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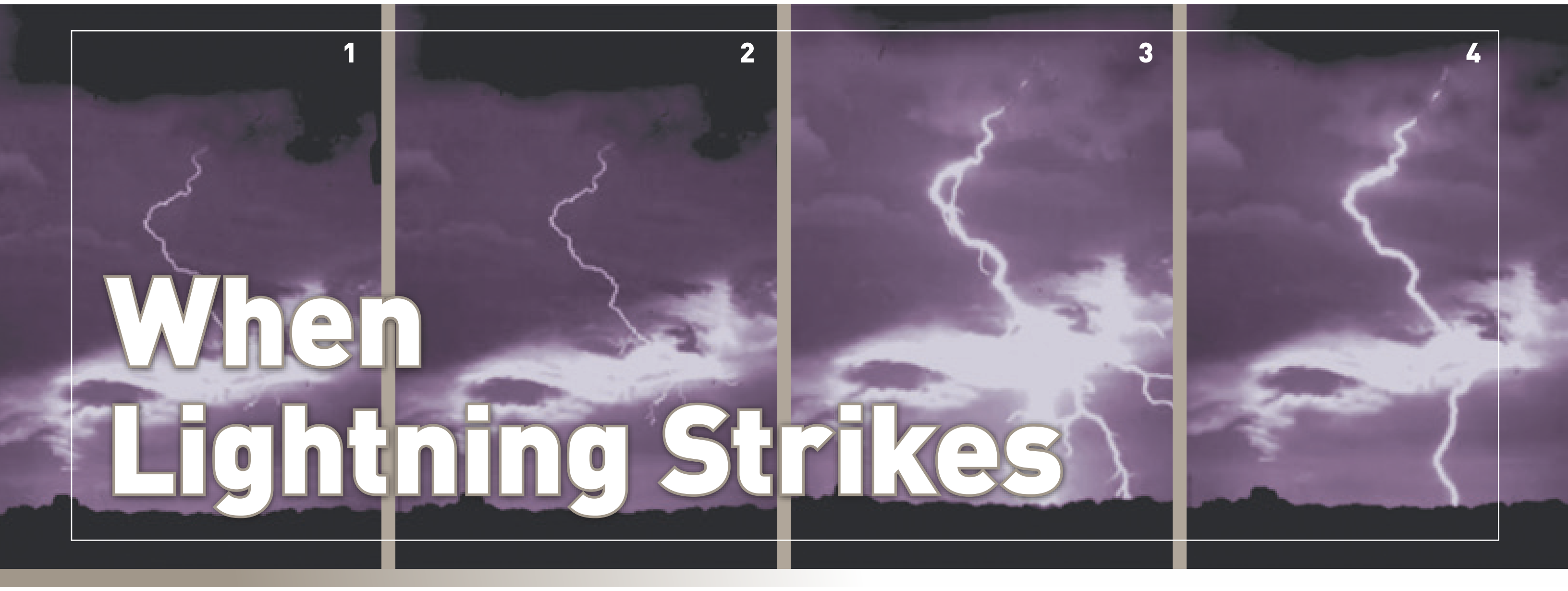


*Lightning is an electrical discharge in the atmosphere. Slow motion video allows scientists to study the build up, release, and dissipation of that discharge.*

# When Lightning Strikes: Florida Institute of Technology Uses High Speed Imagery to Observe Lightning

When you were a child, it's likely your mother urged you to come inside during a storm, especially when there was lightning present. Every year the Earth experiences an average of 25 million lightning strikes during some 100,000 thunderstorms. This equates to more than 100 lightning bolts per second! A typical lightning strike travels at speeds of up to 60 miles per second, and the average length of a single lightning bolt measures between 2-3 miles and can commonly extend as far as 60 miles. A lightning bolt can reach a temperature of roughly 30,000 kelvins – or 53,540 degrees Fahrenheit – hotter than the surface of the sun. This makes lightning one of the most interesting, and dangerous, natural occurrences on our planet. No wonder your mother didn't want you outside during a thunderstorm.

By way of simple definition, lightning is a 'brilliant electric spark discharge in the atmosphere, occurring within a thundercloud, between clouds, or between a cloud and the ground.' Scientists around the globe have been studying the phenomena of lightning for decades to understand weather

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patterns. Recently, this feat has been made easier with the use of high speed imagery from Vision Research, as demonstrated by Dr. Ningyu Liu, Dr. Hamid Rassoul, and a group of Ph.D. students in the Department of Physics and Space Sciences at the Florida Institute of Technology in Melbourne, FL.

Equipped with a Phantom v1210 digital ultrahigh-speed camera from Vision Research, Dr. Liu , Dr. Rassoul, and their students are conducting research in atmospheric electricity by observing and recording lightning strikes. The Phantom v1210 is an excellent camera for this type of project because it has the ability to capture events that are undetectable to the human eye. Thus, it provides large amounts of critical data that the group wouldn't otherwise be able to acquire. At the camera's fullest resolution, it captures images at up to 12,600 frames-per-second, which makes the lightning "visible" to the naked eye so they can properly evaluate and analyze the data.

