This is a new discovery, which is not easily accepted by the public. We have found that the electromagnetic fields and gravitational waves should exist anywhere, anytime and in everything. Study and feel gravitational waves from a new perspective. It will be a great paper for readers.

Conjecture about gravitational waves based on a discovery and its potential applications

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Abstract

Scientific discoveries have given us a much better understanding of the world. Can you imagine that when an acrylic sheet is tapped by hand, the generated electromagnetic field can produce a voltage of 3600 V? The general theory of relativity predicted the existence of gravitational waves. Here, we found that two objects can generate electromagnetic fields under forces, and high frequency interaction can generate electromagnetic waves. We have deduced that gravitational waves generated by the collision of celestial bodies are the same as the electromagnetic field generated by the collision of small stones. When two small stones collide, the generated electromagnetic field can drive the LED. Wind blowing objects was used to verify that there would be electromagnetic field generated by friction between the object and atmosphere. We speculate that there must be super strong electromagnetic field produced by the friction between the earth surface and atmosphere because of the ultra-high-speed rotation and revolution of the earth. The electromagnetic field generated by friction between the fiber cloth and air can drive 1350 LEDs wirelessly, which indirectly verifies that how strong the electromagnetic field generated by the rotation of earth will be. The generated energy radiates outward

in the form of electromagnetic waves and is distributed throughout the out space. This may lead to the formation of earth's ring-shaped gravitational waves. On this basis, it is inferred that the gravitational waves should exist anywhere, anytime and in everything. In addition, several power generation devices including self-powered board for portable devices were designed based on the discovery. These new findings will have far-reaching impact on a range of research fields such as physics, new energy and astronomy.

Keywords: New energy; electromagnetic field; gravitational wave; wireless transmission

1. Introduction

As early as 1916, Einstein predicted the existence of gravitational waves in the universe based on the general theory of relativity.[1,2] The gravitational waves refer to the gravitational radiations generated when the massive objects accelerate. When a large mass of celestial bodies collides, a supernova breaks out, or two black holes collide, there will be the gravitational waves that travel through the universe at the speed of light. The gravitational waves are the waves in the curvature of space and time, which are produced by some violent collisions and explosions in the universe.[3] However, the gravitational wave is a speculation for a long time. In the past six decades, many physicists and astronomers have made countless efforts to prove the existence of gravitational waves.[4-6] Until 2016, LIGO scientific collaboration and Virgo collaboration detected the gravitational wave signals generated by the coalescence of two black holes for the first time, which confirmed the Einstein's predictions about the gravitational waves.[7] Then the gravitational waves open up a whole new window to observe and explore the universe.[1]

As fossil energy depletion and environmental pollution problems from energy still plague humans, the development of new energy has received significant attention.[8-11] The development of renewable energy such as solar energy, wind energy, geothermal energy, ocean energy and biomass energy is rapidly

expanding.[12-20] In the field of mechanical energy collection, triboelectric nanogenerator as an important representative of the new era of energy has greatly expand the possible coverage of energy collection, which helps solving the energy supply problems of distributed and mobile devices with disordered small energy.[21-26] With the fast development of energy technology, more environmentally-friendly and sustainable ways of collecting new energy sources are needed.[27] In Einstein's theory of relativity, it is believed that the gravity is not a force, but the curvature of space and time, the gravitational wave and the energy.[28-30] There is the gravity in all things, so it can be inferred that there should be gravitational waves around everything, and there should be electromagnetic fields in or around everything. Though the gravitational wave can transmit energy in the form of gravitational radiation, it is difficult to collect energy from the gravitational wave.[31,32] It has never been experimentally detected that the gravitational wave can be converted to other forms of energy.

The gravitational waves have always existed in space, and the general theory of relativity has been proven correct.[1,3,30] Then the gravitational waves and electromagnetic fields should exist anywhere, anytime and in everything. Here, we found that any two kinds of objects could produce electromagnetic fields under the force. When an acrylic sheet was tapped by hand, the instantaneous voltage can be up to 3600 V, the instantaneous current can be up to 260 μA. It was inferred from the electromagnetic field generated by the collision of small stones to the gravitational wave generated by the collision of celestial bodies. We inferred that the generation of the earth's ring-shaped gravitational waves is the result of the friction between the rapid rotating earth and atmosphere, which are the electromagnetic waves radiated outward generated by the electromagnetic field. Some power generation devices and self-powered systems based on the new discoveries have been designed, including the power generation cloth, the power generation by human body, and the self-powered board for position location and power supply of portable electronic devices. Therefore, it will have a profound impact on the entire scientific research fields, including physics, astronomy, and new energy.

2. Results and discussions

The electromagnetic field can be generated when there is a force between two objects. Fig. 1a-b show the experimental setup for investigating the electromagnetic field generated by force. A LEDs lamp board was placed on the fixed acrylic sheet (Polymethyl methacrylate, PMMA), which can be tapped by hand from the bottom. The electromagnetic field tester (the maximum range of electric field is 2000 V/m) was overloaded when the distance above the acrylic sheet was less than 5 cm, which limits the detection for electromagnetic field. Fig. 1c shows that the intensity of electric field generated by the tapping can instantaneously reach 1997.73 V/m, when the wireless detection distance is 5 cm above the acrylic sheet. The result shows that the electromagnetic field can be generated by the tapping or rubbing. As shown in Fig. 1d-e, the medium LED lamp board (480 LEDs in series) was all driven. Due to the shooting angle, ambient lighting, exposure time and frequency of the camera, it is hard to capture photos showing that 480 LEDs were all on. However, the LEDs can be seen by the naked eyes that they were all driven and dazzling. (Supplemental Material, Video 1) Even more, Fig. 1f-g show the large LED lamp board (1350 LEDs in series) can be also driven by tapping the acrylic sheet, which reflects the high intensity of the generated electromagnetic field. (Supplemental Material, Video 2)

