A revisit to macroscopic collision theory owing to the electromagnetic radiation by contacting two objects

Xia Cao *

School of Chemistry and Biological Engineering, University of Science and Technology Beijing, Beijing, 100083, China

Beijing Institute of Nanoenergy and Nanosystems, Chinese Academy of Sciences, Beijing, 100083, China

*Corresponding Author: E-mail: caoxia@ustb.edu.cn

Abstract

Can you imagine that when you knock hard on a door with your hands, 1350 LED lights can be lit up, even the stripe lights will be driven？ Science and technologies are all constantly being developed and improved in practice. Any scientific theory is not ultimate and absolutely precise so that no revision is needed. In this paper, we studied the traditional macroscopic collision theory based on the latest research findings: electromagnetic field is generated when two objects collide with each other. Three types of collision phenomena: elastic collision, inelastic collision, and ideal inelastic collision were investigated in detail. We found that electromagnetic field was produced during all three types of collisions, which means mechanical energy is converted into electromagnetic energy during any collision process of two objects. Under the same condition, the quantity of electric energy produced by elastic collision is greater than that of inelastic collision, and greater than that of ideal inelastic collision. Different from the change of mechanical energy into internal energy in the process of collision, the change of mechanical energy into electromagnetic energy in the process of collision will directly affect the law of conservation of momentum in the whole collision system. Thus, the collision theory of macroscopic objects needs slightly modified. The electric power generated in collision can not only be used for lighting, but also it can be used for positioning and tracking. This is completely new discoveries, which will provide new explanations and new ideas and will have a profound and an inestimable impact on some related

scientific research fields, including physics and new energy.

Key words

Collision theory; electromagnetic field; electromagnetic energy; momentum conservation; mechanical energy

1. Introduction

Collison is a very short interaction between two particles or objects.[1-3] The momentum of the whole collision process is conserved. According to the difference of energy transfer, collision can be divided into elastic collision, inelastic collision and ideal inelastic collision.[4] The so-called elastic collision refers to that the mechanical energy of the whole collision system is not converted into internal energy in the collision process.[5, 6], which means there is no mechanical energy loss, and kinetic energy of the whole collision system is conserved in the collision process. The so-called ideal inelastic collision refers to that the collision objects bind together with the same speed after collision.[7-9] The mechanical energy in the collision system lost the most, and the loss of kinetic energy is all converted into the internal energy of the system. Inelastic collision is a collision between elastic collision and ideal inelastic collision. Inelastic collision refers to a collision system in which part of kinetic energy is converted into internal energy in the process of collision.[10-13] And there is a loss of mechanical energy in the process of collision. Kinetic energy is not conserved. In a word, the traditional macroscopic collision theory holds that the momentum of collision system is conserved before and after any collision process. The mechanical energy of the collision system may or may not conserved.

Everything we know about science is the updated understanding of human to nature phenomenon up to now. No principle is absolutely fixed that it can be permanent and segregated from external variation. What we have already known are the principles and laws that have been established based on our current understanding. These ideas and principles might explain the phenomenon that we have observed, via

which they make new and verifiable predictions. However, that does not guarantee their absolute correctness, because scientists are advancing with new data and discoveries.

Recently, we found that electromagnetic field can be generated when two objects collide with each other, which are believed to have triboelectrification charges on their surfaces. Based on this discovery, we studied three types of collisions: elastic collision, inelastic collision and ideal inelastic collision. The experimental results show that electromagnetic field is generated in all three types of collision processes as we have expected. In other words, there is always a part of mechanical energy in the whole collision system being converted into electromagnetic energy in any kinds of collision processes. Different from the change of mechanical energy into internal energy, the conversion of mechanical energy into electromagnetic energy needs to be included in the conservation of momentum. On this basis, we revised the traditional macroscopic collision theory. At the same time, according to the phenomenon of electromagnetic field generated in the collision process, we designed a power generation system, positioning system and path tracking system. And the potential applications in the fields of scientific research fields, including physics and new energy was discussed.

