A critique of the definitions of mass and force

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Abstract

It is not necessary to distinguish between inertial and gravitational masses believing that the nature has chosen them quite proportional to each other by chance, and not necessary to believe that the nature by chance has chosen the power of distance in inverse-square forces exactly equal to two, and not necessary that in trying to define mass (and force) to become involved in a vicious circle using presupposition of existence of inertial reference frame which itself requires pre-definition of mass. Newton's laws of motion are rewritten in a logical manner. Some primary models are presented as guides for discovering the essence of known forces. A model for justifying the force between two electric and magnetic charges, moving relative to each other, is presented. In fact energy has only one form: kinetic energy. The law of action-reaction holds completely and undoubtedly only during the direct collisions of particles.

1 Mass and force

Each mass, because it is mass, necessarily occupies some space. Occupation of space by the mass means that necessarily mass has shape. That each mass has shape necessitates that in a collision between two masses each of the masses makes some prevention against the other. Depending on the shapes of the colliding masses, result of such a prevention can appear in the form of repulsion, attraction or a combination of these two forms, as follows: If the masses don't have such shapes as to be caught in each other (eg are smooth), they will jump from each other during their collision (what we call an elastic collision). But if they have such shapes as to be caught in each other, they will keep being fastened in each other after their collision (an inelastic collision). It is clear that a combination of both the above-mentioned forms can occur. (But in any case, always (before and after the collision), sum of the momentums will remain constant.)

Thus, in simple words, in a definite space we can have a medium consisting of some masses jumping from each other that repel each other during their collisions (like the molecules of a perfect gas which because of these jumps (or repulsions) cause a pressure in the gas), or a medium consisting of some masses catching in each other that in such a case it can be imagined that since due to successive movements different collisions occur, different masses will be caught in each other and gradually will make limited assembled piles (what is similar to the process of formation of celestial bodies from the gases, and maybe is the cause of formation of atoms and masses called generally as elementary particles from original infinitesimal masses).

It can be imagined that every mass has been formed from smaller parts or particles which these particles due to catching in each other (or probably due to exertion of force in other ways) have formed that mass. Thus, let's untie their entanglement in some manner. In this state, still, the above-mentioned situation will be repeated and we shall have some masses that because of collision can be caught in each other or eg because of their collision with other proper masses can be jumped from them. In any case yet we can say that even each of these particles consists of some smaller particles repeating the above-mentioned story. By repeating this process we can say that some particles having infinitesimal masses can be visualized each of which occupying an infinitesimal space, and since they are mass, according to the above-mentioned reasoning they have shape and can be caught in each other or jumped from each other due to collision. Notice that infinitesimals are not necessarily equal to each other and we can have an infinitesimal eg much larger than another infinitesimal. Then we can visualize a space consisting of eg large infinitesimal masses caught in each other which form a rather continuous medium, and another space consisting of eg small infinitesimal masses which form a medium like a perfect gas in which the masses are repelled from each other due to collision. It is obvious that middle cases exist too.