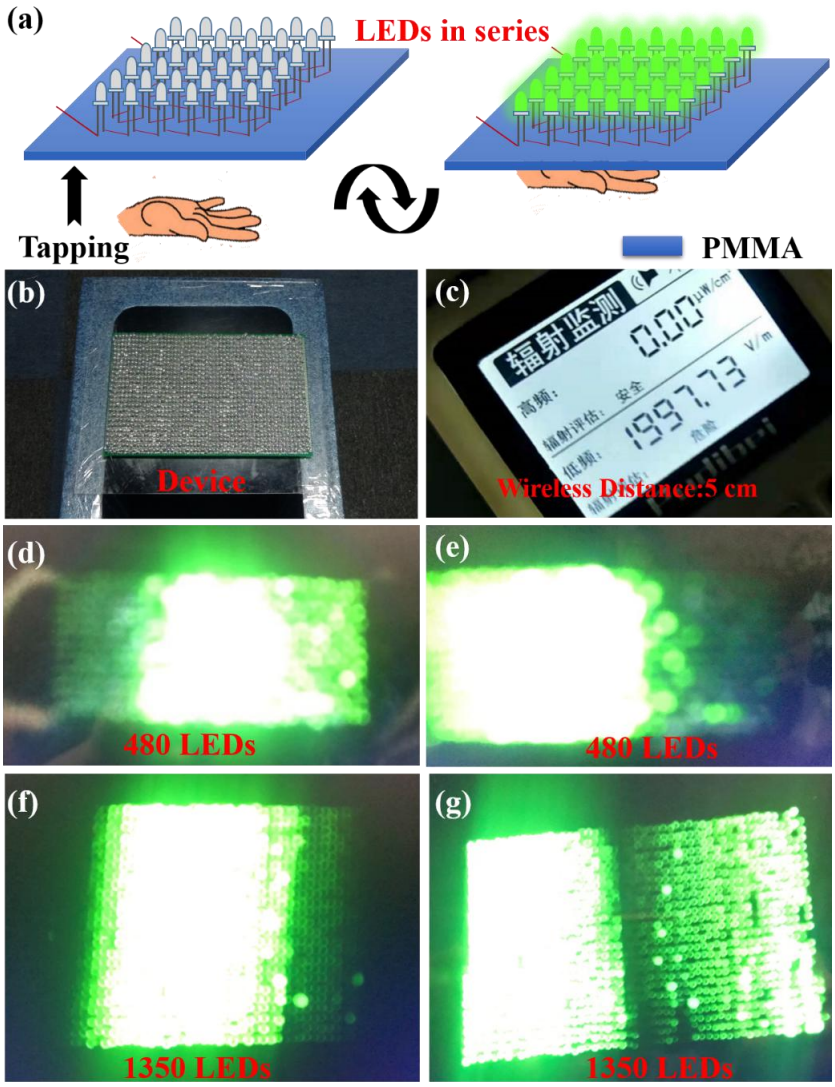

FIG. 1. (a,b) Schematic diagram of the experimental setup and working principle of the device; (c) The electromagnetic field tester (the maximum detection range of electric field is 2000 V/m) at the wireless detection distance of 5 cm; (d-e) 480 LEDs in series were driven by tapping; (f-g) 1350 LEDs in series were driven by rubbing.

The electromagnetic field generated by the tapping was further studied by wireless energy collectors. As shown in Fig. 2a-b, the instantaneous voltage can be as high as 3600 V and the instantaneous current can be as high as 260 μA. The maximum power can up to 0.936 W and the maximum power density is 46.8 W/m^2, which shows a high energy density. Besides, the electromagnetic field generated by continuous tapping can be detected at the wireless detection distance of 5 m as shown in Fig. 2c-d. Fig. 2e shows the schematic diagram of the electromagnetic field

generated by tapping. The direction of the as generated electromagnetic field radiates perpendicularly to the tangent face of the force point and radiates around. The resulting gravity from the electromagnetic field is vertical to the contact surface and points to the inside of the contact surface, which can be proved by simple experiments of attracting small and light objects like scrap paper. As the frequency of human tapping is limited, the electromagnetic field generated is in the low-frequency range. In fact, the oscillating electromagnetic waves will propagate outward, when the speed of tapping reaches a certain high frequency, or two colliding objects are large enough.

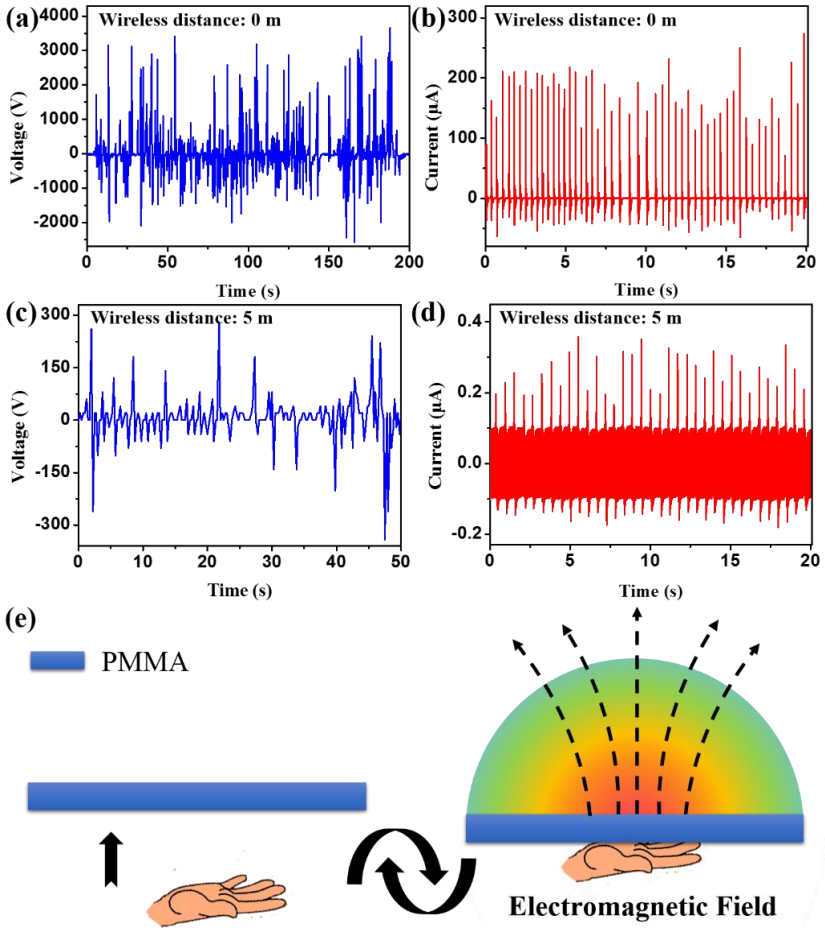

FIG. 2. (a, b) The instantaneous voltage and current of the medium LED lamp board at the wireless detection distance of 0 m; (c, d) The instantaneous voltage and current of the medium LED lamp board at the wireless detection distance of 5 m; (e) Schematic diagram of the electromagnetic field generated by tapping.

The Einstein's general theory of relativity predicts that a powerful gravitational wave is produced when massive celestial bodies or two black holes collide. We found that two objects could generate electromagnetic fields under the forces, even two small stones. Fig. 3a shows the experimental setup for detecting the electromagnetic field generated by the collision of two small stones. The electrical signals can be detected, when two stones collide and move apart constantly. As shown in Fig. 3b-c, the voltage generated by the collision of two small stones can reach 10-20 V, and the current can reach 1-2 μA. The signals were unstable due to the changeable force and different contact position. Besides, the LED can be driven by the collision of two small stones. Fig. 3d-e show the LED was lit up when two stones were collided against each other. (Supplemental Material, Video 3) Since collision of small stones generates electromagnetic fields, we can infer that a collision between two huge stones like the celestial bodies can produce a super strong electromagnetic field, and an ultra-high-speed collision can produce radiating electromagnetic wave. This should be the gravitational wave observed by scientists, which is electromagnetic wave generated by the collision of two objects.

