DETERMINATION OF A NEW FORCE WITH CHARACTERISTICS OF NUCLEAR FORCE AND BOTH ATTRACTIVE AND REPULSIVE COMPONENTS

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Presently, a new force has been determined. It is generated due to interaction between magnetic fields of the interacting particles, e.g., between electrons in electron beams, between protons in proton beams, and between nucleons in nuclei. Due to this force, electrons, protons and nucleons etc. are held together in their respective systems against the repulsive Coulomb force generated between them due to interaction between their charges. Presently, it has also been determined that, due to interaction between magnetic fields of two particles, a repulsive force, other than the repulsive Coulomb force and much stronger, too is generated. The present force has some very important and striking characteristics: (i) it is strong; (ii) short range; and (iii) charge independent, which are exactly the same as we speculate for nuclear force between nucleons to have. Finally, giving plausible arguments and evidences from the well established existing knowledge, it has been tried to conclude that the current cause of origin of nuclear force cannot be true. The presently determined cause should be the actual cause of origin of nuclear force, and the presently determined force should be the actual nuclear force.

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1. INTRODUCTION

We obtain electron beams, proton beams, alpha particle beams etc. despite having repulsive Coulomb force between the particles of the beams due to interaction between their charges. It means there comes into play some force of attraction between the particles of the beams, stronger than the Coulomb repulsive force, and that keeps the particles of the beams bound together in their respective beams against the repulsive Coulomb force between them. But why, how and from where that force of attraction comes into play, we have no knowledge, because electromagnetic theory and all the existing theories fail to explain it.

Electromagnetic theory has wide success to its credit, but why it too fails, probably nobody bothered to think over and find out the cause behind its failure. As we call, electromagnetic (i.e. electro + magnetic) theory, means, theory dealing with the phenomena, where magnetism is generated due to interactions between the flowing particles having charge (e.g. electrons, protons etc.) in the systems (e.g. beams). But the electrons, protons etc. possess magnetism too along with their charge, and hence their magnetism too should play their role during their interactions, as their charges play their role. But we take no account of their magnetism. We take account of only their charges. Consequently, the electromagnetic theory fails.

The role of their magnetism can neither be contradicted nor overruled nor can be ignored, because when the particles possess magnetism too, electromagnetism cannot be assumed to be generated due to their charge. Secondly, and most important, between particles of the beams, two forces, (i) repulsive Coulomb force and (ii) attractive force, are generated, where due to interaction between their charges, the repulsive Coulomb force is generated. Then the attractive force should obviously be generated due to interaction between their magnetism (how it is generated, see section-2). Both the forces, which are of opposite nature, cannot be assumed to be generated simultaneously due to interaction between their charges.

Presently, it has also been determined that, due to interaction between magnetic fields of two particles, a repulsive force, other than the Coulomb repulsive force and much stronger, too is generated. How and when this repulsive force is generated between them that have been explained very clearly and completely (see section-3).

The presently determined force succeeds to give very clear and complete understanding of as to how their beams are obtained despite having repulsive Coulomb force between them (see section-4). It succeeds also to give very clear and complete understanding of a very important but so far unexplained phenomenon: how a magnetic field is generated around the electron beam, why and how that field occurs in a plane perpendicular to the direction of the flow of beam and possesses direction (see section-4).

Finally, giving plausible arguments and evidences from the well established existing knowledge, it has been tried to conclude that the current cause of origin of nuclear force, i.e. the continuous exchange of virtual π mesons between the nucleons, should not be true. The presently determined cause should be the actual cause of origin of nuclear force, and the presently determined force should be the actual nuclear force.

2. EXPLANATION OF WHY AND HOW A FORCE OF ATTRACTION IS GENERATED BETWEEN, FOR EXAMPLE, ELECTRONS OF AN ELECTRON BEAM

Currently, it is assumed that the electron possesses magnetic field around it and spin magnetic moment (μ_s) as the consequence of spin motion of its charge. But it is not true (for detail, see reference-1). The electron in fact possesses magnetism by virtue of nature similarly as it possesses its charge (e) by virtue of nature (see reference-1). This magnetism occurs in the form of a circular ring, shown by a dark solid line circle, Fig. 1, around the charge of electron, where charge has been shown by a spherical ball, Fig. 1(a), and by a thick dark circle, Fig. 1(b). As, for an example, there occur rings around the planet Saturn. This

magnetism and charge of electron, both spin, but in directions opposite to each other, shown by arrows in opposite directions, Fig. 1(b). The spin magnetic moment (μ_s), which the electron possesses, arises due to the spin motion of this magnetism, and occurs in the direction of spin angular momentum of this magnetism. Around this magnetism of the electron, there occurs a magnetic field, which is the same magnetic field the electron possesses. This magnetic field occurs probably in the form of a band of sets of concentric magnetic lines of force all along its (magnetic ring) width, Fig.1, [as, for example, there occurs magnetic field around a current carrying rod of very small length (like a thin chip) in the form of a band of sets of concentric magnetic lines of force all along its length] and this magnetic field spins along with the magnetic ring in the same direction.