For better understanding of what stated above note the following reasoning. Consider two spheres which are quite elastic and have the same mass, size, and shape. Suppose that one of them, which we call it as the second one, is motionless, and the other one, ie the first sphere, approaches it with a constant speed and collides with it directly. After collision, the first sphere stops and the second sphere will move in the same direction (and line) and with the same (constant) speed of the first one. Each of these two spheres has a definite elastic property and so will be deformed to a specified extent, say d, during a specified time, say t, under the influence of a specified force, say F, and again will return to its initial form. Just this property causes the whole momentum to be transferred from one to the other during the definite time of collision. Now, a question: If these two spheres continue to be quite elastic but with a lesser elastic property, ie if each of them will be deformed to an extent lesser than the above-mentioned d under the above-mentioned force F during the above-mentioned time t and return to its initial form, will yet the first one will stop and the second one will move with the same speed of the first one in the direct collision of the first moving sphere with the second stationary sphere? Answer is affirmative. The only difference is that the duration of collision has become less. If the situation proceeds in this manner, ie if the spheres have more lesser elasticity while they are quite elastic, yet the result will remain the same. So, we conclude that if ideally the spheres have no longer any elasticity at all (while they are quite elastic (which this refers to their infinite toughness)), yet the first one will stop and the second one will move with the same speed of the first one due to the above-mentioned direct collision (ie in a collision duration as infinitesimal as zero the spheres will be deformed to an extent as infinitesimal as zero and eventually (ie here immediately), as before, the whole momentum of the first sphere will be transferred to the second sphere). Of course, this is an ideal state which seems is rather applicable to the previously mentioned infinitesimal masses which probably have ideal infinite toughness and zero ductility (and consequently zero elasticity). Clearly, such infinitely tough infinitesimals, having no ductility, can be repelled from each other (in elastic collision) or caught in each other (in inelastic collision) (or will have a middle state) during collision with each other according to their shapes. And also their kinetic energies will be conserved in collisions. This means that if in collisions they repel each other, sum of the kinetic energies before a collision will be equal to this sum after the collision, and if in collisions they are caught in each other, yet, sum of the kinetic energies before a collision will be equal to this sum after the collision but in this state the kinetic energies after collision include not only the kinetic energies of the particles in a specified line (eg the same line of the motion of colliding particle) but also the kinetic energies of the particles in the form of shake of the particles in the pile assembled due to the entanglement of particles in each other after collision (imagine that the mechanism of entanglement of the particles is not so rigid and gives them the possibility of shaking or changing the position about a situation center).

Now let's have a profound look at the subject of mass and force with aid of the conception gained by the above-mentioned discussion.

What is "mass"? What we understand from mass is a perceptible independent existence. What is "force"? What we understand from force is not a perceptible independent existence, although force is not a subsidiary concept like field and its effects are quite perceptible. Indeed, force has no sense without mass, ie force is exerted from mass to mass, and no more. But what is really force itself? Let's try to understand what the force is really. First, let's see with which forces we are acquainted: gravitational attraction force, electric attraction force, electric repulsion force, magnetic attraction force, magnetic repulsion force, and the force that two electric and magnetic particles which are in motion in two different parallel directions exert on each other in the form of forces normal to the plane of their directions of motion (see the 13th article of this book). (To my mind, our knowledge about the nuclear forces is not sufficient, and perhaps the huge energy which becomes free from the heart of nucleus can be justified as follows: While the units bearing positive charges in atom (protons) are sufficiently localized they have such shapes that they can caught in each other. It is clear that when these units have been caught in each other they have stored some enormous potential energy in themselves because they have held some localized positive charges very close to each other, and with untying of their entanglements this huge energy will be released. Maybe neutron is also the product of such an entanglement as mentioned above between a proton and an electron (ie something stronger than the bond between these two in the hydrogen atom).)

Perhaps it can be said that the world contains much tiny particles of various kinds, that we have not succeeded in discovering them yet, which are carriers of some waves propagating with huge speeds (probably very much more than the speed of light). (Think about the above-mentioned aspect of mediums which infinitesimals can make: a rather continuous medium, and a medium similar to a perfect gas.) The sources of these waves are probably partial masses or partial charges, and kind of these waves may be longitudinal or transverse. Then the agent of transferring of attractive and repulsive forces is probably these waves propagating in their proper carrying mediums, and eg probably repulsive forces can be attributed to longitudinal waves (in a medium eg similar to a perfect gas) causing a resultant pressure on the target, and attractive forces can be attributed to transverse waves (eg in a rather continuous medium as mentioned above) causing a resultant tension on the target (see the 12th particle of this book). (Notice the similarities existent between the appearances of demonstration of attractive or repulsive forces and appearances of demonstration of waves, like the proportion of their intensities to the inverse square of distance.) And also, in a raw manner and as a primary try for justifying the phenomenon, we can justify the form of the forces which the above-mentioned two electric and magnetic particles exert on each other as in the following section.