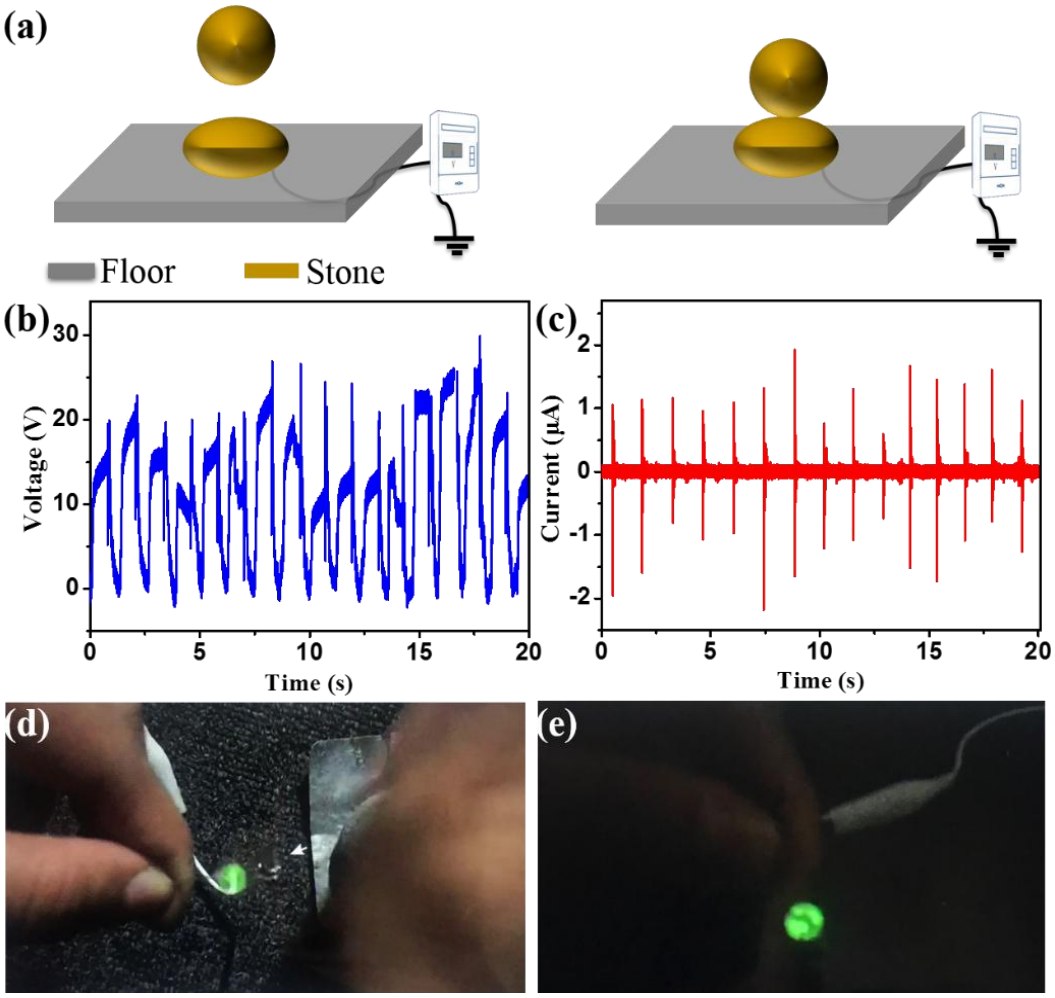

FIG. 3. (a) Schematic diagram of the detection for electromagnetic field generated by the collision of two stones; (b) The voltage detected by the collision of two small stones; (c) The current detected by the collision of two small stones; (d, e) The LED driven by the collision of two small stones.

Electromagnetic fields will be generated by the collision between solids. What about it between gases and solids? What about it between gases and liquids? Will the electromagnetic field be generated when the earth rubs against the atmosphere in the rapid rotation and revolution? As shown in Fig. 4a, the experimental setup was designed to investigate the electromagnetic field generated by the friction between the stone and wind. The detector can measure the electrical signals when the stone was rubbed by the wind from the air blower. Fig. 4b-c show the voltage and current generated by the friction between the stone and the wind at a high wind speed of 10 m/s and a low wind speed of 5 m/s, respectively. The change of electrical signals is

obvious at different wind speeds, which reflects the existence of electromagnetic field. Besides, the friction between the atmosphere and ocean was studied. As shown in Fig. 3d, the experimental setup was designed to investigate the electromagnetic field generated by the friction between water and wind. Fig. 4e-f show the voltage and current generated by friction between water and wind at a high wind speed (10 m/s) and a low wind speed (5 m/s), respectively. The change of wind speed was relatively small and the friction between water and wind was relatively weak, so the voltage did not change much. However, the change of current signals is obvious at different wind speeds, which reflects the generation of electromagnetic field. We also used wind to blow grass and wood, which can generate electromagnetic fields. (Supplemental Material, Fig. S1) The greater the wind, the faster the friction between objects and the atmosphere, and the stronger the electromagnetic field produced. It can be speculated that the electromagnetic fields should exist anywhere, anytime and in everything because of the friction between the earth surface and atmosphere.