Since the electron possesses its linear motion along the direction of its spin angular momentum L_s (see reference-2), in an electron beam, the directions of L_s of all its electrons are oriented and aligned in the direction of linear motion of the beam (for its confirmation, see reference-2). Then, obviously, the planes of magnetism and magnetic field of all the electrons of the beam are aligned in a plane perpendicular to the direction of motion of the beam and they (planes of magnetism and magnetic field of all the electrons of the beam) possess their spin motion in the same direction, i.e. in anticlockwise direction (if the beam is moving towards the face of the clock).

Let us consider two electrons, say A and B, of the beam, which are adjacent to each other and lying in the same transverse plane of the beam moving with velocity v, as shown in Fig. 2(a). Then the planes of their magnetic fields shall lie in the same plane. Let r be the radii of the outermost concentric circular lines of force of magnetic fields of the electrons. If the distance, say d, between their centers becomes $< 2r$, their lines of force start interacting, as shown in Fig. 2(b). Let the distance d between their centers be such that the outermost two lines of force a_1 and a_2 of electron A interact with the outermost two lines of force b_1 and b_2 of

electron B. In the region of their interaction (i.e. in between the electrons A and B), the directions of lines of force a_1 and a_2 of electron A are opposite to the directions of lines of force b_1 and b_2 of electron B, Fig. 2(b). They repel each other in this configuration. Consequently the lines of force a_1, a_2 of the electron A, after their repulsion, are diverted towards the electron B and dragged along with its lines of force b_3, b_4 etc. and pushed behind the electron B, as shown in Fig. 2(b). And the lines of force b_1, b_2 of the electron B, after their repulsion, are diverted towards the electron A and dragged along with its lines of force a_3, a_4 etc. and pushed behind the electron A. Finally the lines of force a_1, a_2 of electron A and b_1, b_2 of electrons B acquire the form, as shown in Fig. 2(b), and around point P, a neutral region is created (i.e. region free from the effects of magnetic fields of electrons A and B). In the process of getting pushed behind, the lines of force a_1, a_2 and b_1, b_2 are expanded, and hence in order to obtain their original positions and form (i.e. shape) as they had before their interaction, they apply some pushing force on magnetic lines of force b_3, b_4 and a_3, a_4 respectively, which in turn apply pushing force on electrons B and A respectively. Because, according to properties of magnetic lines of force, the magnetic lines of force are just like flexible strings and experience the longitudinal tension in its length, hence possess tendency to acquire their original form. In order to verify its truth, we can see Fig. 3, where the lines of force 3,4,5 and 6,7,8 of earth's magnetic field acquire their original positions and forms after coming out from the north pole of a bar magnet placed in magnetic meridian of earth's magnetic field. Consequently, a force of attraction ***F*** is generated between the electrons A and B (for detail knowledge about force ***F***, see section-5.1).

3. EXPLANATION OF HOW AND WHEN THE FORCE GENERATED BETWEEN TWO ELECTRONS DUE TO INTERACTION BETWEEN THEIR MAGNETIC FIELDS BECOMES REPULSIVE

The force, which comes into play due to interaction between magnetic fields of electrons, can be attractive or repulsive. Let us now see how and under what condition it happens to be repulsive.

Let us consider two electrons, say A and B, moving with velocity v parallel to each other but opposite in direction. At some point they are supposed to be adjacent to each other and lying in the same plane, Fig 4(a). In this situation, the planes of their magnetic fields shall lie in the same plane but the directions of spin motion of their magnetic fields shall be opposite, as shown in Fig 4(a). If the distance *d* between their centers happens to be < 2r, their lines of force start interacting, Fig 4(b). Let the distance *d* between their centers be such that the two outermost lines of force a_1 and a_2 of electron A interact with the two outermost lines of force b_1 and b_2 of electron B, Fig 4(b).