2. Results and discussions

Let's first confirm that there is an electromagnetic field after the collision of two objects. Hit the wooden door with your hand, and see if there is an electromagnetic field generated. Figure 1a-b shows the working principle of the device and the photo of the experimental setup for investigating the releasing of electromagnetic energy by collision. Knock one side of the door and put the LED light board and strip light on the other side of the door to collect the generated electromagnetic energy. As shown in Figure 1c-f, electromagnetic field will be generated when the door is knocked hard, and 1350 LEDs were driven wirelessly. More amazingly, the strip lights can be lit up

wirelessly too, which directly reflects how strong the as generated electromagnetic field can be. Because of the difference between camera frequency and light flash frequency, it is difficult for us to capture the moment that all LEDs and strip lights are lit up simultaneously. More shining results can be seen in the video (Supporting Information, Video 1). Surprisingly, Figure 1g-j show that the book can be gradually illuminated by the LED lights, which demonstrates highly efficient capability of power generation. Such a simple method can be used for everyday lighting. In order to study the magnitude of electromagnetic energy quantitatively, the electrical signals of the device were detected. Figure 1k-l show the as generated voltage can reach up to 3108 V, and the as generated current can be up to 57 μA when we knock hard on the door. A preliminary conclusion could be achieved that there is electromagnetic energy released from the collision when two substances collide with each other.

