Classical analysis of the electric conductivity

Hamid V. Ansari
Department of Physics, Isfahan University, Isfahan, IRAN
Personal address: No. 16, Salman-Farsi Lane, Zeinabieh Street, Isfahan, Postal Code 81986, IRAN

September 19, 2007

Abstract

Action mechanism of a conductor is presented in a simple manner. It is proven that this is not the charges themselves that are distributed in the conductor but their substitutes do this act. Also we conclude that probably the electron doesn't have a size so small compared with the dimensions of a molecule. In a discussion relating directly to the subject of surface tension we see why a net negative charge in a conductor cannot leave it.

1 Electric conductor and electron

An electric conductor must have two specifications: 1. The electron must have attachment to the positive ion which is supposed stationary. 2. This attachment must be such weak that the electron can be replaced easily by another electron of an adjacent molecule if a stronger resultant force is exerted on it.

Let's show a positive ion by ◯ and an electron by •. Schematically we can show the molecules of a conductor as the electric dipoles of Fig. 1. When two additional electrons are imposed on this conductor between the set of the molecules, as shown in Fig. 2, the electrons will open out but not uniformly and equally because the location of the positive ions are constant and anyhow each electron must be finally positioned beside a positive ion.

Thus, the imposed electron a will take the place of a', and b will take the place of b', and afterwards a' will take the place of a'', and b' will take the place of b'', and this process will be repeated until at last Fig. 3 will be obtained in which the two electrons e and e' are not the same electrons a and b in Fig. 2 but are their last substitutes. As it is seen each substitute electron has been displaced only to an extent as large as the distance between two adjacent molecules.

Thus, it is not true to think that when some net negative charge has been added to the inner region of a conductor, this is these added electrons themselves that repel each other and directly gather on the outer surface of the conductor.

Now let's, instead of adding two electrons, subtract two electrons from the middle of the set of molecules shown in Fig. 1; see Fig. 4. It's obvious that the resultant force exerted on a is leftward and the one exerted on b is rightward. Thus, Fig. 5 will be obtained.

The resultant force exerted on a' too, as it is observable in the figure, is leftward and the one exerted on b' is rightward. Thus, Fig. 6 will be obtained and this process will continue until Fig. 7 is obtained.

Here too, it is observed that neither any positive ion has been displaced nor any electron has undergone a displacement larger than the distance between two adjacent molecules.

In this manner it is seen that every net charge, negative or positive, added to a conductor will be distributed on the conductor's surface.

Degree of conductivity of an object depends on the capability that the molecule of the object has for substituting an adjacent electron for the electron of itself. If this capability is high, we shall have a good conductor, and if this capability does not exist practically, we shall almost have a good non-conductor (or dielectric). Middle states form semiconductors.

That in the above discussion we say that this is in fact the substitutes of the additional charges that are distributed on the conductor's surface does not mean at all that when necessary the valence electrons of the conductor itself have no capability to be displaced in order to take a particular configuration, but if an electric field is exerted in the conductor the electrons will move and change their distribution in such a way that the electric field inside the conductor will vanish and only the electric field normal to the conductor's surface will exist but this act occurs by distribution of the substitutes. In this respect it's better to ask ourselves why the additional charges embedded in a non-conductor don't distribute themselves towards the non-conductor's surface at least due to their repulsive forces. Naturally the answer is that the molecules of the object act as huge obstacles on the way of the electrons which intend to pass all the length of the non-conductor towards its surface directly and hinder them from passing. This is true even for conductors, ie in conductors the molecules of the conductor are obstacles to direct distribution of the electrons themselves. But if the molecules are to take part in charge distribution towards the surface, ie each of them in an active manner accept an external electron as its own member while expelling its own electron, then the distribution of charge, in such a manner causing the field to vanish inside the conductor and to be normal on the conductor's surface, will take place easily and rapidly.

That the electrons added to the inside of a non-conductor are not able

to distribute themselves onto the non-conductor's surface states another fact too: It seems that the size (not necessarily the mass) of electron is not so small compared with the interatomic spacing. If the size of the electrons were so small in comparison with the interatomic spacings, they would easily be able to distribute themselves onto the non-conductor's surface through the spacings between the molecules of the object. But it seems that the electrons are such voluminous that the molecules, or in fact the adjacency of the molecules, can hinder their direct distribution or movement.

Point:

We studied the mechanism of distribution of the charges added to a conductor onto its surface. Here we present a general indication confirming that the added charges must be distributed onto the outer surface of the conductor: Similar charges must go far from each other as distant as possible and if they are to be distributed on a surface this surface must be the widest surface possible for distribution. But because of the limitation we have on the shape of the conductor the distance and area cannot be maximum simultaneously and then their product, ie the volume containing the surface of distribution, must be maximum, and it is natural that such a surface is outer surface of the conductor which contains the maximum volume available.