In any case what seems almost certain is that we must not suppose force as an independent and invisible existence linking two masses distant from each other, but it is only sufficient that force is attributed to the event occurring in the collision of two particles ie to the prevention of each of the two particles against the motion of the other one during the collision. Therefore, while mass exists really, force should be defined. Forces of attraction, repulsion, and so on, as we saw above cursorily, are consequence of the same collisions of the particles in their wave motions (notice the propagation of sound wave in the air due to the changes in the air pressure arising from the collision of the air molecules with each other).

In this manner the physicists no longer require to distinguish between the so-called inertial and gravitational masses stating after which, without much surprising, that but the nature shows that these two masses are quite proportional to each other! As we know they say that when the pans of a pair of scales, each one bearing a mass, are in balance, if the pans under the masses disappear (or are removed), there won't be any logical reason that the accelerations the two masses gain downwards to be equal to each other, but the nature wants to be so by chance! Because, according to their belief, the balance of the pair of scales shows that the two gravitational masses, defined by m from the relation $F = GMm/d^2$, in the two pans are equal to each other, which this cannot necessitate logically that, while exerting equal forces on them, two inertial masses, defined by m from the relation $F = ma$, in the two pans are equal to each other too and in other words these two masses gain equal accelerations under the equal forces exerted on them. But now considering the discussions of this paper we know that these reasonings are quite baseless and force is the result of transfer of momentum due to collisions of masses which these collisions are either big direct collisions or particle indirect collisions (appeared in the form of wave) like in the case of gravitational attraction. In other words the relation $F = GMm/d^2$ is itself a result of the relation $F = ma$ which applies to much tiny particles in their collisions with our considered mass that exert their collision forces under the banner of gravitational attraction. In this manner we see that the nature not only does not work exceptionally here, but also in the case of inverse-square forces (gravitation) the nature has not exceptionally prescribed the power of the distance exactly equal to two as the physicists have been trying to investigate the degree of exactness of this equality, but as it was said it is a natural consequence of propagation of waves that since their energy is distributed on (two-dimensional) surface, inevitably their intensity decreases with inverse square of distance.

Now with the above-mentioned preparations let's accept the following principles instead of Newton's laws of motion:

1. We accept mass as an undefined concept. (This also necessitates that mass is not created nor destroyed (the law of conservation of mass).)

2. There is a frame of reference named as inertial reference frame in which each mass having no collision with other masses has a constant velocity. (Every other frame of reference having a constant speed relative to this frame is itself an inertial reference frame.)

3. In an inertial reference, sum of the momentums of all of the particles (before and after collision), defined as product of mass and velocity, remains constant (the law of conservation of momentum).

4. In an inertial reference, sum of the kinetic energies of all the particles of each two masses (before and after collision), defined as half of the multiplication of mass and the square of speed, remains constant (the law of conservation of energy).

By accepting the above-mentioned principles, in fact we have defined force as time rate of change of momentum and indeed we have accepted customary Newton's three laws of motion.

A point about the part 4: If we ponder on the previously presented aspect of infinitesimals being able to carry the waves of attraction and repulsion or other forms of wave and the explanation about different forces, we shall conclude that energy has in fact only one form, kinetic energy, and all other forms of energy, including potential energy, are in fact appearances of some sets of kinetic energies of the particles. For understanding of this fact with reference to potential energy imagine an inflated ball which is being shot at a firm wall. This ball will rebound from the wall after colliding with it. Its reason is that during the collision the kinetic energy of the ball before its collision with the wall will be changed into potential energy in the (deformed) ball flattened due to being pressed to the wall, and afterwards, this potential energy will become free and send back the re-formed ball from the wall, ie the potential energy will be changed again into kinetic energy. The question is this: How does the flattened ball store the kinetic energy in itself as potential energy? We try to find the answer: Before the collision, molecules of the air in the ball are moving toward the wall as the ball is moving toward the wall (with the same speed of the ball). At the first moment of touch of the ball and wall these molecules are still moving toward the wall with the same speed. This motion will continue until they reach that inner surface of the ball which is now leaning on the wall and recoil from it. This causes the ball to become flattened. After recoiling of the air molecules from this surface they will move back toward the opposite inner surface of the ball, and after re-forming the ball causes it to get away from the wall. Therefore, as we saw, no special event has occurred except that we have wanted to call the whole events occurred between the moment of the first touch of the ball and wall and the moment of complete separation of them (which are exactly the same processes of motion and collision of the particles) as the potential energy.