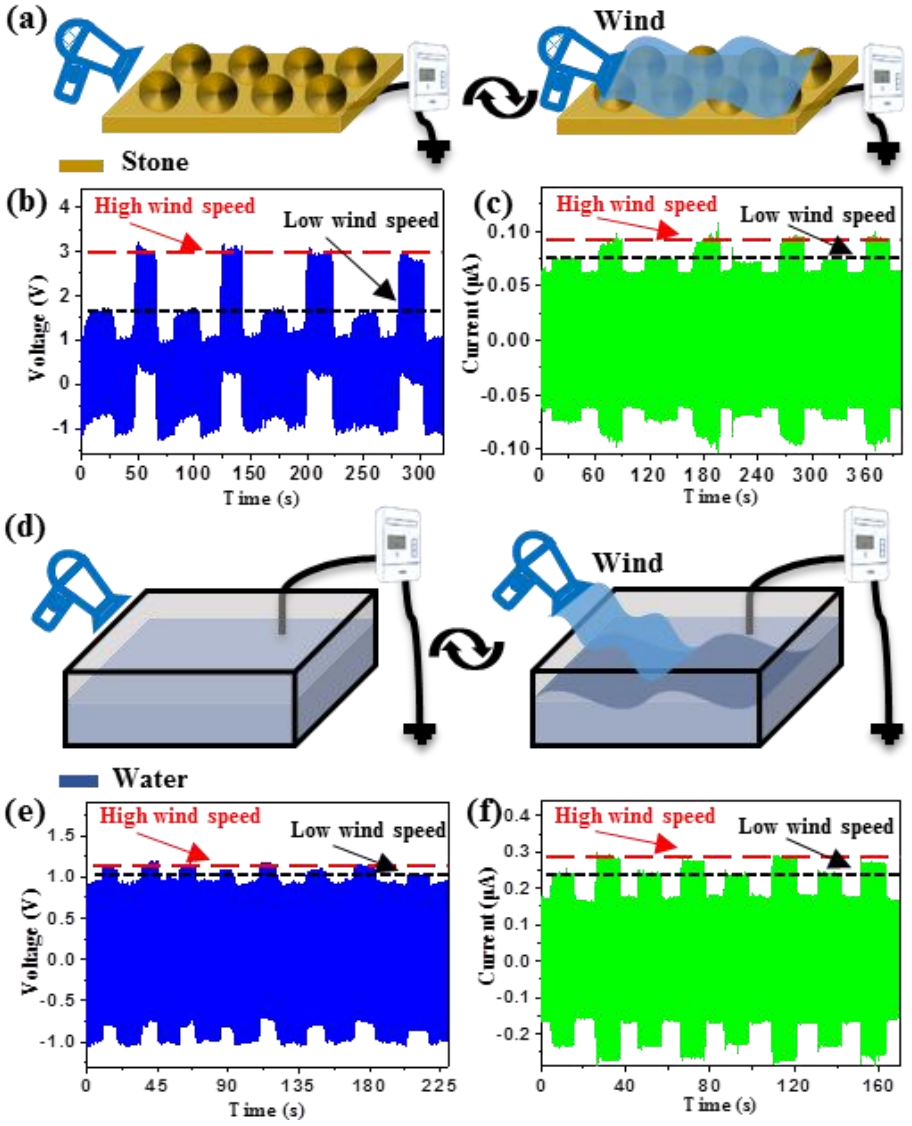

FIG. 4. (a) Schematic diagram of the experimental setup of the detection for electromagnetic field generated by the friction between stone and wind; (b, c) The voltage and current detected by the friction between stone and wind at the high wind speed (10 m/s) and low wind speed (5 m/s); (d) Schematic diagram of the experimental setup of the detection for electromagnetic field generated by the friction between water and wind; (e, f) The voltage and current detected by the friction between water and wind at the high wind speed (10 m/s) and low wind speed (5 m/s).

The faster the object moves in the atmosphere, the stronger the electromagnetic field. How strong can it be? Fig. 5a-b show voltage and current generated by fiber cloth blown by wind at a speed of 10 m/s. It can be seen that tiny electromagnetic fields were generated. Then let us shook the fiber cloth in hands quickly (Equivalent

to increasing the wind speed to increase the friction between atmosphere and the fiber cloth) and see how strong the electromagnetic field would be. As shown in Fig. 5c, the large lamp board can be driven when the fiber cloth was taken close to the LEDs. More amazing is that the large lamp board can be driven wirelessly even if the fiber cloth was not attached to the LEDs. (Supplemental Material, Video 4) The brightness of LEDs is related to the speed of shaking and the distance above the lamp board. The faster the speed of shaking and the greater the force, the greater the brightness of the LEDs. And the closer to the lamp board, the brighter the LEDs. We cannot measure the friction between the fiber cloth and atmosphere, which is equivalent to the friction of the moving cloth in the air. But we can judge qualitatively how small the speed of fiber cloth shaken by hand is compared to the speed of the earth's movement. The earth rotates around the axis of rotation at a high speed of 466 m/s on the equator, and simultaneously revolves around the sun at a high speed of 29800 m/s. How strong the generated electromagnetic field between the earth and atmosphere would be is inestimable. The electromagnetic waves will be continuously released in real time, because the movement of objects in the universe is eternal. It can be speculated that the generated electromagnetic waves around the earth is the earth's ring-shaped gravitational waves observed by scientists. The gravitational waves should exist anywhere, anytime and in everything.