In this situation, in the region of interaction between their magnetic fields (i.e. in region between the electrons A and B) their lines of force a_1, a_2 and b_1, b_2 are not repelled by each other but are dragged along with the lines of force of each other, as shown in Fig. 4(b). Because in this case, when their lines of force come close to each other, they are found moving along the same direction, whereas for their repulsion it is essential that they must be in opposite directions [as occurs in previous case, Fig. 2(b)]. Hence, when their lines of force are dragged along with the lines of force of each other (i.e. a_1, a_2 of electron A are dragged along with b_1, b_2 of electron B) and pass through the space between a_3 and b_3 lines of force of magnetic fields of electrons A and B respectively, they come very close to each other [for convenience, they have been shown overlapping in Fig. 4(b), while actually they do not overlap], because the space left between the lines of force a_3 and b_3 for them to pass through happens to be very narrow, as appears from the Fig 4(b). But, due to their properties (mentioned earlier), they do not want to pass through this space coming very close to each other but want to pass through maintaining their original positions and shape as they had

before their interaction. Therefore, in order to pass through, maintaining their original positions and shape, the lines of force a_1, a_2 apply some pushing force on lines of force a_3, a_4 etc., which in turn apply pushing force on electron A towards our left; and the lines of force b_1, b_2 apply some pushing force on lines of force b_3, b_4 etc., which in turn apply pushing force on electron B towards our right. Consequently, a force of repulsion $\boldsymbol{F}$ between electrons A and B is observed (for detail knowledge about force $\boldsymbol{F}$, see section-5.2).

Thus two electrons, moving parallel to each other but in opposite directions such that the distance d between their centers $< 2r$, are acted upon by a repulsive force $\boldsymbol{F}$.

Since the two electrons, moving parallel to each other but opposite in directions, come close to each other for a very short time (depending on their velocities), they receive a sudden kick type of repulsive force from each other.

4. EXPLANATION OF HOW AN ELECTRON BEAM IS OBTAINED AND A MAGNETIC FIELD IS GENERATED AROUND THE BEAM IN A PLANE PERPENDICULAR TO THE DIRECTION OF ITS MOTION AND HOW THAT FIELD POSSESSES DIRECTION

If we take, as an example, eight electrons, Fig. 5(a), or nine electrons, Fig. 5(b), or seven electrons, Fig. 5(c), adjacent to each other and lying in the same transverse plane of the beam, their lines of force interact and consequently a force of attraction is generated between all the electrons, and the lines of force are obtained around them as shown in Figs. 5(a), 5(b) and 5(c) respectively. In similar fashion, the lines of force of all the electrons, lying in different transverse layers of the beam interact and consequently a force of attraction is generated between all the electrons of the beam and the lines of force of all the electrons acquire the forms as shown in Figs. 6(a, b, c_1 and c_2).

Due to generation of a force of attraction between all the electrons of the beam, all the electrons are bound together and consequently an electron beam is obtained. And the

resultant magnetic field generated around the beam is obtained all along its length in coaxial hollow cylindrical form, as shown in Fig. 6(c_2) [if the beam is having circular transverse cross-section, Fig. 6(c_1)].

In the beam, since the planes of magnetic field of all its (beam) electrons lie in a plane perpendicular to the direction of its motion, and the magnetic fields of all the electrons of the beam possess spin motion in the same direction, i.e. in anticlockwise direction (if the beam is moving towards the face of the clock), the magnetic field generated around and along the length of the beam is obtained in the plane perpendicular to the direction of motion of the beam and it possesses anticlockwise direction.

5. EXPLANATION OF HOW THE FORCE GENERATED DUE TO INTERACTION BETWEEN TWO ELECTRONS VARIES AS THE DISTANCE BETWEEN THEM VARIES

5.1 When the electrons are in position as shown in Fig. 2(b)

The force caused due to interaction between the electrons A and B, when they are in position as shown in Fig. 2(b), varies as

$$F \propto (M-e)^2\, d^{-q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where M and e are respectively the amounts of magnetism and charge of electron, d is the distance between the centers of electrons A and B, $q = a\,d^{b}$, and a and b are the constants, which depend upon the velocities of electrons A and B and on how many their lines of force interact.

Why do the constants a and b depend upon the velocities of electrons A and B? The reason is as follows: the velocity v and frequency of spin motion ω of the electron vary according to the expression [2] $m\mathrm{v}^2 = h\omega$ (where h is Planck's constant) and hence when v of electrons A and B vary, their ω also vary accordingly. When ω of electrons A and B increase, the strengths of magnetic fields, which they possess around themselves, increase.

Consequently, the strength of pushing force by the lines of force of electron A on the electron B, and similarly the strength of pushing force by the lines of force of electron B on the electron A, Figs. 2(b) and 4(b), are increased. And hence the force between the electrons A and B is also increased. This increase in force is accounted in expression (1) by variation in the constants *a* and *b*. [The increase in strength of magnetic field around the current carrying rod when the current through the rod is increased, occurs due to increase in strengths of magnetic fields around the electrons. Because, when the current increases, the velocities of electrons increase which increase their (electrons) ω. And due to increase in ω of electrons, the strengths of magnetic fields around the electrons increase, that consequently increase the strength of resultant magnetic field around the rod caused due to interaction between magnetic fields of electrons.]