As another example consider when we let two like charges get away from each other and attribute a potential energy to them which decreases as they are getting away from each other. We can imagine these two like charges in a medium of the mentioned infinitesimals which through collisions with each other, being transferred through longitudinal waves, exert repulsive force on each other. So, we can say that this is just this same collisions of this tiny particles with the charges that causes them to move, and then, indeed, their kinetic energies decrease after such collisions (which increase the kinetic energies of the charges). Such damped infinitesimals will again gain (kinetic) energy from surrounding infinitesimals. We call these events as the mechanism of release of the potential energy as kinetic energy. (Or we can imagine that when we are bringing two like charges close together we are in fact transferring energy to the tiny particles which are trying to check the charges' approach. So, the kinetic energies of all of these particles (including the surrounding ones) increase.) Also we can imagine that in the case of attraction of two masses or two unlike charges, this is the kinetic energies (an shakes) of the entangled (but loose) chains of infinitesimals which are transferred to the body as increase in its kinetic energy. So, by decrease of the kinetic energies of these particles the kinetic energies of the (approaching) bodies increase.

(Or, we can imagine that when we are moving them away from each other we are in fact lengthening the above-mentioned chains, ie our work will be conserved as increase in the kinetic energies (or shakes) of the increased particles of these chains.)

A point: Temperature (as we have discussed in Paper 11) is proportional to the average kinetic energy of the molecules excluding their potential energies. In more precise words, considering what stated so far, temperature is proportional to the average kinetic energy of those particles which are not infinitesimals (and as we saw the kinetic energies of these infinitesimals can make our customary potential energies). The criterion for thermometry is just this sufficiently big average kinetic energy of sufficiently big particles (or molecules, not infinitesimals) that can affect macroscopic parameters of thermometers.

See a point about the law of action-reaction at the end of the paper.

2 Mechanism of the force between two electric and magnetic charges

As we said attraction is attributed to transverse wave because in this wave stretch of the medium carrying wave is the cause of propagation of the wave and just this stretch means attraction, and repulsion is attributed to longitudinal wave because in this wave pressure of the medium carrying wave is the cause of propagation and just this pressure means repulsion, and the force between two electric and magnetic charges having speed relative to each other is attributed to circular wave that we want to describe it in this section. Before that we note that the general rule governing these waves (transverse, longitudinal or circular) is that firstly because of spreading of the wave energy on the surface perpendicular to the direction of propagation of the wave its intensity is proportional to the inverse-square of distance, and secondly considering Fig. 1 if m in the left pile M (which is not necessarily mass and eg depending on the case can be charge) is the unit radiating the wave influencing the unit m' from the right pile we can say every other similar unit from the pile M also radiates a similar wave influencing, the unit m', and then altogether the force effective on m' is proportional to the total of these particles ie is proportional to M.

Every other particle from the pile M' too has this situation. Thus, altogether the force effective on M' from M is proportional to MM' and also vice versa. Namely, proportion of force to MM'/d^2 originates from the wave property of force exertion.