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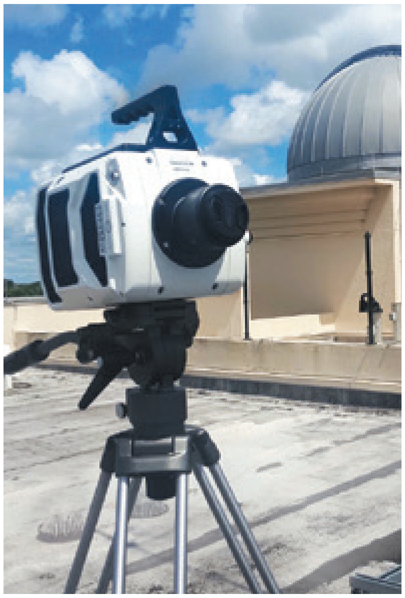
## Lightning and Jets and Sprites, Oh My

This project, at Florida Institute of Technology, is part of a grant funded by the National Science Foundation. Dr. Ningyu Liu, an Associate Professor, wrote the grant proposal because he wanted to be able to study not just lightning, but also the gigantic, high-altitude discharges known as jets and sprites. The jets and sprites are part of a larger subgroup of atmospheric electric discharges called transient luminous events, or TLEs. In contrast to lightning, these discharges are much fainter and typically occur for less time than a typical lightning flash. In fact, sprites were so elusive that they weren't actually confirmed as a phenomenon until the late 1980s.



*Phantom v1210 digital ultrahigh-speed camera.*

For example, gigantic electrical jets emanate upward from the tops of thunderstorms, and jellyfish-shaped sprints spring to life in the upper atmosphere in response to lightning below the clouds. TLEs uniquely establish a physical (electrical) connection between the troposphere (which is where we live) and the lower ionosphere (an electrically charged region 37 to 56 miles above ground). The ionosphere is charged because atoms in this area are ionized (their electrons are removed) by incoming solar wind. Studying the charged ionosphere is important because the freed ions affect radio communication. For example, if we were to get a big solar storm, our GPS systems would probably stop working because the signal would get too scrambled on its way down to Earth.

# Employing the Phantom v1210

The lightning strikes are being recorded from both inside and on top of buildings on the university campus – mostly from inside the Geospace Physics Laboratory. The Phantom v1210 is essential to capturing the action, especially with its proprietary wide-screen CMOS sensor. Julia Tilles, a Ph.D. student member of the research team, explained that the v1210 is being used at the highest frame rate possible that allows the team to account for the large spatial extent of lightning, all while recording at up to 22 gigapixels-per-second.

"We're limited to roughly 100,000 fps because moving to a higher frame rate would make our field of view just too small. At higher frame rates and lower resolution, a lightning channel comes into and out of the frame so fast that we just wouldn't get a lot of information and would have a much lower chance of capturing something in the field of view. The camera's maximum FPS can be as high as 570,000 FPS, but pushing the camera to perform at that rate doesn't give us a good time-resolution to spatial-resolution trade-off. Still, we are experimenting with shooting at slightly higher frame rates," she said.

*Julia Tilles and the graduate research team monitor incoming weather conditions on the roof of a campus building.*

The camera captures data that allows the team to examine electric field measurements and deduce the corresponding orientation of the channel and the direction of the current. "The v1210 is an incredibly sophisticated camera. When we shoot between 7,000 fps to 12,000 fps, we're able to see some of the finer details of a lightning flash, such as branching and leader propagation. This resolution is high enough for us to see many elusive processes taking place below the cloud, and it gives us a nice, full picture. We can also use other data sets, such as the National Charge-Moment Change Network (CMCN), to quantify charge moved during a lightning strike to ground," Tilles said.

Along with the v1210, the research team uses other sophisticated technology, such as LMA data, NEXRAD radar data, X-ray data, electric field data, charge-moment-change data, and NLDN data to further evaluate the videos they capture. "This combination allows us to do things like relate different types of electrical discharges (gigantic jets) to storm dynamics and charge distribution in the storm, as well as relate propagation processes to X-ray generation. It's also important to note that the high-speed videos from the camera become a data set that we can use for future studies as they arise," she described.

Having never used a high-speed digital camera of this caliber before, the team is impressed with the Phantom's simplicity and straightforward functionality. "The camera is working beautifully and it's really simple to operate. If there's one challenge we face, it's that we're often operating in near-pitch black at night, but the camera's low light feature helps tremendously with this during setup," she explained.

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Low-light functionality is one of the unique features of the Phantom v1210. The camera's custom-designed sensor includes 28 micron pixels, which ensure superb light-sensitivity as this is crucial to ultrahigh-speed imaging. Also, the v1210's standard 12-bit depth per pixel yields high dynamic range and provides excellent image quality.

Tilles feels privileged to be working on such a dynamic and forward-thinking project with Dr. Liu and her fellow Ph.D. students and she's excited about what the future holds. "This project would absolutely not be possible without a high-speed camera. I'm so grateful to live in an era where technology this advanced is available and accessible to university programs like ours. It's a true game changer, and it's made all the difference in our research."

## About the Department of Physics and Space Sciences:

The Department of Physics and Space Sciences at Florida Tech offers students a solid foundation in the physical sciences with the personalized attention of our 16 full-time faculty. The department was the first in the country to offer a degree in Space Sciences, and it is still among only a handful that offers this degree today. Graduates obtain employment at NASA, in the private-sector industry, and in academia. The department offers students unique, real-world learning opportunities in a range of areas including: Astronomy & Astrophysics, High-Energy Particle Physics, Space Physics & Space Weather, Lightning Research, Astrobiology, and Planetary Science.

Videos of the study can be seen on YouTube at:

**www.bit.ly/PhantomScience**

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