter einander verbunden werden. Also ist ein Wesen aller Wesen, ein unendlicher Verstand und selbständige Weisheit vorhanden, daraus die Natur, auch sogar ihrer Möglichkeit nach, in dem ganzen Inbegriffe der Bestimmungen, ihren Ursprung ziehet."
> (ANTH, p.358/A148)
>
> (Everything which is related in mutual harmony, has to be connected in a single Being, on which it depends as a totality. Therefore, there is a Being of all beings, an infinite Intellect and independent Wisdom, which is the source of nature, including its possibility, and including the totality of [its] determinations.)

According to Kant, therefore, the ultimate unity of the universe is a result not of physical interaction, but of the connections between all things in God’s mind, that is, (regardless of the religious implications) a result of the unity of the idea of nature which transcends nature (16).

The idea that nature has a history was, even in Kant’s time, not a new one. Kant himself names Democritus, Lucre-

tius, Leucippus, and, primarily, Epicurus as early examples of natural philosophers whose systems of nature have a resemblance to his own (ANTH, 233/A xxiv) (17). Kant, however, is the first to describe the history of nature in Newtonian terms, that is, by making use of at least one force (viz. attraction) which had been mathematically described. He admits that the second basic force (viz. repulsion) is not so clearly described in Newton's system (18), but that it is clearly visible in the activity of dispersed matter, for instance in vapours (id., p.242/A xlvi-xlvii). In fact, he offers an ontological system which could (and in his view should) furnish a basis for Newton's mechanics. In this system the actor is matter (differentiated in small parts) and the activity consists in the two fundamental forces inherent in it.

section 3. A new theorem concerning motion and rest.

In 1758 Kant published a short essay on motion and rest (19). Most of what he says in it can be found also in WSdLK, but some concepts are further elaborated.

Kant, as Descartes did in his Principia philosophiae (20), explains the relativity of motion and rest, concluding that one should not use these terms in an absolute way, but always relatively, that is, always stating with respect to which bodies a body is in rest or in motion. Not even in an ideal, absolute space as in mathematics can motion or rest be absolute, for in such a space, since it is void of corporeal matter, there are no different parts to be distinguished, therefore no different locations (NLBR, p.571/A3).

Obviously, space as such is, according to Kant, indeterminable. It is determinable only by the bodies in it. But Kant does not agree with Descartes that space or extension is nothing but corporeal matter. As a consequence, he never claims that a vacuum is impossible.

The relativity of motion or rest is, for Kant, not only a matter of frames of reference. He uses it to demonstrate the impossibility of absolute rest and, as a consequence of this, the impossibility of the absolute absence of force (in his special sense of the word). Consider, he says, a body A which moves towards a body B which is in rest with respect to other bodies. Strictly speaking, one should say that both A and B take part equally in the change of their mutual relation, since it is the distance between them which decreases. As a consequence, both A and B possess a force which is exerted when they collide:

> "Alsdenn wird man die ganze vorgegangene Veränderung unter
> beide Körper gleich verteilt haben und mit diesen gleichen Kräften werden sie einander auch im Stosze treffen."
>
> (NLBR, p.573/A5)
>
> (Thus one will have divided between the two bodies the whole change which has taken place, and with

these equal forces they will collide with each other.)

From this, Kant says, two corollaries follow:
1. Every body with respect to which another body is moving is also moving itself with respect to this other body, and it is, therefore, impossible that any body would collide with a body which is absolutely in rest.
2. Action and reaction equal each other in the collision of bodies (NLBR, p.574/A5).

This, then, explains the force of inertia ("Trägheitskraft"). A body may seem to be in rest, but it never is. If it collides with another body which is, seemingly, in motion, it can instantly react with a force equal to the action of the colliding body, for it takes part in the same motion, as has been pointed out. Therefore, it is not necessary to think of the force of inertia as a particular kind of force; it is simply the product of motion and mass which every body taking part in a collision must possess (NLBR, p.576/A6).