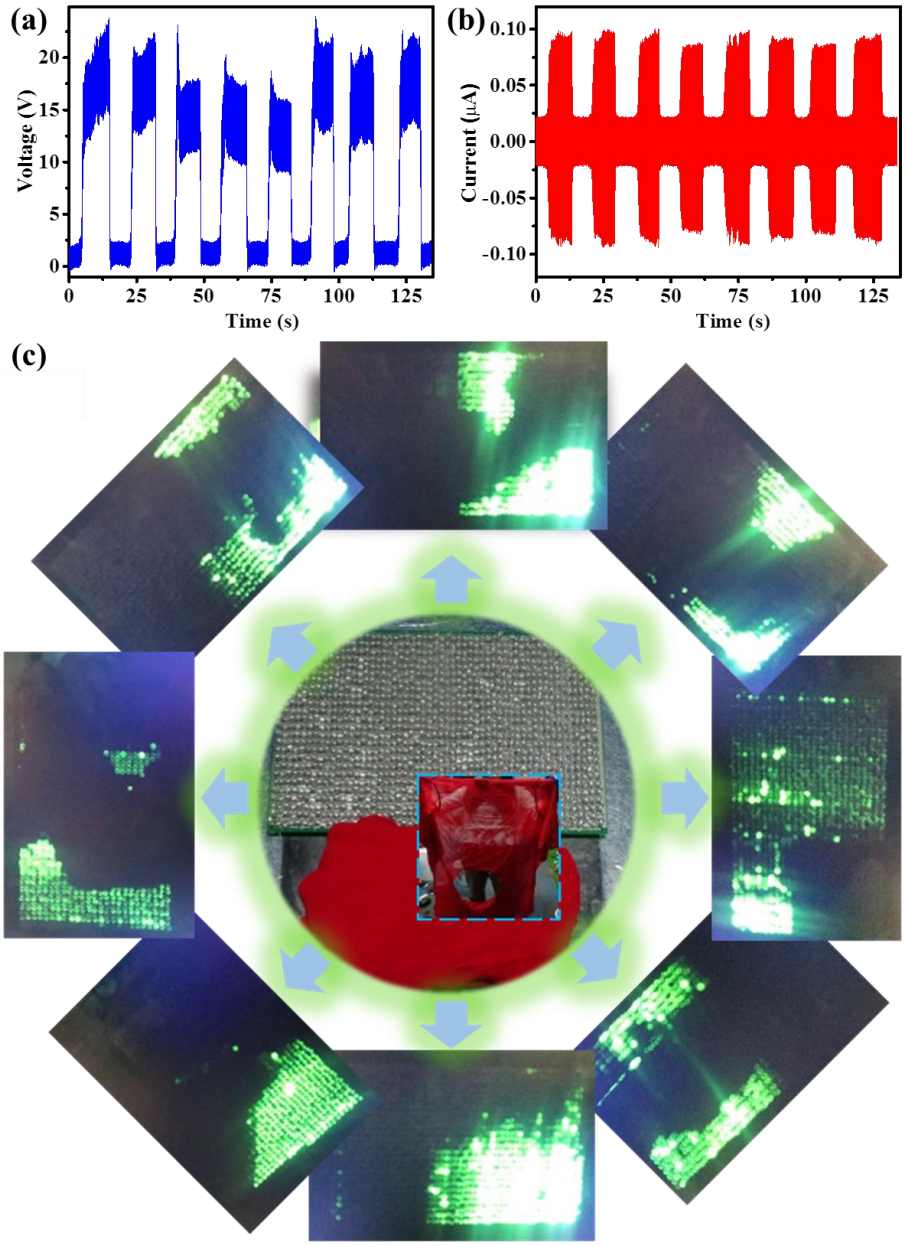

FIG. 5. (a, b) The voltage and current detected by the friction between fiber cloth and wind; (c) The large lamp board of 1350 LEDs in series driven by shaking the fiber cloth in the air.

The electromagnetic field is generated when the earth keeps moving and rubs against the atmosphere. The strength of the generated electromagnetic field should be proportional to the air density of the atmosphere. Therefore, the air density of atmosphere should be large in the place where the geomagnetic field is strong. It is known that the largest strength of geomagnetic field is in the South Pole and the North Pole, and the geomagnetic field in the equatorial regions with the small air

density is the weakest. The air density in the polar regions is larger than other places due to the extremely high pressure and low temperature of the lower layer of air, which leads to the shrinkage and subsidence of air column. This is consistent with our inference. In addition, the geomagnetic field is divided into the South Pole and the North Pole, because the flow directions of the polar vortex are different.[33-36] It is also highly consistent with our research findings. It can be concluded that the electromagnetic field generated by the friction between the earth and the atmosphere is changeable and fast enough to generate high-frequency oscillations, and thus the gravitational waves can be generated. The gravitational waves are perpendicular to each point of action and radiate into the air. Therefore, the ring-shaped waves are generated around the earth and radiate into the universe.

It is known that the long-wave radiation emitted by the warming of the ground is absorbed by the carbon dioxide and other substances in the atmosphere, thus producing the effect of atmospheric warming. The increase of carbon dioxide, ozone, nitrous oxide, freon and small haze particles leads to an increase in the density of the lower layer of air. Based on the new discovery, the increasing air density leads to an increase of the as formed electromagnetic field generated by the friction between air and the earth. Therefore, the greenhouse effect should be the result of electromagnetic radiation, which can produce the thermal effect. These objective facts in nature are exactly consistent with the conjecture based on the experiments of stones, water, fiber cloth and atmosphere. Furthermore, every planet in the entire solar system moves around the sun. The sun can generate huge electromagnetic fields and the sun's core gravity because of the friction with the atmosphere.[30] While other planets also can generate electromagnetic fields by themselves, they are attracted each other by the gravitational forces. They finally reach an equilibrium state centered on the sun's centripetal attraction, which is full of the gravitational waves permeating in the entire solar system.

The gravitational waves and electromagnetic fields can be generated anywhere, anytime and in everything, so collecting energy from the energy fields in the surrounding environment has huge advantages. When we walk, electromagnetic fields

will be generated due to the friction between the human body and clothes. As shown in Fig. 6a-c, the electromagnetic fields can be collected by the human body, so that the fluorescent lamp and small LED lamp board in the hands can be driven directly. Fig. 6d-e show the fluorescent lamp and LEDs driven by human body as the energy collector, which wear different clothes. (Supplemental Material, Video 5 and Video 6) The same method can be also used to collect the electromagnetic fields generated by the friction between the shoe and the ground. The power generation cloth was designed to drive 480 LEDs and 3 W bulbs. (Supplemental Material, Fig. S2, Video 7 and Video 8) All of these phenomena provide a new way for the generation of new micro-nano energy, which can be used in many fields like wearable devices and self-powered sensing.