Also we notice that for attraction and repulsion forces (related to relevant waves) if M and M' both have a single uniform velocity relative to the medium carrying wave (in other words if while these two retain their positions relative to each other there exists a wind of the medium with a uniform velocity), as before each of M and M' will receive waves with the same frequency from the other one and no difference will be obtained to the stationary state (or the state of nonexistence of wind) and then still the same force will be exerted on each of M and M' due to the other one (this is a simple problem the reader can solve it easily. For example easily we can say that the frequency of the siren of a stopped ambulance is the same for a stopped hearer regardless of the speed and direction of the blown wind).

Now let's try to describe (in fact justify) the force between two electric and magnetic charges. Consider fundamental unit of electric charge and fundamental unit of magnetic charge as q and b respectively. Suppose that q and b are stationary relative to the medium carrying wave. A series of circular waves are radiated from b towards q. Tiny particles of the carrying-wave medium around q have circular wave motion (or in other words they circulate) and the resultant of their effects on q, which is stationary, is neutral.

Now suppose that q gains speed v normal to the line connecting q and b. It is clear that considering that q goes into the left circular waves with its gained speed and considering the direction of rotation of the circular waves shown in Fig. 2 inward force (towards the inside of the page) will be exerted on q from the left waves.

For better perception of the subject visualize some tops as shown in Fig. 3. Suppose in this figure a, b, c, a', b' and c' as points of a single body which is moving towards the tops. Suppose that the tops all rotate in a single direction eg clockwise. Suppose that the speed of the body towards left is small. Thus, in a time interval only the points a and a' get involved in the blades of the tops A and A' and because of the rotation the tops push the body downwards. Now if the leftward speed of the body is such more as in the same above-mentioned time interval not only a and a' get involved in A and A' but also b and b' get involved in B and B', then the force directing the body downwards will be increased (eg will become twice). And also if the leftward speed of the body is again such more as in the same time interval c and c' get involved in C and C' too, then the downward force exerted on the body by the tops will be increased more (eg will become thrice). In other words the leftward speed of the body is proportional to the downward force exerted on the body by the action of the tops. Now considering the above description it is seen that in Fig. 2 the force directed toward the inside of the page exerted on q having the speed v is proportional to this speed.

And now let's proceed to the mechanism of the force arising from q exerted on b. Beforehand, for better understanding of the subject consider a linear oscillator like a in Fig. 4 which is in a wave-carrying medium. If the oscillator doesn't have any linear speed relative to the medium and only oscillates, then path of the oscillation in the medium will be as shown in Fig. 4(a) and just this form of oscillation will be propagated as wave in the carrying-wave medium. If this oscillator while oscillating gains the speed v eg towards left, its effect in the carrying-wave medium will be as shown in Fig. 4(b), because the linear speed of the oscillator is towards left and the situation is as if the effect of the wave is drawn towards left because the factor producing the wave is moving towards left relative to the carrying-wave medium, and just this form of effect will be propagated as wave in the carrying wave medium.

With this explanation now consider the particle q from Fig. 2 that creates circular oscillations or in other words circular waves. If q has no speed relative to the wave-carrying medium, circular waves will be sent from q to around b which will cancel the effects of each other on b (see Fig. 5). But if q has the leftward speed v, its effect in the wave-carrying medium will be as a circle drawn towards left. This means that the circular waves around b (sent from q), now that q has gained speed towards left, are drawn towards left. And this means that the effect of the circular (or in fact elliptical) waves of the right side on b is more than the effect of the similar waves of the left side, and as a result a resultant force towards the outside of the page will be exerted on b. In simple words suppose that in a situation that q is stationary relative to the medium, circular waves of the right and left sides of b (sent from q), when seen from below in the direction of the line connecting b and q, are as shown in Fig. 6(a) which exert a resultant zero force on b. When q in Fig. 5 gains leftward speed, according to what we said these circular waves are drawn towards left and creates the situation shown in Fig. 6(b) in which a resultant force towards outside of the page (in Fig. 5) is exerted on b.

