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# Physics Experiments Take Images ‘Back in Time’

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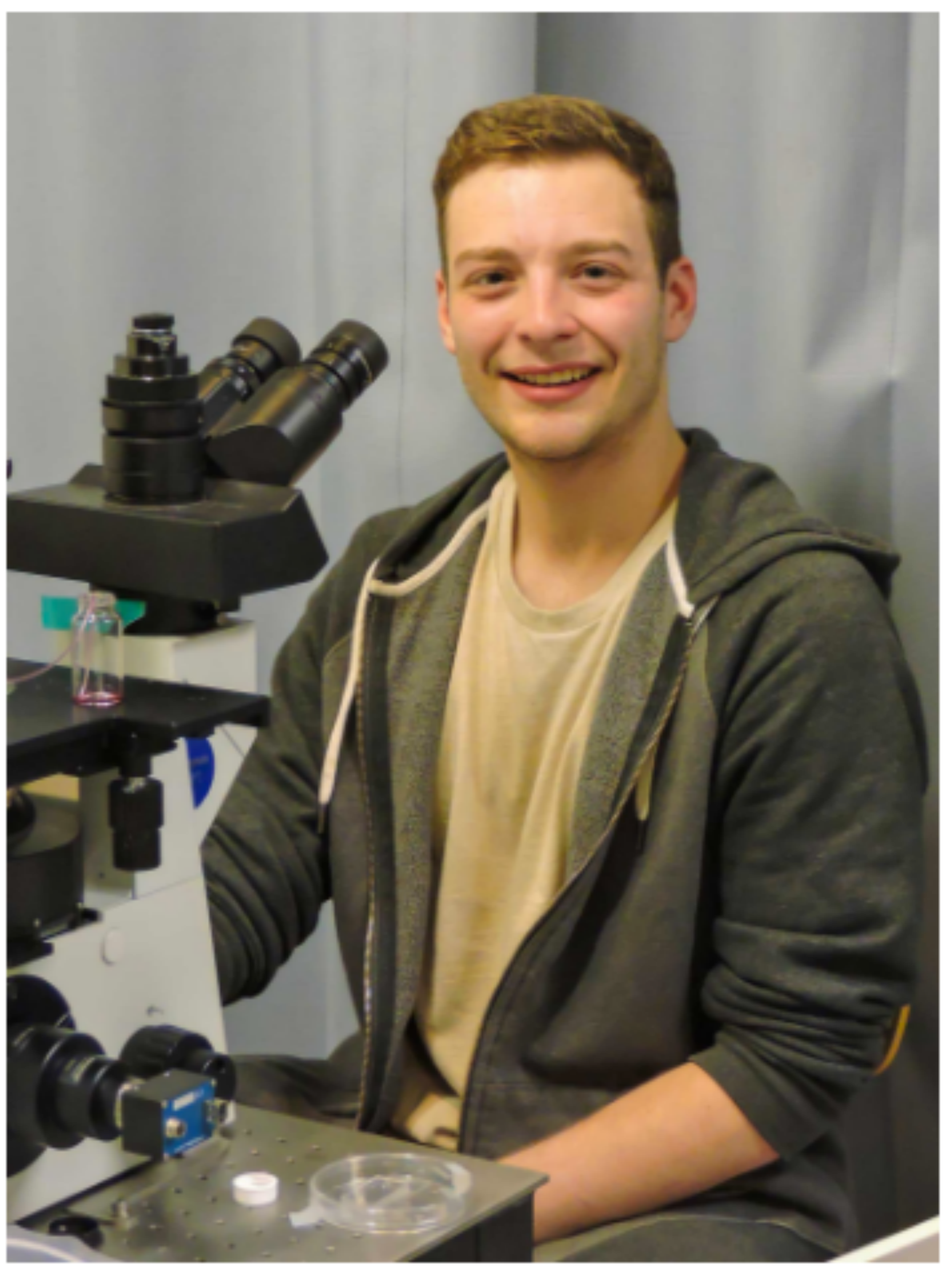
BLOOMINGTON, Ill.— An international team of physicists including Illinois Wesleyan University Professor of Physics Gabe Spalding has shown waves of light can seem to travel back in time.