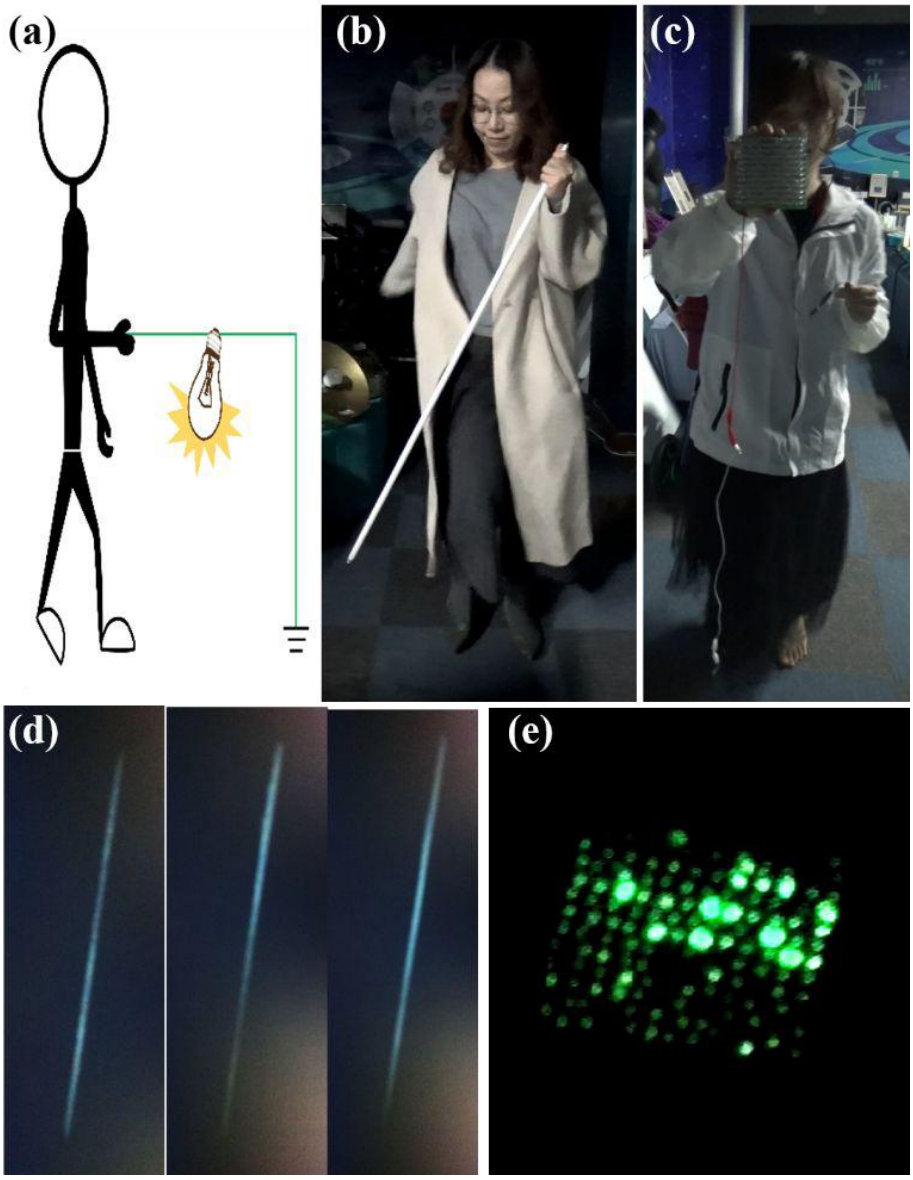

FIG. 6. (a) Schematic diagram of the power generation by human body; (b, c) Photos of the experimental setup of the power generation by human body; (d, e) Photos of the fluorescent lamp and LEDs driven by human body as the energy collector.

Furthermore, any substances can be used to generate electricity when they are under force. A self-powered board was designed for position location and power supply of portable devices d. Fig. 7a-b show the schematic diagram of the position location and the photo of a self-powered board. The LEDs can be driven by the electromagnetic field when the finger touches at the bottom of PMMA board. Due to the distribution of the electromagnetic field and the LEDs connected in series, the

brightness of LEDs at the touching point is the strongest, while the brightness near the touching point will gradually weaken. As shown in Fig. 7c-e, the column of LEDs was driven by the electromagnetic field when the board was touched on the left, in the middle, and on the right position. (Supplemental Material, Video 9) The brightness of three columns of LEDs was different, because it was affected by the force of touching in different positions. As shown in Fig. 7f, this discovery is expected to be applied in the screen location by the digital and miniaturized design. In addition, the large LED lamp board can be easily driven by slightly touching or rubbing the back, which demonstrates a good and simple way of power generation as shown in Fig. 7g. (Supplemental Material, Video 10) The power board can be also integrated with portable electronic devices to achieve the self-powered mode. This simple way of position location and power supply has a wide range of applications in the fields of man-machine interactive devices and portable devices.

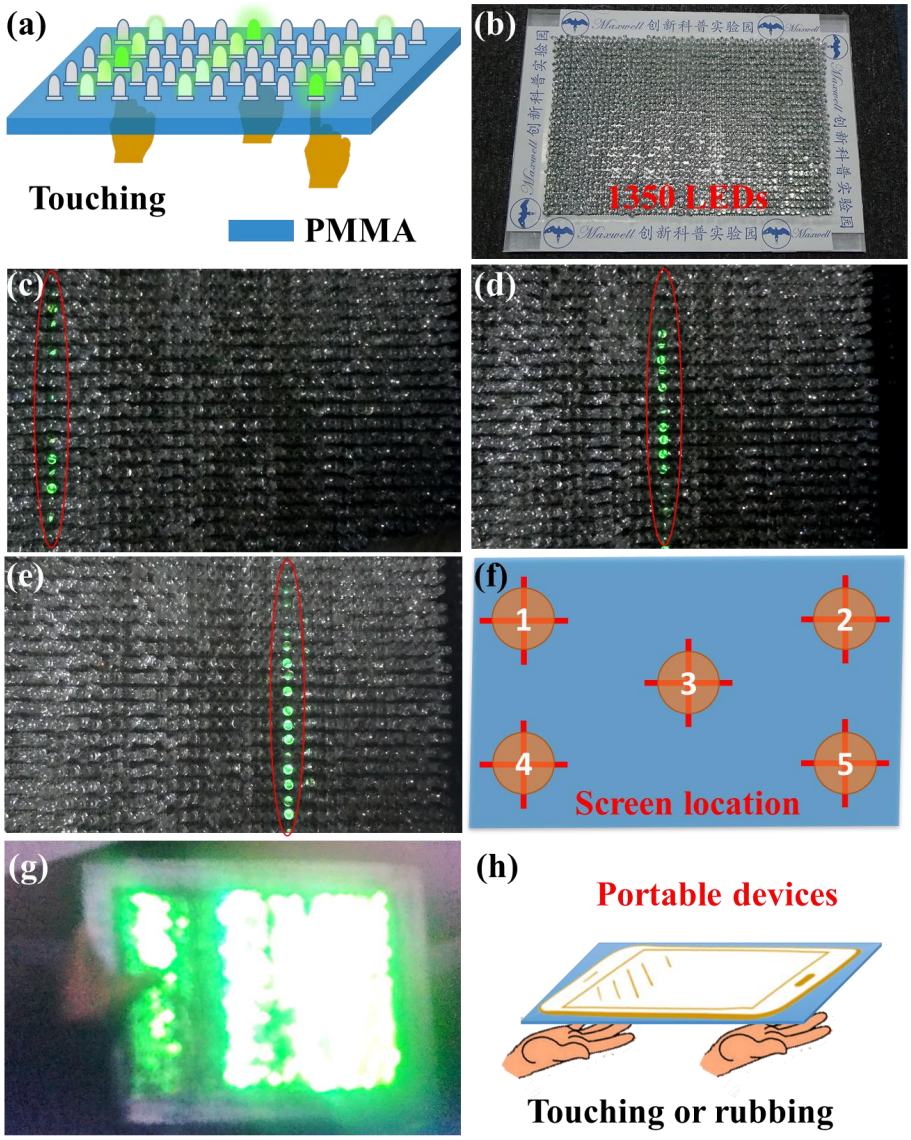

FIG. 7. (a) Schematic diagram of the position location for touching based on the LEDs driven by the electromagnetic field; (b) Photo of the large LED lamp board (1350 LEDs in series) for position location; (c-e) Photos of the LEDs driven by the electromagnetic field when touching the left, the middle, and the right position; (f) Schematic diagram of the screen location for man-machine interactive devices; (g) Photo of the large LED lamp board driven by slightly touching or rubbing the back; (h) Schematic diagram of the self-powered board for powering portable electronic devices.

3. Conclusions

In conclusions, it was found that the interaction between two objects under force can generate the electromagnetic field. High-frequency interaction can generate the oscillating electromagnetic waves. The existence of gravitational waves predicted by the general theory of relativity and the formation mechanism of earth's ring-shaped gravitational waves were deduced. As the limitation to the length of the article and the research time, many models are only briefly presented to fully explain the latest findings of gravitational waves and related natural phenomena. A systematic study of gravitational waves and applications is underway, and we will continue to report relevant research results.