Why do the constants *a* and *b* depend upon how many lines of force of electrons A and B interact? That is as follows: when the electron B lies exactly in the plane of electron A, the complete band of sets of co-centric lines of force of electron B lies exactly in front of the complete band of sets of co-centric lines of force of electron A. Therefore they all interact, and hence the force caused due to interaction between them happens to be maximum. When the electron B does not lie exactly in the plane of electron A but is shifted (forward or backward), only a part of band of sets of co-centric lines of force of electron B lies in front of a part of band of sets of co-centric lines of force of electron A. Therefore, now less number of sets of co-centric lines of force of electron B interact with less number of sets of co-centric lines of force of electron A, and hence the force caused due to interaction between them is reduced. As the shift of the electron B from the plane of electron A increases, fewer sets of co-centric lines of force of electron B lie in front of fewer sets of co-centric lines of force of electron A. Therefore fewer sets of co-centric lines of force of electron A and B interact.

Hence the force caused due to their interaction is reduced. This variation in force is accounted in the expression (1) by variation in the constants *a* and *b*.

Force F is actually the resultant of two forces F' (attractive force caused due to interaction between the magnetisms of the electrons A and B) and F'' (repulsive force caused due to interaction between the charges of the electrons A and B), i.e. ***F = F'- F"***, because electron possesses charge and magnetic field both, and hence F is generated as the consequence of interaction between their charge and magnetic field both. As d decreases, F' and F'' both increase. Consequently, after attaining a maximum value at $d = D$ (where $d = e^{-1/b}\ and > d'$), because at $d = D$, $(dF/dd) = 0$ and $(d^2F/dd^2) =$ -ve, F starts decreasing as d decreases.

5.1.1 Evidences to confirm the truth of the above force (i.e. of eqn. 1)

There is no mathematical proof to confirm the truth of the above expression (1) but evidences are from the well established existing knowledge. For example, the electron, proton, α particle beams are obtained due to component F' of force F, but due to component F", the above beams do not persist for long time.

But here some may argue, then the neutron beams should persist for indefinitely long time, while we find exactly contrary to that. The reason behind it is that the neutrons are the unstable particles and they decay into protons emitting β particles after their mean life time (about 15 minutes), and consequently, very shortly, the neutron beam is converted into a proton beam. Further, when the neutrons decay, due to the collisions of the emitted β particles (before their emission from the beam) with the rest of the neutrons of the beam, the alignments of the neutrons are destroyed and consequently the beam is destroyed. (However, the neutron beams can be made strong. But how, it shall be discussed sometimes later on because that is beyond the scope of the present paper.)

For more evidences to confirm the truth of expression (1), see section-6.2.1.

5.2 When the electrons are in position as shown in Fig. 4(b)

The force caused due to interaction between the electrons A and B, when they are in position as shown in Fig. 4(b), does not vary according to expression (1), but varies as

$$F \propto (M+e)^2 \exp(-a\,d^{\,b}) \quad \text{.....} \quad (2)$$

In this position, since the forces F' and F'' both are repulsive, the nature of variation of F with d happens to be different from expression (1).

5.2.1 Evidence to confirm the truth of above force (i.e. of eqn. 2)

There is no mathematical proof to confirm the truth of the above expression (2) too but evidence is from the well established existing knowledge, see section-(6.2.2).

6. VERY IMPORTANT AND STRIKING CONCLUSION (Determination of the actual cause of origin of nuclear force and of nuclear force)

6.1 Determination of the actual cause of origin of nuclear force

There are two types of forces, which come into play between two electrons:

1. That, which is caused due to interaction between their charges; i.e. Coulomb force,
2. That, which is caused due to interaction between their magnetic fields, i.e. the present force. This force:

(i) does not come into play between them always but comes into play only under certain conditions, e.g., when they are in position, Fig. 2(b), or in position, Fig. 4(b);

(ii) is charge independent (it since arises due to interaction between magnetic fields of electrons, obviously it happens to be charge independent);

(iii) is short-range (because it comes into play only when $d < 2r$);

(iv) is strong.

Over the claim that this force is strong, some may argue as to if this force is strong, electron beams should persist for a long time as, e.g., laser beams persist, while we do not find so. The reason (in addition to a reason mentioned in section-5.1.1) is that the velocities

of electrons in electron beams are not exactly equal and unidirectional. For persistence of any beam, these characteristics are necessary otherwise, due to collisions among the electrons, the persistence of the beam is destroyed (for detail, see reference-2).