For better understanding of this subject visualize some people that every one of them is turning in the same direction a spring, connected, at its end, to a weight, round his (or her) head. They intend to exert an impact on a body round which they have gathered in each time of turning the weight. See Fig. 7(a). Now suppose that a strong wind blows from the right toward the left. This wind causes the form of the rotation of each weight to change from circle to an ellipse drawn leftwards. It is clear that while the people have not changed their positions, only the impacts of the right persons will be exerted on the body and will push it downwards. See Fig 7(b).

An accurate analysis must show that the situation of b in Fig. 5 is equivalent to the situation of q in Fig. 2, ie in other words either q has the velocity v or q is stationary but b has the velocity $-v$ the force exerted on q (or b) will remain unchanged; anyway the law of action and reaction will remain established. Therefore, generally form of the force existent between two electric and magnetic charges having speed relative to each other in the form shown in Equations (5) and (7) in the 13th paper of this book is justified physically in the above manner. (Note: In the above discussion we assumed implicitly that if the wave sent from b to q is eg clockwise in the direction of advancing from b towards q, then the wave sent from q to b will be counter-clockwise in the direction of advancing from q towards b, and this seems rational and natural.)

A point about the law of action-reaction: As we said, force is attributed to the blockage of infinitesimals against each other in their collisions, and since this blockage is the same for the two sides in a collision we conclude that the magnitudes of the forces exerted on two colliding infinitesimals are the same and their directions are opposite to each other and since the points of exertion of these forces are the same (point of collision) they are also collinear (ie they lie on the same line). This is in fact the same law of action-reaction. We said also that for the forces bodies exert on each other through distance (like gravity and electric and magnetic attraction and repulsion) we must consider a medium of infinitesimals in the space between them through which the force is eventually transferred from a body to another body by successive collisions. For instance consider a number of marbles being placed in a row. Another (external) marble, having a speed parallel to this row, collides with the first marble of this row and stops. The reaction force on this colliding marble has been exerted from the same first marble of the row causing its stop. Due to this collision the first marble of the row moves toward the second marble until collides with it and stops but this second marble will move toward the third marble. This act will be repeated until finally the last marble of the row will collide with another (external) marble placed at the end of this row causing its motion and stop of itself. In this state we say that there is some force exerted on this (recent) marble the magnitude of which is equal to the force the first colliding marble exerted on the first marble of the row. Therefore, it is said that the action of the first colliding marble on the last marble of the row is the force finally exerted on it, and the reaction of this action is some force, as big as the action force, exerted on the first colliding marble which is in fact the same force at first the first marble of the row exerted on the colliding marble and stopped it.

As we see while we speak of the action-reaction law we don't notice the events occurred between the two bodies. In numerous cases this negligence causes no problem, ie the same law of action-reaction as stated for colliding particles holds also for them. For example for gravity, which, as analyzed, is probably related to a transverse wave, we can imagine that a (point) mass propagates such a transverse wave toward another (point) mass and due to this propagation is pulled toward the propagation direction of the wave (ie toward the other mass). (We can experience such a pull by waving a rope.) When the transverse wave reaches the other mass, as we analyzed before, it will exert a pulling force on it which is attributed to the action of the first mass on the second mass while its reaction was in fact the same first pull exerted on the first mass toward the second mass.

Thus, we are lucky that for familiar attraction and repulsion forces the law of action-reaction holds regardless of the (microscopic) events occurred between the two bodies. But this is not the case always. For example for the force two electric and magnetic particles exert on each other the lines of the forces are not the same and here we cannot simply ignore what happened between the two charges. About this force, considering the model presented beforehand, perhaps we can say that the circular wave created by the particle a will exert an inward force (toward the inside of the page) on the particle b during its collision with this particle which is entering the wave in Fig. 8. And the reaction of this force, or in fact the reaction of the impact of the mentioned collision, causes a (which is the source of this circular wave) to be driven outwards (toward the outside of the page) (just like when you are standing northwards and stretch your right arm and exert a westward force on a body while you yourself will be driven eastwards). That these forces are not collinear have been discussed in Paper 24 too.

