# The Nature and Principle of Charge Interaction and Coulomb's Law

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What is "electronic charge"? Why there are two kinds of charges? Why do the same charges repel, and dissimilar charges attract each other? Why does their behavior agree with Coulomb's Law? These are among the most basic questions of physics. Let us assume the existence of a kind of microparticle in the universe, which we can call an electon for our purposes here. Three situations are possible: if an object contains a surplus of electons, it will be positively charged; if a deficit of electons, it will be negatively charged; if an object contains electons equal to its expected value, in the saturated state, it is neutral. The charged objects, containing these electons, have the ability to exchange charged or uncharged microparticles in order to achieve a neutral state. The acting force between two charged objects comes from the exchange of charged and uncharged microparticles. The same charges repel, and dissimilar charges attract each other. The value of force is consistent with Coulomb's Law. The material between two charged objects affects the value of the acting force between them, but does not affect the direction.

**Keywords:** charge, nature, positive, negative, attract, repel, Coulomb's Law

## 1. Introduction

Long ago, humans observed the phenomenon of electricity, and recognized that there are only three options: positive, negative and neutral. A particle is considered to have a charge if it carries either positive or negative electricity. The same charges repel and dissimilar charges attract each other. The quantity of electricity in charge is called charge quantity. In 1785, Coulomb (CA Coulomb, 1736-1806) derived Coulomb's Law of electrostatic interaction through torsion balance experiments [1]. Since then the study of electromagnetic phenomena has entered the era of quantitative research. As early as 1774, British physicist Cavendish (H. Cavandish, 1731-1810) discovered a law which was more accurate [2], but unfortunately the result has not been recognized. Many people tested the accuracy of Coulomb's Law [3-8]. However, what really is charge? Why are there two kinds of charges? Why do the same charges repel each other and dissimilar charges attract each other? Why does it comply with Coulomb's Law? These questions are what people want to solve, but actually seldom discuss [9-10], and so far have not resolved.

In this paper, first, the nature of the charge is discussed, and then the charge interaction principle and Coulomb's Law are researched.

## 2. Electric Phenomena and Charge

What on earth is electricity? Let us assume there is a kind of microparticle in the universe, tentatively called an electon, which is considered as a magnetic energy in literature [10]. If an object contains more electons than expected, it is in a surplus state, and positively charged; if an object contains fewer electons than expected, it is in a scant state, and negatively charged; if an object contains electons equal to its expected value, it is in a saturated state, and is neutral.

Objects with positive charges in space releases surplus electons to the outside world, so the quantity of positive charges is decreasing gradually. Objects with negative charges in space absorbs electons from the outside world, so the quantity of negative charge is decreasing.

## 3. Interaction between Charges

### 3.1. A Single Charge

Objects which are positively charged, having surplus electons, will emit electons to the outside world. These objects then absorb micro-particles which electons lack or neutral micro-particles in order to achieve basic balance of mass. Because the emission and absorption of micro-particles in the space is in the spherically symmetric state, the resultant force is zero.

Objects which are negatively charged, will absorb electons from the outside world. These objects are able to absorb the electons by releasing micro-particles which the electons lack. This again achieves a basic balance of mass. Because the emission and absorption of micro-particles in space is in a spherically symmetric state, the resultant force is also zero.

### 3.2. A Positive Charge and a Negative Charge

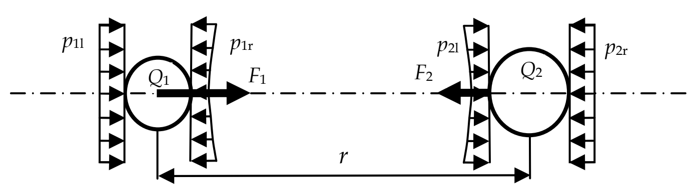


**Fig. 1** Heterogeneous charges making two objects attract each other

Two objects ~~as~~ are shown in Figure 1, whose charge quantities are respectively $Q_1$ and $Q_2$. $Q_1$ is positive electricity, $Q_2$ is negative electricity, and the distance between the centers of them is $r$. Apart from the direction of the two attracting objects, the two other directions vertical to the connection will be self-balancing, because there is no interference by other objects and charges. For this reason, the force only exists between the two objects.

For convenience, the mass of a micro-particle of surplus electons is $m_e + \delta$, and its positive charge number is 1; the mass of a micro-particle of scarce electons is $m_e - \delta$, and its negative charge number is 1; the mass of a saturated micro-particle is $m_e$ with charge number 0. We can then assume $\delta << m_e$, the mass of any micro-particle of the three types is $m_e$; at the same time, assume that their velocities are $v$.

