World-leading research reveals how lightning produces gamma rays

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How lightning produces gamma rays

This observation confirms the hypothesis that terrestrial gamma rays, or TGFs, associated with lightning are the result of a strong electric field accelerating electrons to nearly the speed of light.

In observations made in Kanazawa City, Ishikawa Prefecture, Japan, a team of researchers led by physicist Yuuki Wada of Osaka University used an advanced multi-sensor setup to record lightning strikes in slow motion across multiple wavelengths.

" The ability to study extreme processes like TGFs originating from lightning allows us to better understand the high-energy processes occurring in the Earth's atmosphere ," Wada explains .

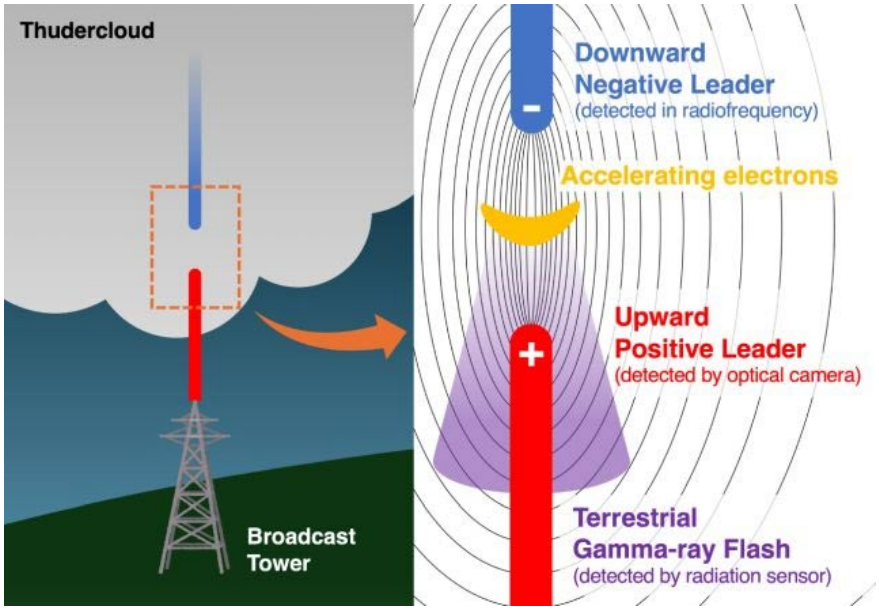
Although cloud-to-ground lightning occurs quickly, it is not instantaneous and requires a path created by a conducting lightning bolt. Air is not naturally a good conductor of electricity, but the buildup of charge in the atmosphere due to storm activity can create a channel of ionized air through which the current can flow. This is a conducting lightning bolt, and they can occur from cloud to bottom or from ground to top.

It is thought that TGFs are the result of electrons accelerating to near the speed of light in strong electric fields created by thunderstorms. These chains are called relativistic runaway electron avalanches and are accepted as the explanation for TGFs.

When electrons suddenly decelerate, deflected by collisions with atomic nuclei in the atmosphere, **the loss of energy manifests itself as gamma rays** - a form of decelerated radiation known as bremsstrahlung radiation.

Researchers have set up a ground-based device to monitor lightning across radio, optical and high-energy wavelengths, which can collect detailed information on microsecond time scales.

Interestingly, their results showed that TGF and lightning do not occur simultaneously; instead, TGF occurs before lightning. But we are talking about extremely small time intervals; to the human eye, they appear to occur simultaneously. Only with modern equipment can we see the reality.



The team observed two main lightning bolts, one negatively charged and swooping down from a thunderstorm cloud to a TV tower on the ground, the other positively charged and curving up from the tower.

Just before the two oppositely charged streams meet, a highly concentrated electric field appears between them, in which the electrons are accelerated to relativistic speeds.

The first gamma-ray photon was detected just 31 microseconds – 31 millionths of a second – before the jets collided. The entire TGF burst lasted until 20 microseconds after the jets met to form the lightning bolt.

This is the first time scientists have observed and recorded this process, providing new and highly detailed insight into **how lightning storms can generate enough energy to produce gamma radiation – the most powerful form of light in the electromagnetic spectrum** .

" The multi-sensor observations made here are the first in the world ," said physicist Harufumi Tsuchiya of the Japan Atomic Energy Agency . " *Although some mysteries remain, this technique has brought us closer to understanding the mechanism of these gravitational radiation bursts* ."

The research was published in the journal Science Advances.