4. Experimental section

Experimental materials: Polymethyl methacrylate (acrylic board, PMMA), small LED lamp board (10 cm*10 cm, 216 LEDs in series), medium LED lamp board (20 cm*10 cm, 480 LEDs in series), large LED lamp board (30 cm*20 cm, 1350 LEDs in series), LEDs (3.2 V), bulbs (3 W, 12 V), fluorescent lamp (28 W, 6500 K), water, stone, fiber cloth.

LEDs lamp boards for collecting the electromagnetic field: The medium LED lamp board and large LED lamp board were placed on the fixed acrylic sheet, and the acrylic sheet was tapped from the bottom by the hand.

Fluorescent lamps for collecting the electromagnetic field: The fluorescent lamps were placed on the fixed acrylic sheet, and the acrylic sheet was tapped from the bottom by the hand.

Stones for generating the electromagnetic field: A stone was put on the floor and connected to the test instrument. Another stone was used to constantly collide the stone on the floor. And a LED can be driven after connecting to the circuit.

Water for generating the electromagnetic field: Water was put in an open tank and connected to the test instrument by wire. When the wind from the air blower blows, the electrical signals can be detected.

Fiber cloth for driving the LEDs and fluorescent lamps: The large LED lamp board and fluorescent lamps were laid flat and fixed, respectively. The fiber cloth was shaken above the lamp board to make it fully frictional with the air, resulting in the electromagnetic field. While shaking the fiber cloth, keep it close to the lamp board and fluorescent lamps.

The power generation cloth: The human body wearing the power generation cloth was connected to LEDs or bulbs in series, which were connected to ground. When the cloth was flapped by the fabric, the LEDs or bulbs can be driven.

The human body as collector: The two ends of the LEDs were separately connected to wires. The other end of one wire was connected with hand, and another wire was connected with ground..

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). Electromagnetic field was measured by electromagnetic field tester (Pudibei 620).

Reference

[1] M. C. Miller and N. Yunes, Nature **568**, 469 (2019).
[2] C. L. Bennett, Science **307**, 879 (2005).
[3] B. Brugmann, Science **361**, 366 (2018).
[4] J. Abadie *et al.*, Nature Physics **7**, 962 (2011).
[5] A. Abramovici *et al.*, Science **256**, 325 (1992).
[6] M. J. Valtonen *et al.*, Nature **452**, 851 (2008).
[7] B. P. Abbott *et al.*, Phys Rev Lett **116**, 061102, 061102 (2016).
[8] C. Liu, F. Li, L. P. Ma, and H. M. Cheng, Adv Mater **22**, E28 (2010).
[9] S. L. Candelaria *et al.*, Nano Energy **1**, 195 (2012).
[10] N. L. Panwar, S. C. Kaushik, and S. Kothari, Renewable & Sustainable Energy Reviews **15**, 1513 (2011).
[11] H. Kim, S. Yang, S. R. Rao, S. Narayanan, E. A. Kapustin, H. Furukawa, A. S. Umans, O. M. Yaghi, and E. N. Wang, Science **356**, 430 (2017).
[12] A. S. Arico, P. Bruce, B. Scrosati, J. M. Tarascon, and W. van Schalkwijk, Nat Mater **4**, 366 (2005).
[13] M. Elimelech and W. A. Phillip, Science **333**, 712 (2011).
[14] D. Larcher and J. M. Tarascon, Nat Chem **7**, 19 (2015).
[15] A. Mishra and P. Bauerle, Angewandte Chemie **51**, 2020 (2012).
[16] F. Diaz-Gonzalez, A. Sumper, O. Gomis-Bellmunt, and R. Villafafila-Robles, Renewable & Sustainable Energy Reviews **16**, 2154 (2012).
[17] T. Hisatomi, J. Kubota, and K. Domen, Chem Soc Rev **43**, 7520 (2014).
[18] P. Pardo, A. Deydier, Z. Anxionnaz-Minvielle, S. Rouge, M. Cabassud, and P. Cognet, Renewable & Sustainable Energy Reviews **32**, 591 (2014).
[19] S. A. Kalogirou, Progress In Energy And Combustion Science **30**, 231 (2004).
[20] Y. Tian and C. Y. Zhao, Applied Energy **104**, 538 (2013).
[21] Z. L. Wang, ACS Nano **7**, 9533 (2013).
[22] Z. L. Wang, J. Chen, and L. Lin, Energy & Environmental Science **8**, 2250 (2015).
[23] F. R. Fan, Z. Q. Tian, and Z. L. Wang, Nano Energy **1**, 328 (2012).
[24] Z. L. Wang, Mater. Today **20**, 74 (2017).
[25] Y. Jie, J. M. Ma, Y. D. Chen, X. Cao, N. Wang, and Z. L. Wang, Advanced Energy Materials **8**, 1802084 1802084 (2018).
[26] X. Cao, Y. Jie, N. Wang, and Z. L. Wang, Advanced Energy Materials **6**, 1600665, 1600665 (2016).
[27] N. Armaroli and V. Balzani, Energy & Environmental Science **4**, 3193 (2011).
[28] B. P. Abbott *et al.*, Physical Review D **93**, 1802084, 122008 (2016).
[29] J. Adamek, D. Daverio, R. Durrer, and M. Kunz, Nature Physics **12**, 346 (2016).
[30] X. Dong, Nat Commun **7**, 12472, 12472 (2016).
[31] M. Ruiz, M. Alcubierre, D. Nunez, and R. Takahashi, General Relativity And Gravitation **40**, 1705 (2008).
[32] K. Saikawa and S. Shirai, Journal Of Cosmology And Astroparticle Physics, 35, 035 (2018).
[33] B. M. Kim, S. W. Son, S. K. Min, J. H. Jeong, S. J. Kim, X. Zhang, T. Shim, and J. H. Yoon, Nat Commun **5**, 4646, 4646 (2014).
[34] M. R. Schoeberl, L. R. Lait, P. A. Newman, and J. E. Rosenfield, Journal Of Geophysical

Research-Atmospheres **97**, 7859 (1992).

[35] D. W. Thompson and S. Solomon, Science **296**, 895 (2002).

[36] D. W. J. Thompson and J. M. Wallace, Geophysical Research Letters **25**, 1297 (1998).

Acknowledgements

Patents have been filed to protect the reported inventions.