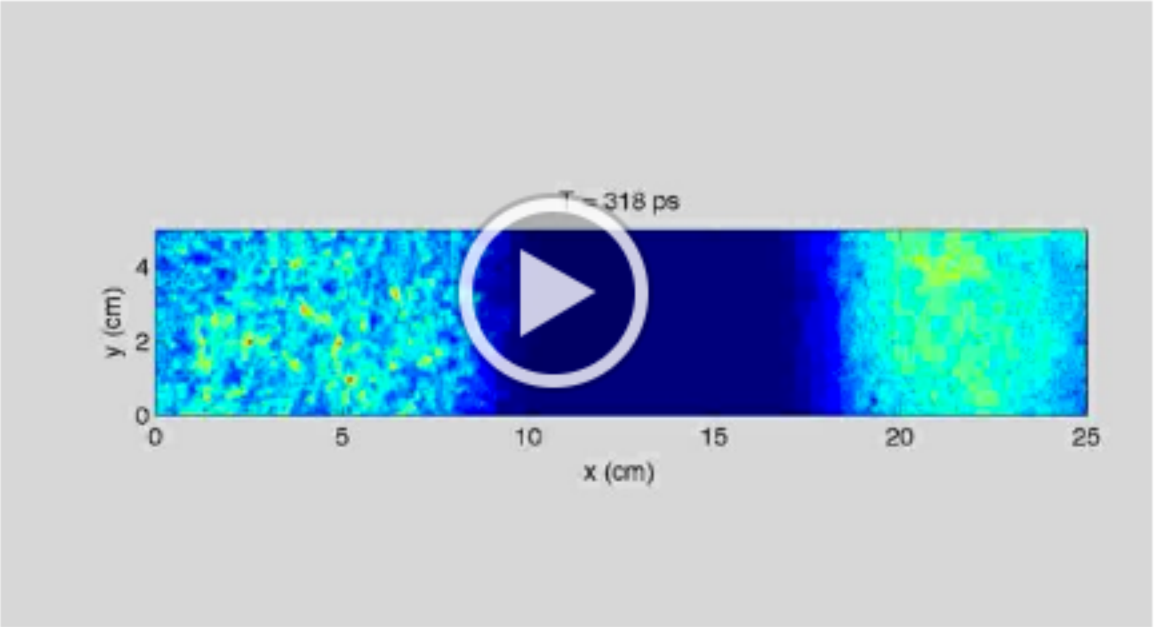
Joseph Richards '16 says being a co-author of this research has catapulted him into the next level of graduate study.

It may seem like science fiction, but the experiment did not violate the laws of physics. Spalding, his physics student Joseph Richards '16 and a team of scientists tackled a century-old intuition from Lord Rayleigh regarding the speed of sound. Rayleigh theorized that music being played on an object traveling faster than the speed of sound, a supersonic jet for example, would result in a listener hearing the music playing in reverse. The Spalding team simulated what an observer standing still would see when looking at a superluminal (faster than the speed of light) occurrence. The results of the scientists' experiment, conducted last summer at Heriot-Watt University in Edinburgh, Scotland, have been published in Science Advances.

"The existence of an absolute limit, the speed of light, is the natural source of the question: what would happen if we cross this limit?" lead author Mattero Clerici told a writer for a post on IFLScience. "Light sources, however, may move faster than the speed of light when their speed is not associated with the physical motion of matter. Following this line of thought, we devised a way to experimentally investigate the [effects] of superluminal motion."

The B. Charles and Joyce Eichhorn Ames Professor of Physics at Illinois Wesleyan, Spalding has long worked with advanced imaging, and came up with the idea for studying superluminal spot motion and mathematically determined the conditions for observing time reveals and spot pair creation and annihilation. Using a new sort of camera based upon an array of single-photon avalanche diodes (SPADs), researchers captured scattered laser light by shining ultra-short laser pulses at different points on the screen. Researchers were able to create a live video of the light traversing the surface in picoseconds (a picosecond is a unit of time equal to one trillionth of a second). "This is incredible in its own right," said Richards, who was tasked with verifying that the light sources had indeed moved at superluminal speed.

The experiment showed pairs of images forming and annihilating each other. In a video of the experimental results, virtual spot pair annihilation corresponds to a spot source changing its speed and crossing the boundary between sub- and superluminal speed. "A local observer would report that the wavefront is moving from left to right at every point, but once the spot becomes superluminal, there is time reversal," said Spalding.




A video of the experimental results

He described a further phenomenon in the experiment where a local observer would report a wavefront that is always moving from left to right, but the time reversal associated with the transition to superluminal velocities gives rise to detection of a pair of spots – one moving forward in time and one moving backward in time.

The new findings might have applications far beyond the ultra-high-speed cameras. Spalding said faster-than-light imaging will open many areas of scientific inquiry. "For example, it may play an important role in new, advanced forms of microscopy based upon very rapid signals from fluorescently tagged biomolecules," said Spalding.

For Richards, however, the impact has been immediate.

Spalding, center, works to bring hands-on science to the very young at a Young Scholars Science Camp at IWU.

"To have a publication of this magnitude to my name before the end of my undergraduate career is quite rare," said Richards. "My experience with Dr. Spalding both here at Illinois Wesleyan and in Scotland has most certainly catapulted me into the next level of graduate study and I am forever grateful to both him and the University."

For more than a decade Spalding has traveled to Scotland in the summer to work with cross-functional teams of scientists and engineers, often accompanied by Illinois Wesleyan students such as Richards. A native of Glenview, Ill., Richards said he was both "absolutely terrified but also excited" to work in a lab with Spalding's longtime collaborators in Scotland. "However, Dr. Spalding was very helpful in settling me into my new position, and we quickly hit the ground running."

In Scotland Richards said he learned a great deal pertaining to the process of academic research. "I feel I have a strong grasp on the process from start to finish and feel confident that I can be a benefit to research groups in the future," said Richards, who will enter the master's program in electrical and computer engineering at the University of Illinois Urbana-Champaign this fall.

Spalding is currently on sabbatical in Scotland, where he has been working on yet another version of array-based versions of SPADs. He has been promoting educational versions of such detectors as a cornerstone to a new generation of instructional labs in modern physics. To date, he has shipped 420 such SPADS to colleges and universities across the country. Spalding's leadership in making this equipment available across the country, and his research in the field of optical micromanipulation was detailed in an IWU Magazine article.