As another example consider a closed container full of a liquid. Suppose that there are two similar nonparallel cylindrical openings on this container with two similar pistons in them. When we exert an additional inward force on one of these pistons (eg due to the collision of a marble with it (such that after the collision the marble will stop)), there will be an outward additional force, as big as the first one, exerted on the second piston (which, eg, can throw another similar motionless marble on the second piston with the same force as the inward one). We may say that the force exerted on the second piston (or marble) is the action of the first piston (or marble) while its reaction is the force exerted on the first piston (or marble) by the liquid (which is balanced by the force exerted on the liquid by the first piston (or marble)). Here we see that these two (action and reaction) forces are not even parallel to each other (while if the two mentioned marbles collide with each other directly (without this intermediate liquid), the law of action-reaction will hold for them completely).

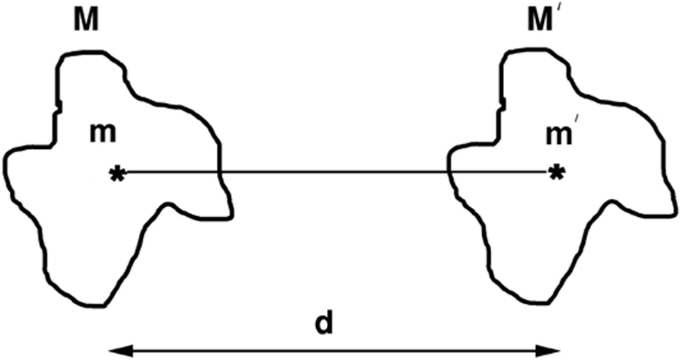

Fig. 1. *Every unit has influence on other units through wave*

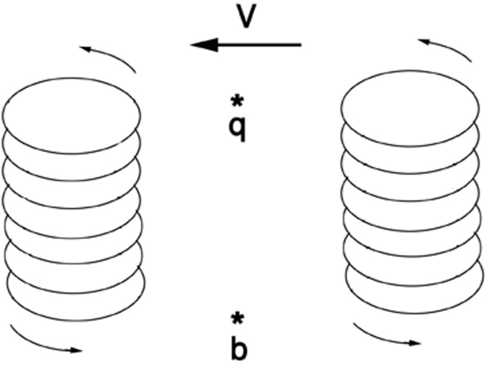

Fig. 2. *Circular waves arising from b propagated toward q.*

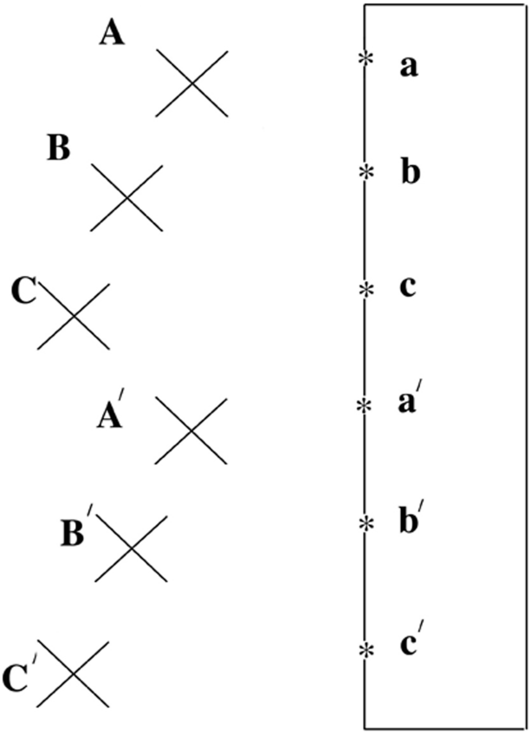

Fig. 3. *A block moving towards a series of rotating tops.*

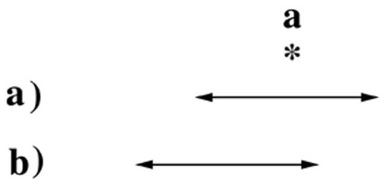

Fig. 4. *An oscillator and its effect in the medium when it is stationary (a) and when it has leftward speed (b).*