Supporting information

The power generation cloth

As the fiber cloth can be fully rubbed against the air to generate the electromagnetic field, the power generation cloth was designed based on the friction between the cloth and the fabric. As shown in Fig. S2a, the bulb connected to hand can be driven by continuously flapping the cloth with the fabric. Human body is used as good energy collector. Fig. S2b shows the white power generation cloth worn by a person, whose left hand is connected to the medium LED lamp board. As shown in Fig. S2c-d, the 480 LEDs can be driven by the power generation cloth when the person flapped the sleeve of cloth with the red fabric. Besides, four 3 W bulbs in series were connected with the power generation cloth to test its performance. (Fig. S2e) Fig. S2f-g show that the 3 W bulbs can be also driven by the power generation cloth. It is convenient to integrate the power generation cloth with wearable devices to realize the self-powered mode due to its simple and flexible structure.

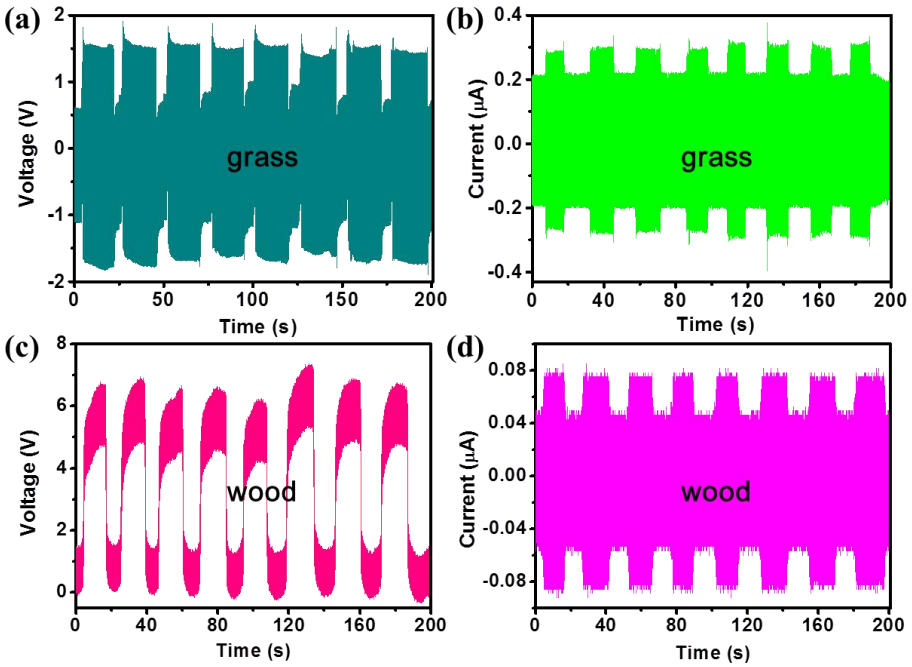

FIG. S1. (a, b) The voltage and current detected by the collision between grass and wind; (c, d) The voltage and current detected by the collision between wood and wind.

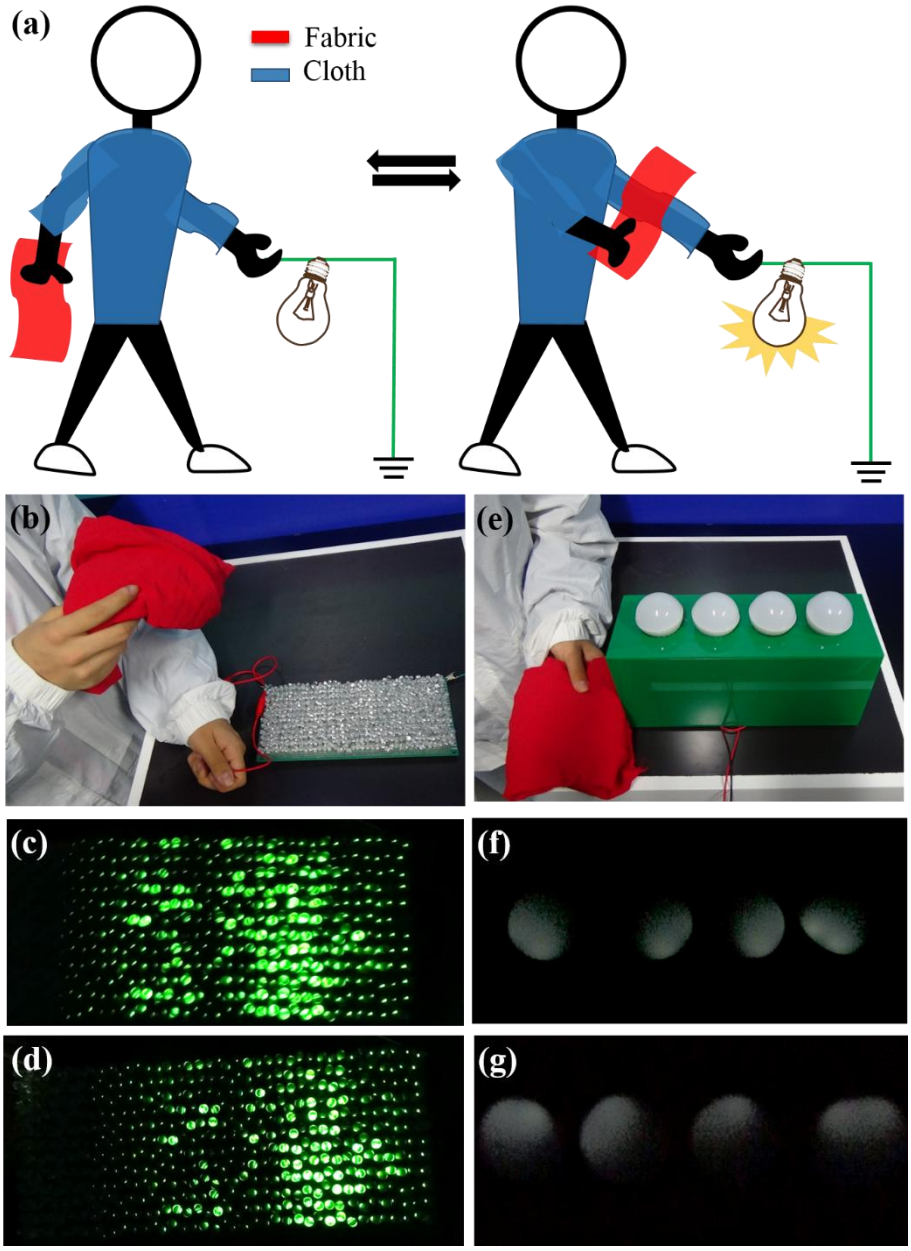

FIG. S2. (a) Schematic diagram of the power generation cloth for wearable devices; (b) Photo of the experimental setup of power generation cloth with 480 LEDs in series; (c, d) Photos of the 480 LEDs driven by the power generation cloth; (e) Photo of the system of power generation cloth with the 3 W bulbs; (f, g) Photos of the 3 W bulbs driven by the power generation cloth.