Firstly, consider the object with positive charge $Q_1$ on the left. Assume that it exchanges its positive charges at an amount of $M_1$ to the left and right at the same time. At the left side of the object $Q_1$, in order to maintain the mass of the object after exchanging $M_1$ positive charges, the object has to absorb $N_{1l}$ micro-particles with negative charge and $Z_{1l}$ natural micro-particles, and release $P_{1l}$ micro-particles with positive charge. It meets

$$\left.\begin{aligned} N_{1l} + Z_{1l} = P_{1l} \\ P_{1l} + 2N_{1l} = M_1 \end{aligned}\right\} \tag{1}$$

The momentum acting on the left side of the object having positive charge $Q_1$ is $p_{1l} = (Z_{1l} + N_{1l} + P_{1l}) m_e v$.

On the right side of the object $Q_1$, in order to maintain the mass of the object after exchanging $M_1$ positive charges, the object has to absorb $N_{1r}$ micro-particles with negative charge and $Z_{1r}$ natural micro-particles, and release $P_{1r}$ micro-particles with positive charge

$$\left.\begin{aligned} N_{1r} + Z_{1r} = P_{1r} \\ P_{1r} + 2N_{1r} = M_1 \end{aligned}\right\} \tag{2}$$

The momentum acting on the right side of the object having positive charge $Q_1$ is $p_{1r} = (Z_{1r} + N_{1r} + P_{1r}) m_e v$. The force toward right of the object with positive charge $Q_1$ is

$$\begin{aligned} F_1 &= (Z_{1l} + N_{1l} + P_{1l}) m_e v - (Z_{1r} + N_{1r} + P_{1r}) m_e v \\ &= 4(N_{1r} - N_{1l}) m_e v \end{aligned} \tag{3}$$

There is a negative charge $Q_2$ providing micro-particles with negative electricity on the right, while not on the left. Therefore, since $N_{1r} > N_{1l}$ and $F_1 > 0$, this is the source of attraction. The larger the positive charge $Q_1$, the greater $N_{1l}$ and $N_{1r}$; the larger the negative charge $Q_2$, the greater $N_{1r}$; the further the distance, the smaller $N_{1r}$. This is the qualitative description of the source and the preliminary law of the attraction between opposite charges. The actual interaction is more complex.

Coulomb's Law proves $N_{1r} - N_{1l} \propto \frac{Q_1 Q_2}{r^2}$, so (3) is rewritten

$$F_1 \propto \frac{Q_1 Q_2}{r^2} m_e v \tag{4}$$

Introduce coefficient $k$, then (4) is rewritten

$$F_1 = k\frac{Q_1 Q_2}{r^2} \tag{5}$$

It is Coulomb's Law, where $k$ is the Coulomb constant in physics.

Analysis of the object with negative charge $Q_2$ on the right may get a result

$$F_2 = k\frac{Q_1 Q_2}{r^2} \tag{6}$$

Visible $F_1 = F_2$, expressed by the formula

$$F = k\frac{Q_1 Q_2}{r^2} \tag{7}$$

### 3.3. Between Two Positive Charges

If the two objects in Figure 1 are positively charged, $N_{2l}$ is the number of micro-particles with positive electricity that are absorbed by the left side of $Q_1$; $N_{2r}$ is the number of micro-particles with positive electricity that are absorbed by the right side of $Q_1$; the force, toward left, acting on the object with the positive charge $Q_1$, is

$$F_1' = 4(N_{2r} - N_{2l}) m_e v \tag{8}$$

The repulsive force between two charges is still calculated by formula (7).

### 3.4. Between Two Negative Charges

If the two objects in Figure 1 are both negatively charged, $N_{3l}$ is the number of micro-particles with negative electricity that absorbed by the left side of $Q_1$, and $N_{3r}$ is the number of micro-particles with negative electricity that absorbed by the right side of $Q_1$, then the force, toward left, acting on the object with the positive charge $Q_1$, is

$$F_1'' = 4(N_{3r} - N_{3l}) m_e v \tag{9}$$

The repulsive force between two charges is still calculated by formula (7).

### 3.5. Influence of Medium between the Two Charges

If something is inserted between two charged objects, which hinders charged micro-particles from passing between two objects, then the acting force between two objects decreases; if this substance contributes to the passage of charged micro-particles between two charged objects, then the acting force between two objects increases.

## 4. Conclusion

1. If an object contains a surplus of electons, it will be positively charged; if a deficit of electons, it will be negatively charged; if an object contains electons equal to its expected value, it is neutral.
2. The charged objects have the ability to exchange charged or uncharged micro-particles in order to achieve a neutral state. The sum of external forces on single charged object in uniform space is zero.
3. The force between two charged objects is due to the exchange of charged and uncharged micro particles. The same charges repel, and dissimilar charges attract each other. The value of force is in conformity with Coulomb's Law.

4. Any material between two charged objects affects the value of the force between them, but does not affect the direction of the force.

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