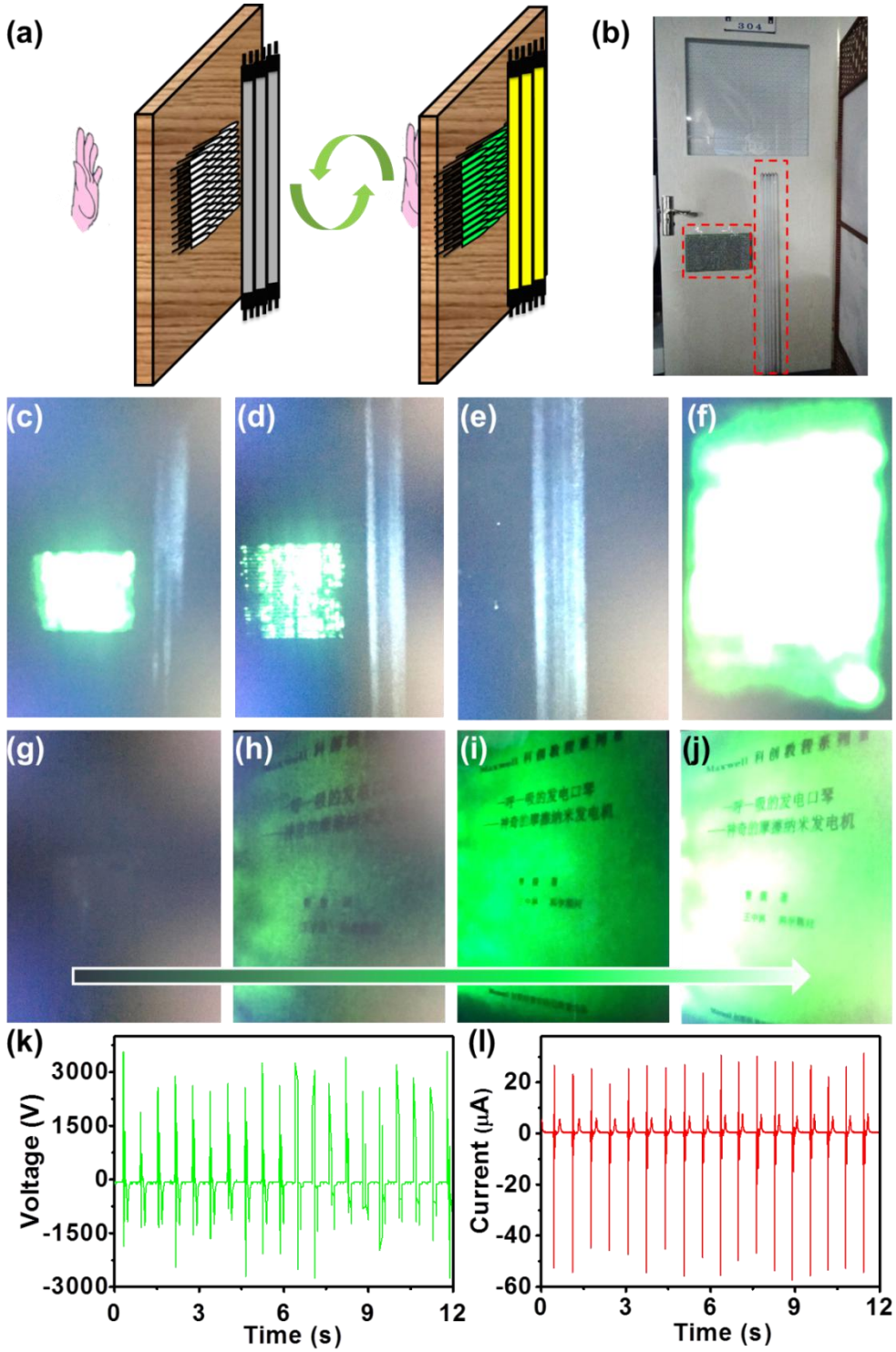

Figure 1. (a) Experimental setup and working principle of the device; (b) Photo of the experimental setup; (c-f) The LED light board and strip light were driven by knocking the wood door; (g-j) Books illuminated by the lights; (k) The voltage of the device knocked by hand; (l) The current of the device knocked by a hand.

In order to prove that any type of collisions will produce an electromagnetic field, three different types of collisions have been investigated here. An elastic collision is an encounter between two bodies in which the total kinetic energy of the two bodies after the encounter is equal to their total kinetic energy before the encounter. The collision of Newton's cradle can be approximately considered as elastic collision. Thus, we choose Newton's cradle to study if there is electromagnetic field in the elastic collision process. Figure 2a showed the experimental setup and working principle of the elastic collision device When the ball on the right side was pulled horizontally and let it go, it would drop down and collide with the static ball on the left. Then the right ball stopped. The left-hand ball was bounced to a certain height then dropped and collide with the right-hand ball. The two balls constantly collided with each other until they all stopped. The left-hand ball was connected to the electrometer to detect the signals. Figure 2b showed the photo of the elastic collision setup and the real time signal change curve. As shown in Figure 2c-d, the electromagnetic field was produced continuously when the balls collide with each other until the collision stopped. Both the voltage and current decreased with the decreasing of collision force. The maximum voltage and the maximum current can reach 10 V and 160 nA, respectively. We also studied the influence of materials on the strength of the electromagnetic field produced by elastic collision. As shown in Figure 2e-f, both the voltage and current generated by the glass ball are lower than those of generated by the metal ball in the same design. The quantity of electromagnetic field produced by elastic collision is related to the materials of the objects.

