

# Scientists find clues to the mystery of what causes lightning

March 1 2016, by Lisa Zyga

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Photograph of a ‘bolt-from-the-blue’ lightning discharge during a nighttime storm over central New Mexico, taken from a distance of about 50 km. The storm occurred on the evening of August 19, 2010. The in-cloud channels of such discharges are obscured from view optically but are being imaged in increasing detail using VHF mapping techniques. Credit: Harald Edens

It's well-known that lightning is an electric current—a quick, powerful burst of charge that flows within a cloud or between a cloud and the ground. But surprisingly, scientists still don't fully understand how the initial spark forms that generates such powerful lightning.

In a new paper published in *Nature Communications*, researchers from Langmuir Laboratory at the New Mexico Institute of Mining and Technology near Socorro, New Mexico, have reported observations of a rare but extremely powerful type of [lightning](#) spark, or discharge, called narrow bipolar events. The scientists found that this powerful type of lightning is caused by a newly recognized type of discharge called fast positive breakdown, and the data suggests that this same discharge initiates most or even all of the [lightning flashes](#) typically seen in thunderstorms. These sparks travel at speeds that are fast even for lightning—around 10 to 100 million meters per second—and produce very powerful radiofrequency (RF) radiation as high as a few megawatts, making them the strongest natural sources of RF radiation on Earth.

This discovery is surprising, since previous simulations have shown that lightning breakdown appears to be negative, meaning the spark moves upward in the cloud from a negative to a positive region. In positive breakdown, the spark moves downward from a positive to a negative region.

"It is impossible to simulate thunderstorm conditions in a conventional laboratory," coauthor William Rison at the New Mexico Institute of Mining and Technology told *Phys.org*. "The sparks in thunderstorms are hundreds of meters to kilometers long, a scale that is orders of magnitude larger than in any laboratory environment. Theorists have been trying to simulate these conditions in computer experiments, and the most plausible results have suggested that the sparks are initiated with relativistic electron avalanches, which is a type of negative breakdown. Our results clearly show that the initiation is with a positive

breakdown, not a negative breakdown."

The results could help scientists better understand how a cloud can generate a current that is powerful enough to cause lightning. Currently, the largest electric fields that have been measured inside thunderstorms are several times weaker than what is needed to break down cloudy air and initiate lightning.

In general, lightning occurs when the positive and negative electric charges in a cloud separate in different parts of the cloud. Charge separation sets the stage for lightning to form either between the negative and positive parts of the cloud (intracloud lightning), or downward to the ground (cloud-to-ground lightning), where it often strikes a tree, telephone pole, or other tall object.

Over the past few decades, researchers have gained a better understanding of how the charges become separated in thunderclouds. Data and simulations show that charge separation occurs when small hail-like particles called "graupel" and ice crystals collide with one another in a cloud. The charges are separated as the heavier graupel particles fall, while the lighter ice crystals are carried upward by updrafts in the turbulent thundercloud. This process is somewhat like how rubbing your feet on carpet separates charges in your body, causing you to produce static electricity when you touch a metal doorknob.

Since the 1990s, one of the leading proposals for lightning formation is that the initial spark comes from relativistic electrons that come from either high-energy cosmic rays or a process called relativistic runaway electron avalanche. However, the new results cast doubt on this idea.

"If relativistic electron showers were the initiating events for [lightning flashes](#), then the motion of the breakdown would be initially upward for intracloud flashes between the mid-level negative and upper positive

charges," Rison explained. "Using a recently developed broadband interferometer to observe the propagation of electrical breakdown in [lightning](#), we found that the propagation direction of narrow bipolar events is downward rather than upward, showing they are caused by downward-developing positive rather than upward-developing negative breakdown."

Both negative breakdown and positive breakdown can move charges, which can intensify the fields at both ends of the cloud. But the data here shows that all flashes for which the interferometer could determine the motion exhibited an initial breakdown that was fast and positive.

The next step is to investigate how fast positive breakdown develops physically. Fast positive streamers have been observed in sprites, a type of electrical breakdown that occurs in the upper atmosphere where the pressure is several orders of magnitude lower than in thunderclouds. The discharge observed here move at the same fast propagation speeds but at lower altitudes and higher pressures.

"Theorists are now trying to determine how fast positive breakdown works at the higher pressures inside thunderclouds," Rison said.

**More information:** William Rison, et al. "Observations of narrow bipolar events reveal how lightning is initiated in thunderstorms." *Nature Communications*. [DOI: 10.1038/ncomms10721](https://doi.org/10.1038/ncomms10721)

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Citation: Scientists find clues to the mystery of what causes lightning (2016, March 1) retrieved 20 March 2024 from <https://phys.org/news/2016-02-scientists-clues-mystery-lightning.html>

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