2 Why electric charge cannot leave conductor

Let's consider matter as set of electric dipoles. One pole of each of these dipoles is electron. Electron has a volume comparable with the volume of the positive pole (at least at present think so) but its mass is very much less than the mass of the (proton) positive pole. Assume a fixed temperature. In this temperature the above-mentioned dipoles related to a matter, or its so-called molecules, due to positive-negative attraction of the dipoles can be fitted with each other in such a way that the center of mass of each molecule remains nearly fixed. We call such a matter as solid. Since anyway there exists some temperature, we must consider a dynamic state for the molecules, ie we must accept that the molecules, and chiefly the negative poles of them (due to their lightness), have tremor and slight movements in their own seats. If our matter is conductor (notice the definition of conductivity in the previous section), in an immediate interchange with adjacent molecules the electron of each molecule can be being replaced by another electron of an adjacent molecule while is replacing the electron of another adjacent molecule. This means that there are always some random closed electric currents inside a conductor dynamically.

As we said each dipole of the matter is under the influence of the

related electrical attractions of all the molecules immediately adjacent to it, and then if this dipole or molecule is inside the matter, resultant of forces exerted on it, arising from all the surrounding molecules, which are immediately adjacent to it, is zero on average. But if the molecule is on the surface of body (of our matter), it will feel only a resultant attraction toward the inside of the matter exerted on itself arising from the attractive forces of the molecules of the body exerted on it (ie simply its negative pole is attracted by the positive poles adjacent to it in the matter and its positive pole is attracted by the negative poles adjacent to it in the matter, and similar poles are not, in principle, positioned adjacent to each other in formation of the matter (which requires attraction not repulsion)); see the 7th paper of this book which has a detailed discussion about surface or depth tension. Thus, depth tension (or what at present is called as surface tension wrongly) is present in solids or even, somehow, in gases in addition to liquids.

Now consider a conductor. Imagine that only a single electron has been injected into this conductor. Considering the above-mentioned random closed electric currents and that the electrons of the different molecules are replaced by each other dynamically we can say that each time, this single electron will be seen in a random place in the conductor, but this doesn't mean that this electron itself will undergo the displacements between the points it is seen each time but its substitutes will be in these points in different times (see the previous section). But if we inject more than one electron into the conductor, the repulsion between additional electrons (which are these electrons themselves or their substitutes) and existence of the above-mentioned dynamic state will necessitate immediate distribution of the substitutes of these additional electrons onto the outer surface of the conductor.

As we said the positive pole is very much heavier than the negative pole (but not larger). In a dynamic state this means that in a solid the center of mass of the positive pole remains almost stationary but the center of mass of the negative pole will change its position regularly around the positive pole esp considering the above-mentioned dynamic state. When the above-mentioned additional electrons are distributed on the surface of the conductor the molecules (or dipoles) of the conductor's surface will undergo local shift in the position of their negative or electron pole around the positive pole in such a manner that the additional electrons on the surface feel the attraction exerted on them by the positive poles of the surface molecules. The possibility of such a local shift of the electrons of the surface molecules is also provided by the repulsion of these additional electrons. In simple words if we suppose that Fig. 8 is an uncharged conductor, Fig. 9 will be the same conductor having two additional electrons distributed on the conductor's surface before the above-mentioned local electron shift, and Fig. 10 will be the same one after this shift and getting a stable state for the additional electrons (on the conductor's surface) being under the influence of the attraction of the near heavy nuclei while the repulsion of the far light electrons being less on them.

Then, in other words, the additional electrons, distributed on the surface, due to the depth tension of (or resultant attraction exerted by) the adjacent molecules of the conductor cannot leave the conductor, and this (which can be interpreted as depth (or (wrongly) as surface) tension) is the reason that why the net negative charge or the additional electrons distributed on the outer surface of the conductor cannot escape from the conductor. Also, without any need to be explained more, the above discussions clarifies this fact perfectly that why a net positive charge distributed on the conductor's surface cannot leave the conductor.

Fig. 1

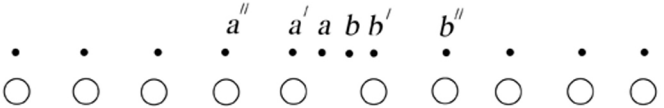

Fig. 2

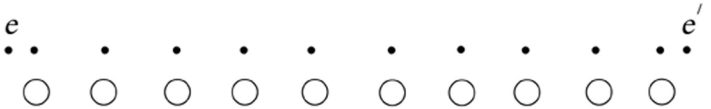

Fig. 3

Fig. 4

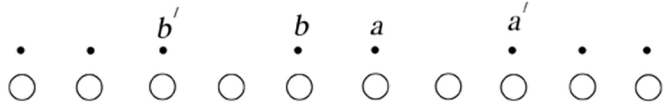

Fig. 5

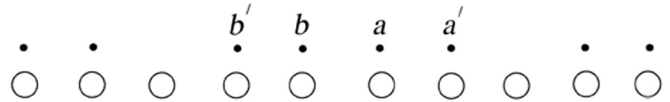

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10