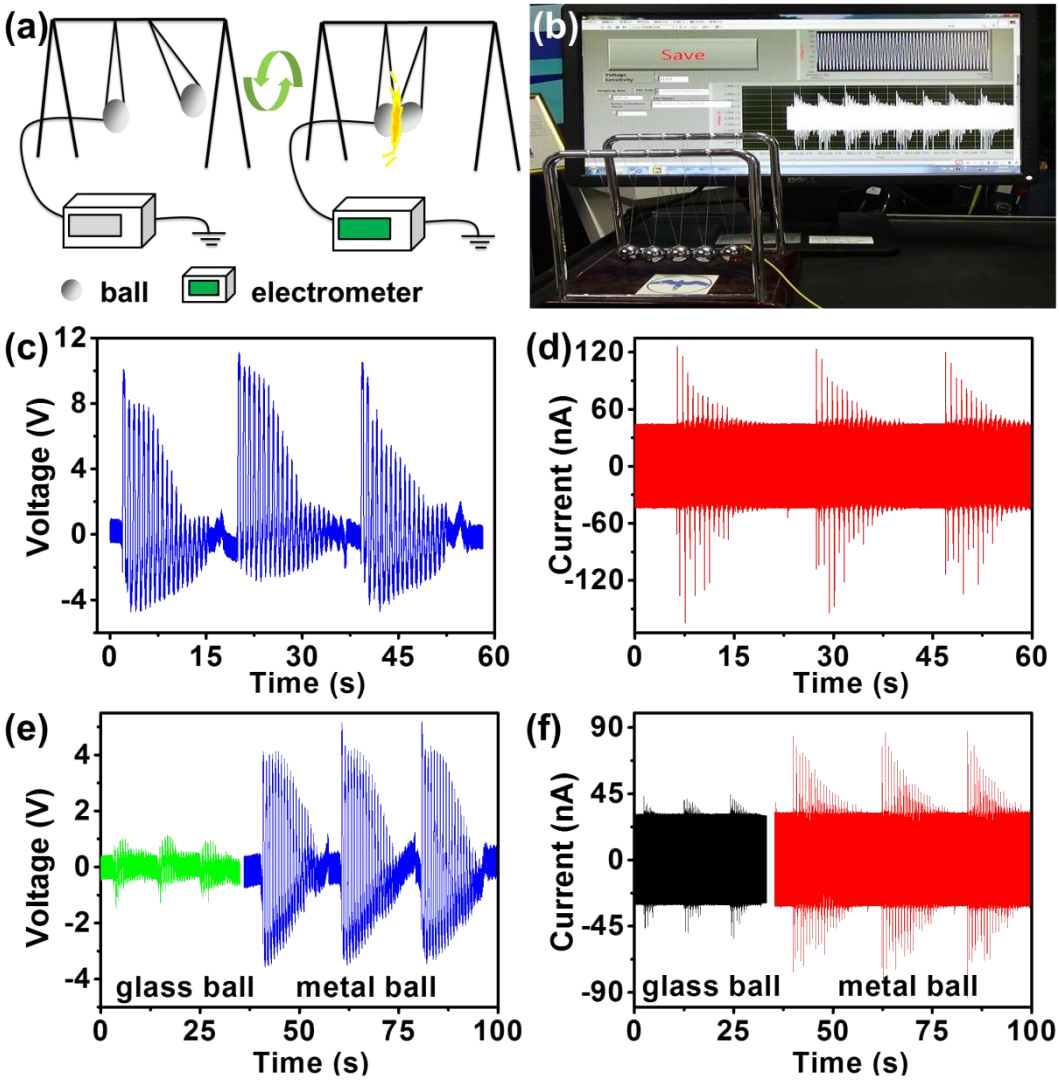

Figure 2. (a) The experimental setup and working principle of the elastic collision device; (b) Photo of the elastic collision setup; (c) The voltage generated by the elastic collision of metal balls; (d) The current generated by the elastic collision of metal balls; (e) Comparison of the voltage generated by elastic collision between glass ball and metal ball; (f) Comparison of the current generated by elastic collision between glass ball and metal ball.

Elastic collisions occur only if there is no net conversion of kinetic energy into other forms. It is an ideal state. Most collisions process in our life are inelastic. Figure 3a show the experimental setup and working principle of the elastic collision device. Figure 3a-b shows the schematic diagram of the experimental setup and the photo of

the device. We put the elastic ball in the acrylic ball shell and shake the acrylic ball to make it collide with the elastic ball, which is easy to be deformed, so the collision process between the elastic ball and acrylic shell is inelastic. As shown in Figure 3c-d, the electromagnetic field is also generated when the elastic ball collides with the acrylic ball. The maximum voltage of the device can reach up to 120 V and the maximum current of the device can reach up to 3 μA, respectively. What's more amazing is that the electromagnetic field generated by the collision between the elastic ball and the acrylic ball shell can drive the LEDs, showed by Figure 3e. When acrylic ball is shaken intensively, the elastic ball will collide with the acrylic shell, which leads to the generation of the electromagnetic field. And when the ball passes over the light board, the LEDs lights will be driven wirelessly. This principle has a good application prospective in power generation, locating, and path tracking.