Kant warns that one should not rashly ascribe motion or changes in motion to internal forces. Motion is an external phenomenon, laws of motion are laws of experience ("Erfahrungsgesetze"), and one cannot jump from these external facts to theoretical conclusions concerning internal bodily qualities or states. Theoretically, one should point out that:
1. If a body possesses internal forces, these forces should be in equilibrium when the body is in rest. How, then, is it possible that this equilibrium changes instantly into a certain reaction?
2. And if this were possible, the reaction would cancel the action, and rest would be the result always; which is contrary to experience. Furthermore, if the force of inertia would be an internal force, it would be a natural force and, therefore, restoring equilibrium after the collision, which means that the body would come to rest (NLBR, p.575/A5-6).

Although Kant’s argument may be somewhat confused (21), the point he is making is clear. One should, he claims, distinguish between internal and external. Since motion is relative and external, one may not draw from it conclusions about the internal state of bodies. This seems to imply that the internal state of a body is absolute as compared to its external state, but Kant does not say this explicitly.

After repeating his law of continuity, according to which a force is exerted gradually (see section 1), Kant makes clear how, according to his concepts of motion and rest, collision should be conceptualized.

First he says that he will abstract from the force of elasticity ("Federkraft") and consider only collisions in which the two bodies involved approach each other perpendicularly.

Consider, he says, two bodies. A has a mass of 3, B a mass of 2. B is at rest with respect to the space it is in. A is in motion with respect to the space B is in, with

a velocity of 5. Since the two bodies partake equally in this motion, proportional to the respective mass of the other, B must be considered to move towards A with a velocity of 3, A towards B with a velocity of 2. As a consequence, the forces in collision are both the product of 3 and 2, they equal each other, therefore the bodies are at rest with respect to each other after they have collided. But with respect to the surrounding space, A is moving towards B with a velocity of 5, or, which amounts to the same, B and the space it is in are moving towards A with a velocity of 5. A negates a velocity in B proportional with its own respective velocity, which was 2, but not in the space B is in, since A only works in B (or, which amounts to the same, B negates in A a velocity of 3, which means that A decreases 3 degrees in velocity with respect to the space B is in, that is, A's velocity towards B's space is 2, or, B's space is moving toward A with a velocity of 2), therefore the space B is in moves onward with a velocity of 2. But B is at rest with respect to A. Therefore B is in motion with respect to the space it is in, with a velocity of 2 in the opposite direction. A is at rest too. Therefore it moves along with B, with respect to the space B is in (NLBR, pp.579-580/A8).

It is, from a modern point of view, easy to say that Kant, ignoring all elasticity, cannot apply a law of conservation, and hence cannot claim to found a system of mechanics in the modern sense. Also, that, since he ignores elasticity, the bodies will of course be at rest after colliding with each other, since no amount of motion can be passed on; that the argument of two forces which neutralize each other is mistaken; and that the relative motion of the bodies with respect to the surrounding space after collision demonstrates Kant's utter confusion.

Nevertheless, all this is, I think, rather beside the point. Regardless of the scientific correctness of his mechanics, Kant is still consistent, here, in pointing out that motion is relative and external and cannot simply be reduced to internal forces. The main point is that the forces, present in collision, neutralize each other inasfar as they are active in the colliding bodies, and that yet motion appears after the collision, not with respect to the bodies as such, but with respect to their external situation, viz. their situation in space. With this, Kant wants to make clear, I think, that collision and relative motion do not require internal changes in the bodies; the changes are external.

section 4. Conclusions.

It is clear that Kant's concept of living force is inspired by both Leibniz's concept of primitive force and Newton's concept of **vis insita**. In contrast to Leibniz's concept of primitive force, however, Kant's living force is not the ultimate and sufficient reason of the existence of a substance. A substance can exist without being related to other substances, but living force has no meaning without this relation. This seems to be the reason why

Kant states that living force is contingent instead of necessary, and that it does not follow from essential properties. In this, he seems to follow Newton, who also refused to regard force as an essential property (22). One should, however, observe that Kant applies a kind of Leibnizian distinction between logical necessity and real or physical necessity; living force is not logically necessary, but physically it is. In his later metaphysical and logical essays (1755,1763), Kant elaborates on this distinction.

It is important to notice that in Kant's view living force is able to intensify by its own virtue, but not infinitely so. His corollary about finite velocities (see section 1) entails this. If there were infinite velocities, the living forces never could intensify enough in order to preserve the necessary amount of motion. As a further consequence, conservation of motion as a universal law would become impossible.