The nuclear force, which happens to be charge independent, short-range and strong, and the nucleons possess magnetic field, should therefore be caused due to interaction between the magnetic fields of nucleons. But unfortunately, in any of the existing theories to explain nuclear force, no account of interaction between the magnetic fields of nucleons has been found. Surprisingly, we take account of interaction between the charges of protons but totally forget to take account of interaction between the magnetic fields of nucleons. Can it ever be possible that the interaction between charges of protons takes place but not between the magnetic fields of nucleons?

Most surprisingly, in Yukawa's meson field theory [3], the field of virtual π mesons is assumed in the nuclei and their continuous exchange between the nucleons is assumed as the cause of origin of nuclear force. But it gives rise to numerous such questions for which no explanation can be given. For example, how can the field of virtual π mesons, which physically do not exist, occur? How can virtual π mesons have charge, that too positive or negative? Can it practically ever be possible? If it is possible then how, can it be explained? Further, for virtual π mesons, the account of the property of possession of charge by the π mesons has been taken, but not of the property of possession mass by them, while they possess mass too. Why is this double standard? Furthermore, as far as the author's knowledge is concerned, it is believed that there exist only matter and energy in the universe and they are inter-convertible. In which category do the virtual π mesons lie? These questions raise serious concerns about Yukawa's hypothesis of a field of virtual π mesons.

Secondly, in proton beams, the protons are held together in their respective beams against the repulsive Coulomb force between them. Are they held together due to continuous

exchange of π mesons between them? If yes, then how are the electrons held together in electron beams and the alpha particles held together in alpha particle beams? If we say that the protons are not held together in their beams due to continuous exchange of π mesons between them, then how are they held together in their beams? Since the protons are held together in proton beams, there must positively be some cause behind that. What is that cause? Can that be other than the presently determined cause, i.e. the interaction between their magnetic fields?

Most importantly, due to interaction between magnetic fields of nucleons, a repulsive force too is generated, which is necessary to cause, e.g. α and β decays etc. Whereas the continuous exchange of π mesons gives rise to only attractive forces. The existing assumption that the Coulomb repulsive force between the protons provides the repulsive force in nuclei to cause e.g. α and β decays etc. cannot be true. The Coulomb repulsive force is too weak (about 100 times) and hence it cannot cause α and β decays etc. The repulsive force too should be strong, of the order of the magnitude of attractive force. The Gamow's theory [4], though explains α decay successfully assuming Coulomb repulsive force as the cause behind it, is not true. Because it is based on the explanation of phenomenon, Transmittance T = finite for particles having energy $E < V$ (where V is the barrier potential energy), explained assuming wave nature of the particles, while this phenomenon takes place due to their particle nature, not due to their wave nature (see reference-2). Secondly, Gamow's theory fails to explain β decay.

6.2 Determination of nuclear force

The equations (1) and (2) should work as the expressions for nuclear force between the two nucleons when they are found in positions as shown in Fig. 2(b) and Fig. 4(b) respectively. The evidences (see sections-6.2.1 and 6.2.2) verify their truth.

6.2.1 Evidences to confirm the truth of equation (1) as an expression for nuclear force between two nucleons

Eqn. (1) enables to give almost a complete understanding of deuteron, alpha particle and nuclei (see reference-5) which confirms the truth of equation (1) as an expression for nuclear force between two nucleons.

6.2.2 Evidences to verify the truth of eqn. (2) as an expression for nuclear force between the two nucleons

The events/phenomena of α and β decays are observed due to force of the nature expressed by equation (2) between the interacting particles (see reference-5). It confirms the truth of equation (2).

7. EVIDENCE TO CONFIRM THE TRUTH OF THE PRESENTLY DETERMINED CAUSE OF ORIGIN OF NUCLEAR FORCE AND EXPRESSIONS OF NUCLEAR FORCE

As in electron beam, the electrons are held together due to interaction between their magnetic fields and the consequently generated force of the nature expressed by eqn. (1), similarly, in proton beam and α particle beam, the protons and α particles should also be held together in their respective beams due to interaction between their magnetic fields and the consequently generated force of the nature expressed by eqn. (1). But the protons and α particles are the nuclear particles. If, due to interaction between magnetic fields and force of the nature expressed by eqn. (1), the protons and α particles can be bound together in their respective beams, similarly, due to interaction between magnetic fields and force of the nature expressed by eqn. (1), they should be bound together in nuclei too.

8. FINAL CONCLUSION

Since the interaction between magnetic fields of the interacting nucleons, as the cause of origin of nuclear force, cannot be contradicted or overruled, and the nuclear force varying

according to equations (1) and (2) together enables to give almost complete understanding of deuteron, alpha particle and nuclei (see reference-5), a final conclusion can be drawn that the presently determined cause as the origin of nuclear force, and the eqns. (1) and (2) as the expressions for nuclear force, should be true.