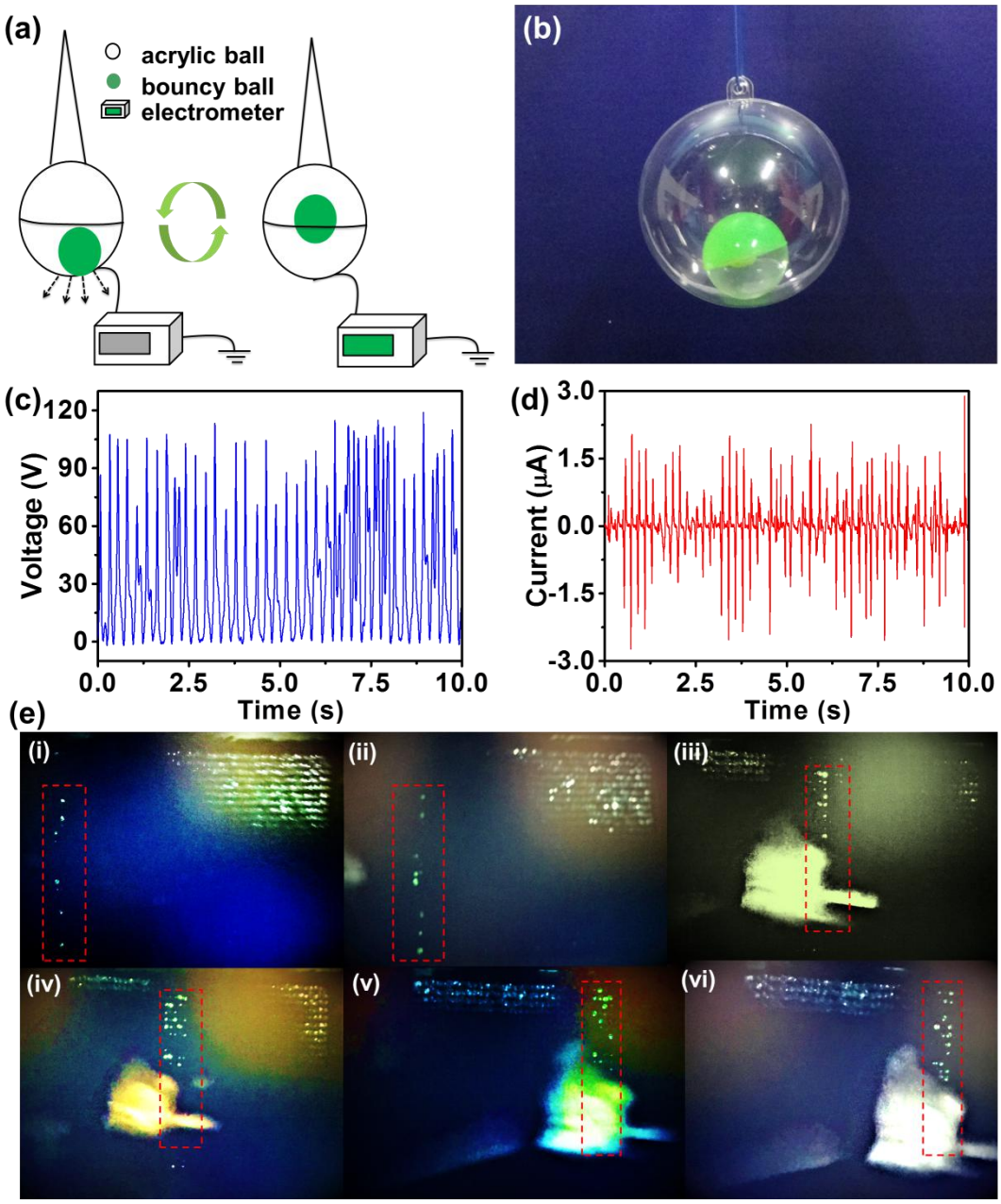

Figure 3. (a) Schematic diagram of the experimental setup; (b) The photo of acrylic ball and elastic ball; (c) The voltage of the inelastic collision; (d) The current of the inelastic collision; (e) The light board driven by the ball wirelessly. Photos i-vi show the position of the light varies with the movement of the ball.

Besides, we studied the electromagnetic field produced by the ideal inelastic collision. The experimental device is shown in Figure 4a. We used the dough ball to hit the dough mud. The dough ball remains perfectly still after hitting the dough mud,

so the collision between the dough ball and the dough mud is a ideal inelastic collision. As shown in Figure 4b-c, it can be seen that there was also electromagnetic field generated when the dough ball hit the dough mud. The voltage and current can reach 12 V and 28 nA, respectively.