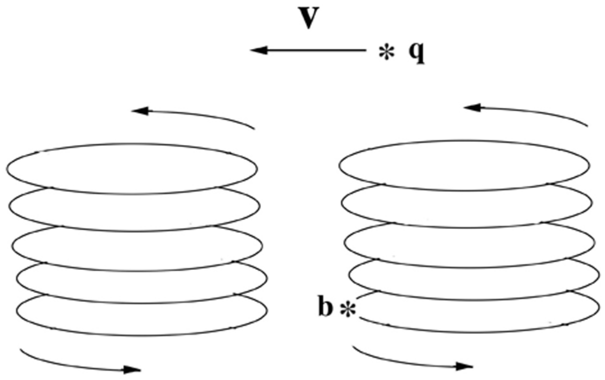

Fig. 5. *Circular waves arising from q propagated towards b.*

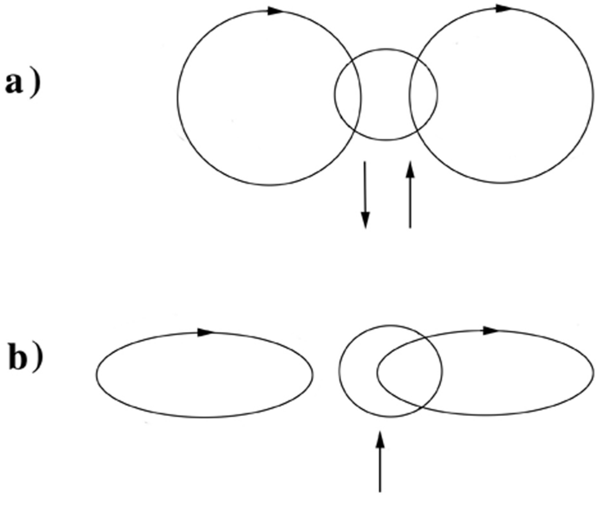

Fig. 6. *Circular waves around b are drawn towards left causing a resulatant force on it.*

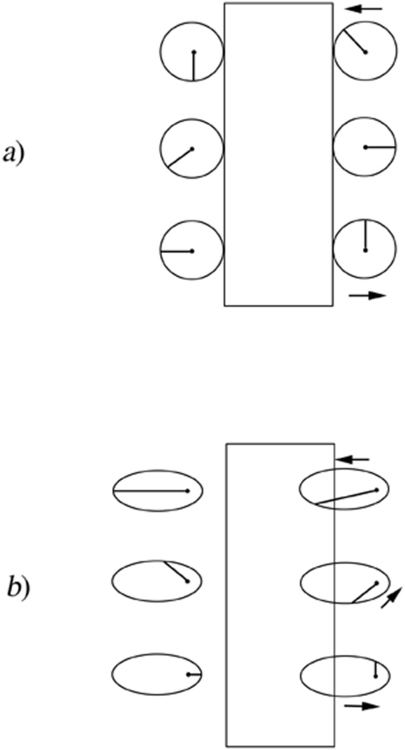

Fig. 7. *Circular rotations when changed to elliptical ones will exert a net force on the block.*

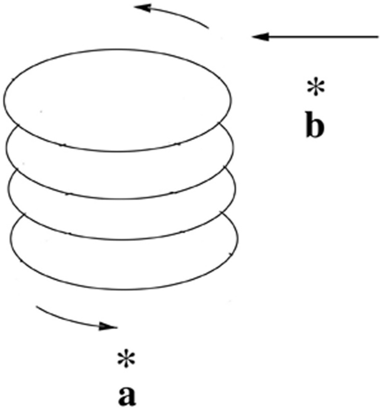

Fig. 8. *Action and reaction in a circular wave.*