

Tiny Particles Charge Like Capacitors

Lab experiments provide new details about the charge-transfer process that occurs in ash clouds and other collections of particles.

By **Mark Buchanan**

Granular particles in volcanic ash plumes or in industrial powders often become electrified through triboelectric charging—the direct transfer of charge from one surface to another. Studying this process in more detail, a research team has now increased the precision of a previously developed technique for measuring the charge transfer between two particles forced to collide repeatedly [1]. The team showed that a previously proposed theory that treats the pair like a capacitor—a standard electronic circuit element—fits the data well. The researchers found that the charging process follows a consistent pattern over many collisions, information that they hope will lead to improved modeling of charging in complex real-world settings.

When two small solid particles make contact and then separate,



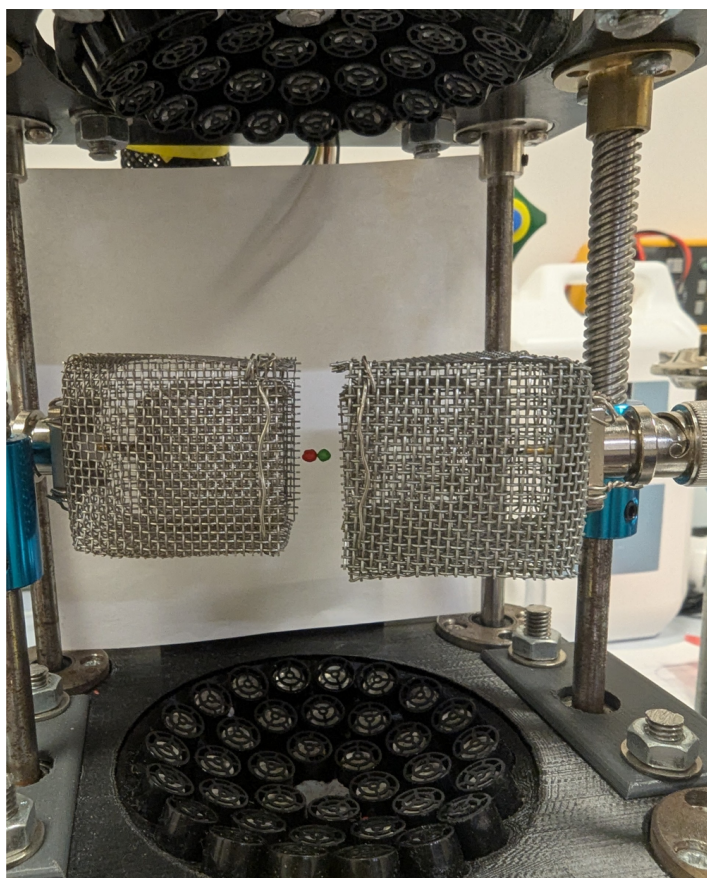
Electric volcano. Triboelectric charging caused by collisions of ash particles electrifies volcanic plumes, influencing how high they go and how long they remain in the atmosphere.

Credit: Mxmoreess/stock.adobe.com

they often exchange charge. But much remains unknown about the process, says aerosols science PhD student Tom O'Hara of Bristol University in the UK. In 2020, a research team led by Heinrich Jaeger of the University of Chicago reported an experiment in which two submillimeter polystyrene particles, levitated in air and moved by sound waves, could be made to repeatedly collide, with their charges measured after each collision [2]. The team found that the charges on the two particles accumulated gradually and with a linear growth trend. But O'Hara says that the scatter in some of the data suggested a possibly nonlinear trend that could be revealed with higher-precision measurements, which might be expected, since nonlinearity is predicted by some theories.

To achieve higher precision, O'Hara, along with his PhD supervisor Karen Aplin and colleagues, built Faraday cages—sensitive wire-mesh structures able to accurately measure the total charge on each particle after each collision. As in the earlier experiments, the researchers found that the amount of charge exchanged between any two particles was highly random, flowing in either direction with a wide range of possibilities. However, each pair was consistent, exchanging about the same amount of charge in each collision, which was also reminiscent of the previous results.

This linear charging trend held up to about 15 collisions (about one minute). After that, in experiments lasting for more than 60 collisions, the charge grew at a slower rate. The researchers believe that the slowdown could occur for a variety of reasons. Charge carriers may be gradually depleted, or the buildup of charge on a particle may generate a repulsive force that resists further transfer—an effect proposed by previous researchers. O'Hara and colleagues found that they could fit the data by



Collision course. In the experiment, the two particles are in the central acoustic trap. Following each collision, the particles move into their respective Faraday cages, which measure their accumulated charges. The distinct colors of the particles help the researchers to follow them over many collisions.

Credit: T. O'Hara/Bristol University

treating the particle pair according to the so-called condenser theory, where the particles behave like the parallel plates of a capacitor.

"This work fills a gap, and the results have the potential to be very useful," says soft matter physicist Galien Grosjean of the University of Barcelona in Spain. He is surprised by how quickly the charging rate decreases, and he says the experiment "potentially gives access to some very useful information on the microscopic charging mechanism."

O'Hara says that he's fascinated by "the contrast between the stochastic nature of individual collisions and the remarkably predictable behavior that emerges when those collisions are repeated many times." In future work, the researchers hope to overcome some of the current limitations of their apparatus. The present setup is restricted to lightweight materials such as polystyrene, but higher-power transducers and different geometries may allow a wider range of materials.

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REFERENCES

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2. A. G. Kline *et al.*, "Precision measurement of tribocharging in acoustically levitated sub-millimeter grains," *Rev. Sci. Instrum.* **91**, 023908 (2020).