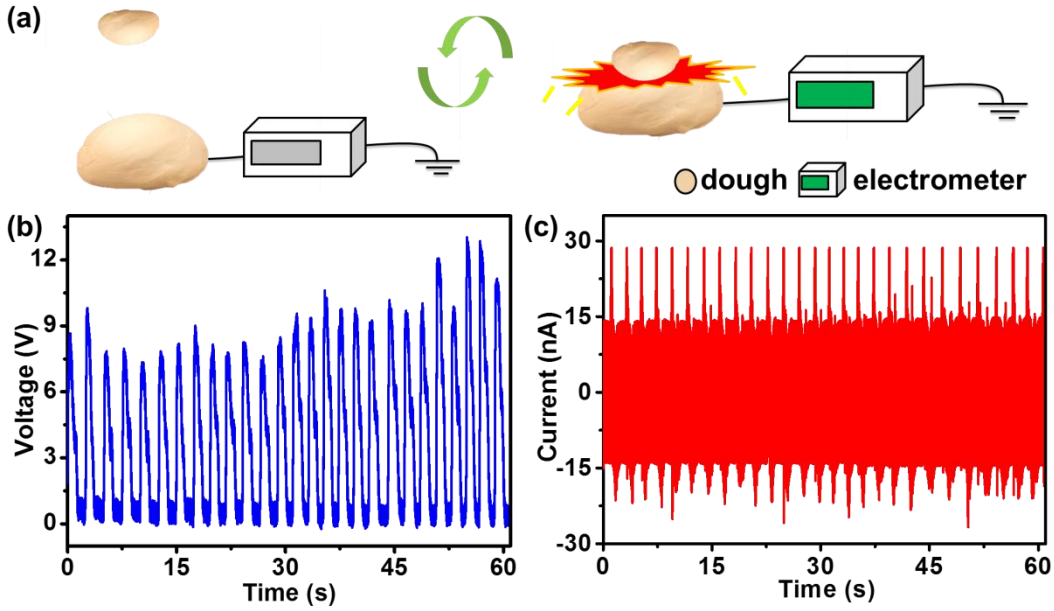

Figure 4. (a) Schematic diagram of the experimental setup for the ideal inelastic collision; (b) The voltage of the ideal inelastic collision of dough; (c) The current of the ideal inelastic collision of the dough.

Next, we compared the magnitude of the electromagnetic fields generated by the three types of collisions. We used the same ball of Newton's cradle to verify the directional comparison of the electromagnetic energy generated by the three collision processes. The experimental devices are shown in Figure 5a-c. A copper foil was pasted on the surface of the ball and the impacted object to keep the same conditions. Another ball was pulled and released at the same horizontal height, the ball covered with copper foil, the ball covered with dough and copper foil, and the ball covered with the dough mud and copper foil were impacted, respectively. As shown in Figure 5d-e, both the instantaneous currents and voltages generated in three situations from large to small are elastic collision, inelastic collision and ideal inelastic collision.

Therefore, when the same objects collide at the same external force at the same speed, the electromagnetic fields generated from large to small are elastic collision, inelastic collision and ideal inelastic collision.