ACKNOWLEDGEMENT

The author is grateful to his respected teacher, Prof. Ashok Kumar Gupta, Professor of Physics (Retd.), Allahabad University, Allahabad (U.P.), INDIA, for his continuous encouragement, time to time discussion, sincere advice and help.

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FIGURE CAPTIONS

Fig. 1: (a) Spherical ball, dark solid line circle and concentric broken line circles respectively represent the charge, magnetism and magnetic field of electron. (b) Cross sectional view of electron where, in order to introduce arrow marks with the ball of charge to show the direction of its spin motion, the ball of charge has been shown by a dark thick solid line circle.

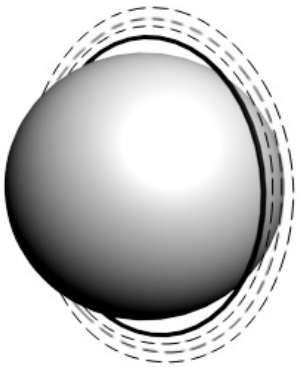
Fig. 2: (a) Transverse cross sectional view of motion of two electrons A and B lying in the same plane and at distance *d* apart while moving parallel to each other in the same direction with the same velocity v; (b) Transverse cross sectional view of interaction between their magnetic fields when the distance *d* between them is reduced to < 2r.

Fig. 3: Longitudinal cross sectional view of interaction between the earth's magnetic field and the magnetic field around a bar magnet, placed in magnetic meridian.

Fig. 4: (a) Transverse cross sectional view of motion of two electrons A and B at the instant when they are in the same plane and at distance *d* apart while moving parallel to each other with same velocity v but opposite in directions. (b) Transverse cross sectional view of interaction between their magnetic fields when the distance d between them is reduced to < 2r.

Fig. 5: (a), (b), and (c) Transverse cross sectional view of interaction between the magnetic fields of electrons lying in the same plane while moving parallel to each other in the same direction with the same velocity v.

Fig. 6: (a), (b), and (c_1) Transverse cross sectional views of magnetic fields created around the electron beams having cross sectional area of different shapes. (c_2) Longitudinal view of magnetic field created around the electron beam.



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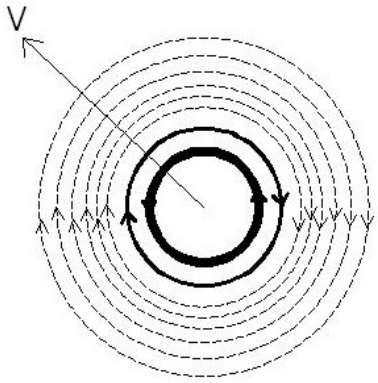

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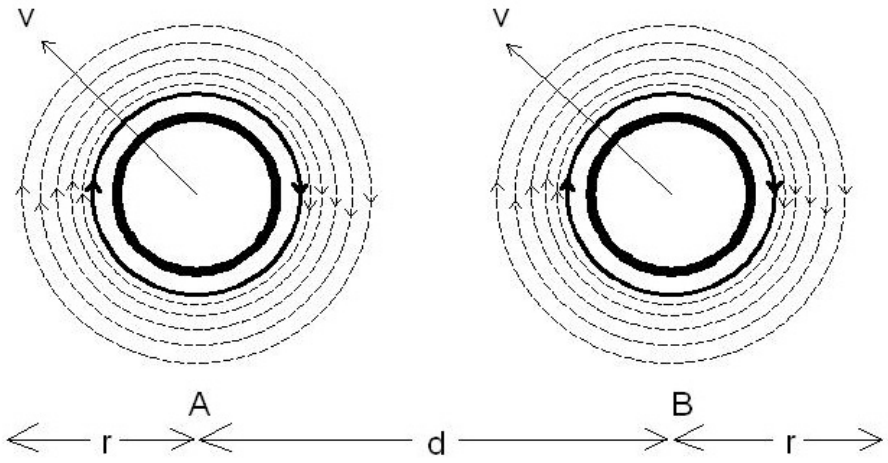
Fig. 1



