# Experiment to Clarify Ancient Physics Discovery Yields More Questions

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In approximately 600 B.C., the Greek philosopher Thales of Miletos discovered that rubbing certain materials together, such as amber and wool, can cause both to become electrically charged, one positive and one negative. This phenomenon is useful for several industrial processes, including printing and filtration, and has sparked much interest and study. Still, scientists cannot fully explain how rubbing-induced charge transfer occurs or how that transfer affects surrounding objects.

Scientists at Rutgers University have recently completed an experiment designed to help illuminate the phenomenon (known as the triboelectric effect) – but that initially left them scratching their heads instead.

In the July 31, 2007, online edition of *Physical Review Letters*, they describe their experiment: separating a mixture of red and blue "art-sand" particles by pouring them into a positively charged acrylic cylinder using a miniature version of a "vibratory feeder," a machine typically used to move dry goods from storage hoppers into processing machines. The scientists charged the cylinder triboelectrically by rubbing it with a nylon glove. Based on this initial condition, they expected to the grains to exhibit certain behaviors.

As the grains traveled down the feeder, they became positively charged due to friction. When they reached the end and fell through the air, they cleanly separated into two streams – one red and one blue – and formed two piles on the bottom of the cylinder. The experiment is similar to one performed in the 19$^{th}$ century by British physicist Lord Kelvin, who

noticed that a charged stream of water droplets induced a charge in a second water-droplet stream positioned next to it.

Due to the slightly different chemical composition of the grains, the blue grains pick up slightly more positive charge than the red. The scientists assumed, based on the law of electrostatics, that each positively charged blue grain would induce a negative charge on the metal feeder. Accordingly, they reasoned that because the blue grains have more positive charge, they would feel a stronger pull toward the feeder than the red and fall as close to the feeder as possible.

Oddly, the opposite behavior occurred: The red grains fell closer to the feeder.

Upon examining the feeder, the group noticed that a small beard of red grains, perhaps five or 10 grains thick, had built up on the feeder lip. This was also odd, since the blue grains carry more positive charge and were more likely to stick. Further, no blue grains stuck to the beard, but rather, as the scientists write, a “paradoxical repulsion” took place. The blue grains glided over the red and over the edge.

Thus, the two colors separated *before* they fell. It appears, therefore, that the positive charge on the cylinder did not influence the grains' behavior.

Fernando Muzzio, a scientist involved in the study, told *PhysOrg.com* that he and his colleagues had also subjected some “real-world” materials to the same experimental setup, including typical pharmaceutical powders, which have the potential to experience these triboelectric-induced issues during processing. The group observed essentially the same results.

“I suspect that once we start looking, we will find similar unexpected behaviors in many places. It remains for future study to determine the

extent to which these phenomena can be controlled to avoid quality problems, or even better, to develop new methods of processing," Muzzio said.

Citation: Amit Mehotra, Fernando J. Muzzio, and Troy Shinbrot, "Spontaneous Separation of Charged Grains" *Phys. Rev. Lett.* 99, 058001 (2007)