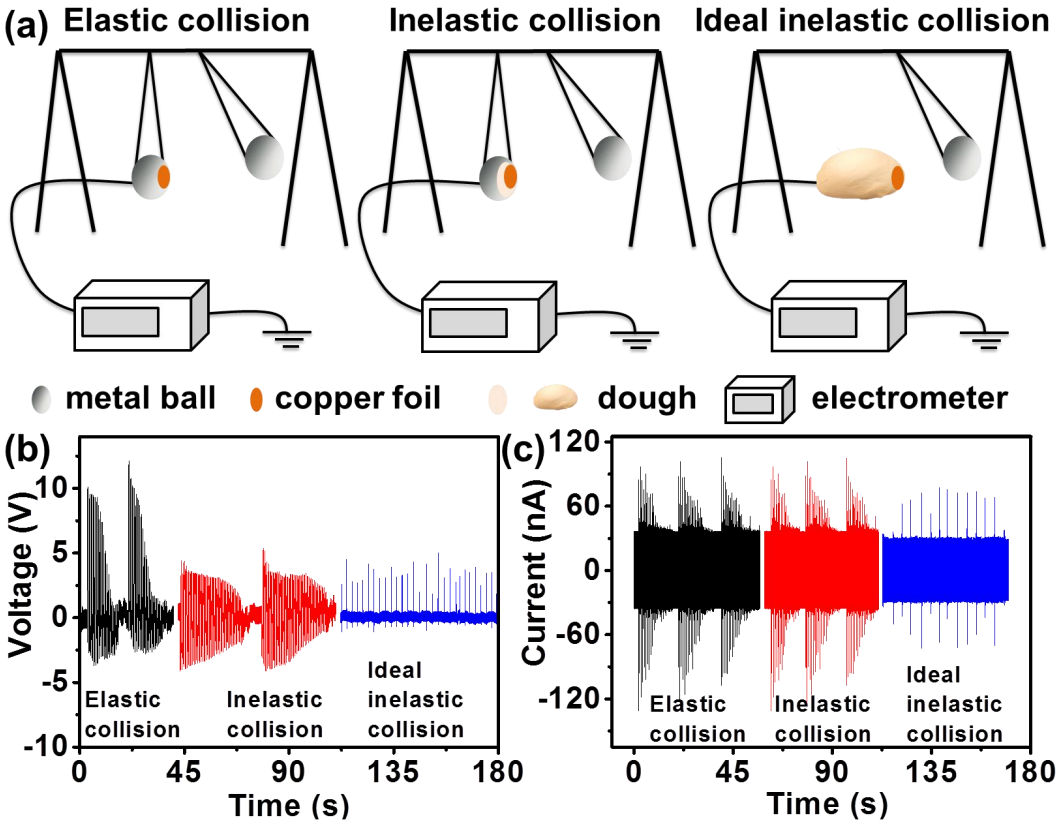

Figure 5. (a) The experimental setup for comparison of the elastic collision, inelastic collision and ideal inelastic collision; (b) The voltage of three types of collision; (c) The current of three types of collision.

The above results show that electromagnetic field can be generated during a collision. The reason for the electromagnetic radiation is possibly due to the objects were charged owing to triboelectrification effect on surfaces. However, the traditional macroscopic collision theory does not consider the generation and existence of electromagnetic fields in the process. So we make the following improvements. According to the characteristics of energy conversion in the collision process, the collision process of macro objects can be divided into three types. The first one is elastic collision that the electromagnetic energy generated by collision is the largest. If we ignore the loss of mechanical energy converted into electromagnetic energy in the

collision process, the momentum and kinetic energy of the system are conserved before and after the collision. The second case is inelastic collision that the electromagnetic energy generated by collision takes the second place, because part of mechanical energy is converted into acoustic energy, electromagnetic energy and internal energy. If we ignore the loss of mechanical energy converted into electromagnetic energy in the collision process, the momentum of the system before and after the collision is conserved, but the kinetic energy is not conserved. The third is the ideal inelastic collision that the electromagnetic energy generated by collision process is the smallest. The kinetic energy loss is completely converted into electromagnetic energy and internal deformation energy.

3. Conclusions

In conclusions, we find that electromagnetic field is generated in the collision process of two objects, which makes a minor revision to the classical macroscopic collision theory. According to the classical macroscopic collision theory, the conservation of momentum holds in all three collision processes. For elastic collision: the momentum of collision system is conserved, but the mechanical energy is not converted into internal energy, and there is no kinetic energy loss. For inelastic collision, momentum of collision system is conserved, mechanical energy is partially converted into internal energy, and kinetic energy of the collision system is not conserved. For an ideal inelastic collision, momentum of collision system is conserved, and kinetic energy of the system is lost significantly, and the loss of the kinetic energy is completely converted into internal energy.

Based on our new findings and experimental results, we have improved the traditional macroscopic collision theory as follows: electromagnetic field is generated in any collision process. And the momentum of the collision system is not exactly conserved, and mechanical energy is not conserved as well. The order of how much mechanical energy converts into electromagnetic energy in three collision processes is: elastic collision is greater than inelastic collision and greater than ideal inelastic

collision. The so-called elastic collision is to ignore the electromagnetic energy generated in the collision process, and the momentum of the collision system is conserved, and so is mechanical energy. The so-called inelastic collision is that part of the mechanical energy of the collision system is converted into electromagnetic energy and internal energy in the collision process, and the momentum and mechanical energy of the collision system are not conserved. The ideal inelastic collision means that the collision objects are combined together after the collision, and the loss of kinetic energy is the largest, and the loss of mechanical energy converted into electromagnetic energy is the smallest component. We anticipate that our results will modify our understanding about collision theory in classical physics.