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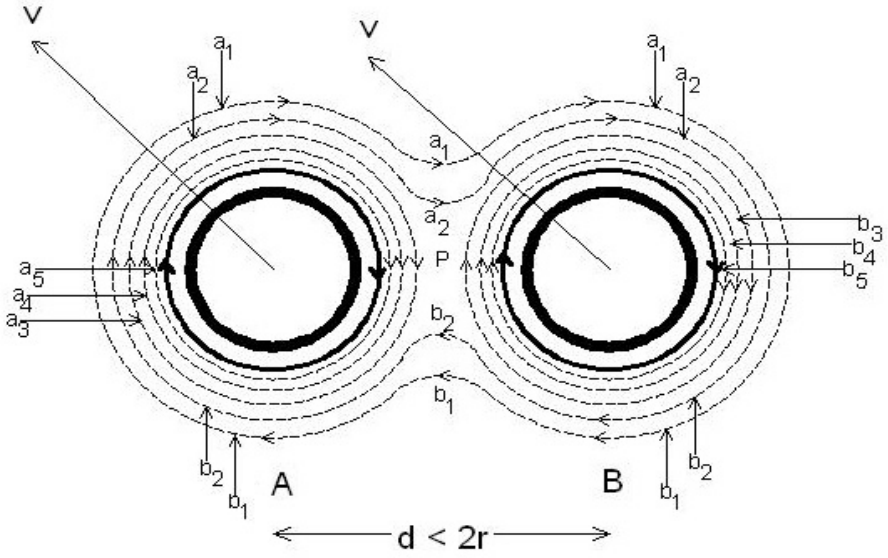

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Fig. 2

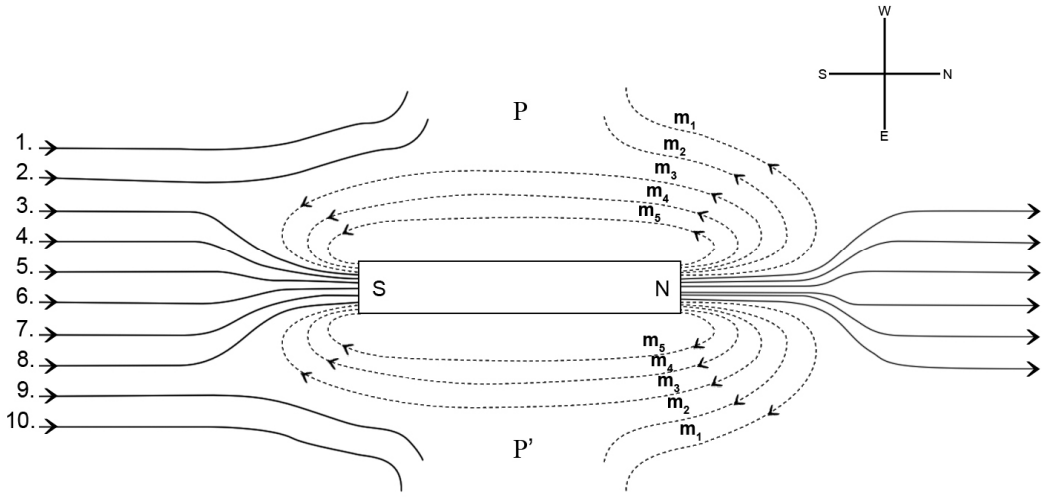
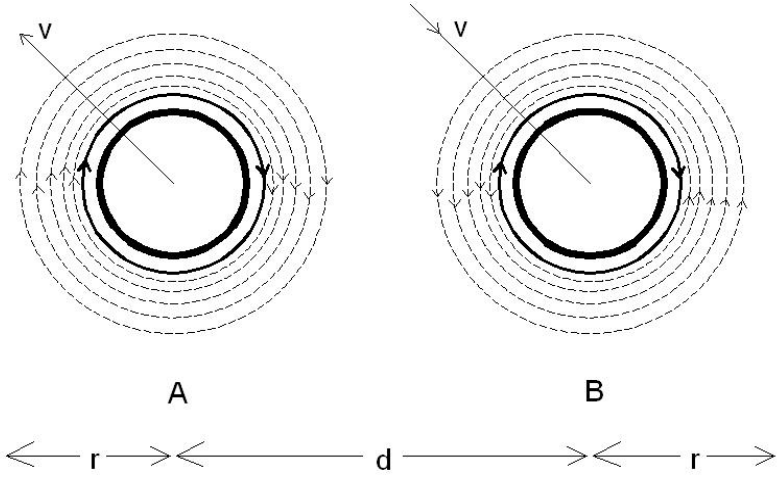