Living force is contrasted with dead force by Kant. Living force is something internal which is externally active (hence its contingency, for its activity presupposes external relations). Its external activity consists in changing the state of another body; internally, it maintains the state of its own body. Dead force, on the contrary, is only external; it is, in fact, only the passing on of motion between bodies (by collision).

This contrast (viz. maintaining state of motion versus changing state of motion) appears also in other texts by Kant, but the terms living and dead force are not used anymore.

In ANTH, the concept of force is elaborated. The idea that force, by relating substances to each other, forms space (see section 1) is repeated in this essay, but now force is specified as attraction. Attraction is the force that unifies the universe and makes it into one space (see section 2). In Kant's system it is implied that attraction needs its complement, viz. repulsion, to do so. Repulsion prohibits all matter to be finally contracted in one point. Therefore, repulsion and attraction together form unified extension. But Kant, in this essay, emphasizes the role of attraction. This may be a result of the fact that the theory is primarily physical (not metaphysical, although metaphysics is included in it) and explicitly related to Newton's theory of mechanics.

From a dialectical point of view, Kant's theory has two interesting features which are both fundamental to this theory.

The first feature is the idea that matter is organized by two forces which seem to be opposite to each other, viz. attraction and repulsion. Engels claims that Kant conceived of matter as the unity of attraction and repulsion (23), but, strictly speaking, in ANTH this is not quite true. Kant states that both attraction and repulsion are inherent to matter, that matter is organized by the activity of these forces, and that the universe resulting from this is a single and united system, but not that matter as such is the unity of these forces. As will

appear below, however, in Kant's other essays some supporting evidence can be found for Engels' interpretation.

As concerns the nature of the opposition of these two forces, this is made clear in Kant's metaphysical essays (see chapter 6).

Kant no longer needs a first Unmoved Mover who gives the universe its total quantity of motion. The motion of the universe no longer has an external source. Since matter possesses its two forces, motion originates within the universe itself. The universe starts its own process of organization.

This leads to the second feature, viz. the idea that the process of organizing matter is everlasting. As has been pointed out above, the universe is, according to Kant, partly organized and partly chaos still to be organized. When the organization has reached a certain degree, disorganization will commence, and again succeeded by organization, and so forth. Furthermore, the universe is infinite, which entails that the initial organization will never be completed absolutely. Kant's universe resembles an infinite pond on the surface of which concentric ripples of organization alternate with ripples of disorganization in a never ending series.

In Kantian physics, force plays an important role. Without relation, there can be no order, and without order, there can be no space, says Kant. Forces establish relations. Physically, this means that particular motions occur in space which is established by the activity of attraction and repulsion. This space, which is in fact the universe as a unity, is the general framework in which the particular frames of reference can be situated. As Kant claims that there is an ultimate centre of gravity which acts as the point of support for the entire universe and which makes it into one single unity, there is reason to call this general framework absolute space, although Kant himself does not use this term in the essays reviewed above.

In section 2, I have already pointed out the problems involved with this ultimate centre of an infinite totality. Here, it can be added that, if there is no ultimate centre and hence no general framework, there is nothing to be determined as particular frames of reference. But if there is an ultimate centre and hence a general framework, the relativity of motion in particular frameworks should be seriously questioned; for it is obvious that in that case the motion of a body is related to an absolute centre, and, therefore, has an absolute value.

Kant makes clear that, in general, he does not assume internal forces which cause change of motion; change is, as is motion, a matter of relations and, therefore, external.

The role of living force, that is, the force which preserves the state of motion a body is in, however, is not quite clear. On the one hand Kant says that it has its origin within a single body itself, but on the other hand it refers to motion, and motion is an external phenomenon.

This problem, though, may be alien to Kant's ultimate ontological system, as living force may only be a vanishing remnant of Leibnizian influence; the concepts of living and dead force are only found in WSdLK, not in the other essays reviewed here (but, as will appear, in some way the concept reappears). This is not the case, however, with Kant's concept of space and motion as external relations of bodies, which appear consistently in all his texts.

In general, the concepts of internal state and external state must be made clear in metaphysics, for, although it is obvious that Kant applies them in his physics, their systematic meaning is not made clear in it.