4. Experimental section

The power door: Prepare a wooden board of the same material as the wooden door to place it horizontally. The electrode was fixed to the bottom of board, and pat the board with hand at the top to record its current and voltage. The light board with 1350 LEDs and 5 daily tube lights were fixed on the wooden door. When people rub or slap on the other side of board, the LEDs and tube lights can all be driven.

The elastic collision of Newton's cradle: Two balls of Newton cradle were used, one of which was attached to an electrode, and the other was pulled and released in a fixed height by hand. And the other ball was pulled and released in the linear distance of 2cm, 5cm, 10cm, 15cm and 20cm from the fixed electrode. The current and voltage of the electrode were measured when they collided.

The inelastic collision of Newton's cradle: Two balls of Newton cradle were used, one of which was attached to a thin layer of dough and an electrode, and the other was pulled and released in a fixed height by hand. The current and voltage of the electrode were measured when they collided.

The ideal inelastic collision of Newton's cradle: A ball of Newton cradle was used, the electrode is fixed on the ball. The ball was pulled up to a certain height and released. The ball would hit the dough, and they were ideal inelastic collision. The

current and voltage of the electrode were measured when they collided.

The inelastic collision of elastic ball and acrylic ball: A small elastic ball was installed in a large acrylic ball, and an electrode was fixed on the outside of the acrylic ball. The large ball was shaken to measure the current and voltage of the inelastic collision. The large ball was shaken above the LEDs board, and the LEDs can be driven where the ball was moved.

The ideal inelastic collision of dough: Prepare a large and a small dough, place the large one on the table, and bury the electrode on the large dough. The small dough was pulled and released in a certain height, and they were ideal inelastic collision. The current and voltage of the electrode were measured when they collided.

Electrical measurement: The current was measured by an electrometer (Keithley 6514) with computer measurement software written in LabVIEW. The voltage was measured by a digital storage oscilloscope (DSO-X 2014A).

Reference

1. Dicke, R.H., *THE EFFECT OF COLLISIONS UPON THE DOPPLER WIDTH OF SPECTRAL LINES.* Physical Review, 1953. **89**(2): p. 472-473.
2. Lane, N.F., *THEORY OF ELECTRON-MOLECULE COLLISIONS.* Reviews Of Modern Physics, 1980. **52**(1): p. 29-119.
3. Smith, F.T., *LIFETIME MATRIX IN COLLISION THEORY.* Physical Review, 1960. **118**(1): p. 349-356.
4. Gryzinski, M., *CLASSICAL THEORY OF ATOMIC COLLISIONS .I. THEORY OF INELASTIC COLLISIONS.* Physical Review, 1965. **138**(2A): p. A336-+.
5. Miller, M.L., et al., *Glauber modeling in high-energy nuclear collisions.* Annual Review Of Nuclear And Particle Science, 2007. **57**: p. 205-243.
6. Weinstein, J.D., et al., *Magnetic trapping of calcium monohydride molecules at millikelvin temperatures.* Nature, 1998. **395**(6698): p. 148-150.
7. Burlak, G. and B.A. Malomed, *Stability boundary and collisions of two-dimensional solitons in PT-symmetric couplers with the cubic-quintic nonlinearity.* Physical Review E, 2013. **88**(6).
8. Cizek, M., et al., *Inelastic low-energy electron collisions with the HBr and DBr molecules: Experiment and theory.* Physical Review A, 2001. **63**(6).
9. Larriba, C. and C.J. Hogan, *Free molecular collision cross section calculation methods for nanoparticles and complex ions with energy accommodation.* Journal Of Computational Physics, 2013. **251**: p. 344-363.
10. Inokuti, M., *INELASTIC COLLISIONS OF FAST CHARGED PARTICLES WITH ATOMS AND*

MOLECULES - BETHE THEORY REVISITED. Reviews Of Modern Physics, 1971. **43**(3): p. 297-&.

11. Inouye, S., et al., *Observation of Feshbach resonances in a Bose-Einstein condensate.* Nature, 1998. **392**(6672): p. 151-154.
12. Olive, K.A., et al., *REVIEW OF PARTICLE PHYSICS Particle Data Group.* Chinese Physics C, 2014. **38**(9).
13. Patrignani, C., et al., *REVIEW OF PARTICLE PHYSICS Particle Data Group.* Chinese Physics C, 2016. **40**(10).

Acknowledgements

Patents have been filed to protect the reported inventions.