Fig. 3



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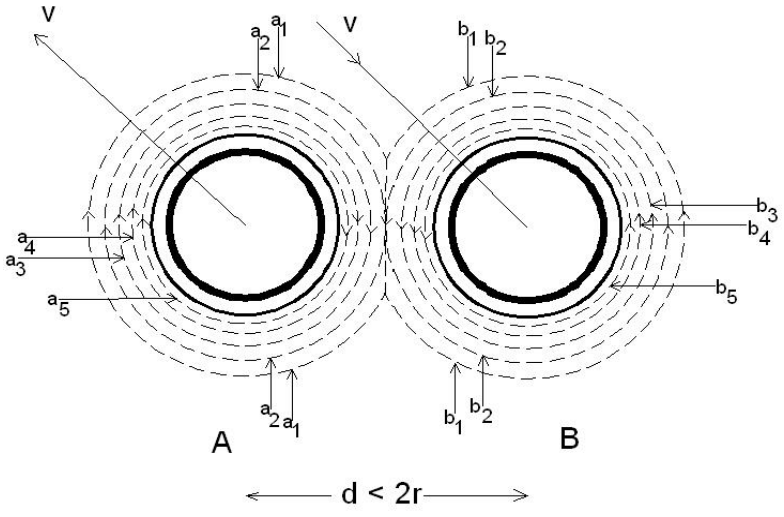
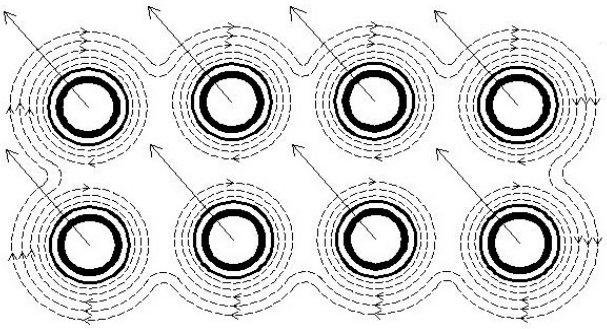
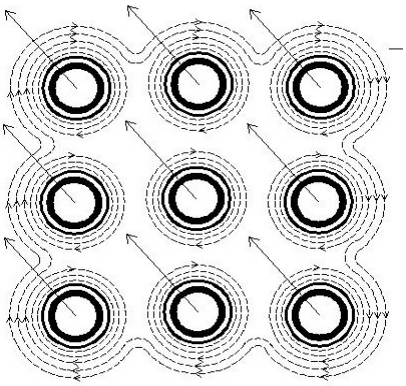


(b)

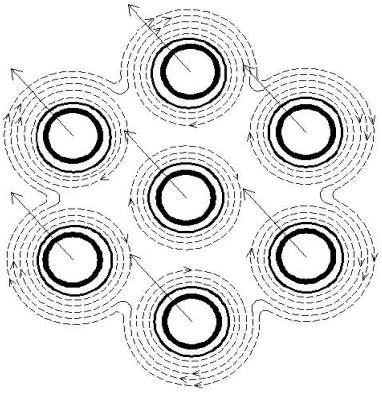
Fig. 4



(a)

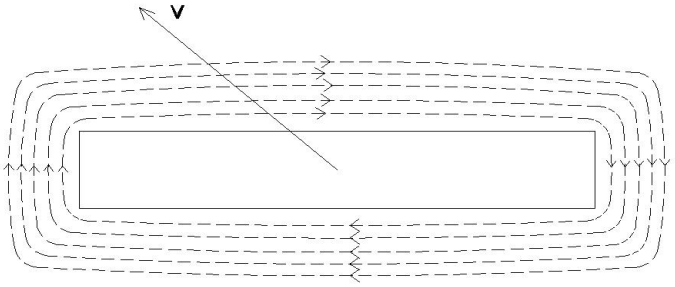


(b)

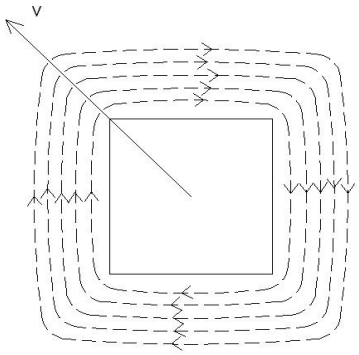


(c)

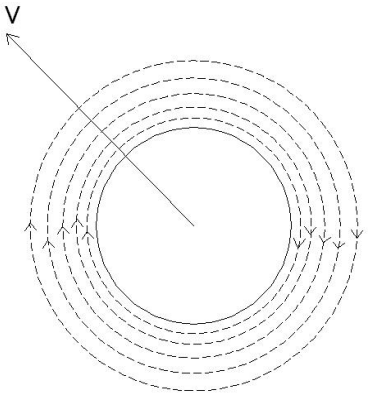
Fig. 5



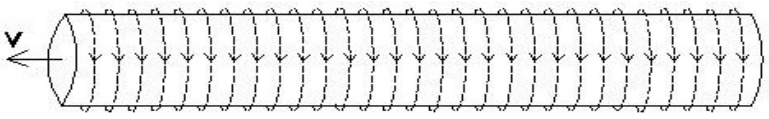
(a)



(b)



(c_1)



(c_2)

Fig. 6