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future is here

IIT-I innovation captures explosions like never before

Our Staff Reporter
INDORE

In a significant stride towards innovation in high-speed imaging, IIT Indore in collaboration with the Defence Research and Development Organisation (DRDO) has developed a groundbreaking technique which promises to transform the way we visualize and understand explosive events, making it a game-changer in fields like aerospace, defence, and industry.

The research is led by Prof Devendra Deshmukh, a faculty at IIT Indore.

Imaging fast-moving particles during explosive events has long been a challenge for scientists. Traditional techniques, such as Shadowgraphy, Schlieren, and X-ray imaging, offers a minimum exposure time of only about 1 microsecond—to capture images.

The research team

"This is a very-high exposure time (as compared to the speed of the phenomena) and often results in blurred images resulting in loss of details, leaving researchers with incomplete information of high-speed phenomena. Yet, understanding the behaviour of these fast-moving objects and phenomena is critical, especially in sectors where safety and precision are paramount, such as defence and aerospace," Deshmukh said.

To address this challenge, Deshmukh and his team have developed a novel imaging method using the principles of Digital Inline Holography.

This approach allows for a much sharper and more detailed visualization of objects even in dust or combustion cloud, something that was previously difficult to achieve.

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The captured images not only provide clear picture to the researchers, but also make it possible to accurately extract a wealth of information about the objects' velocity, acceleration, and distribution in space. This level of detail is essential for researchers who need to understand not just where the objects are, but how they move and behave in the chaotic aftermath of an explosion.

IIT Indore director Prof Suhas Joshi said "What makes this method truly stand out is its ability to significantly enhance time resolution. While conventional methods were limited to 1 microsecond exposure times, this new technique can capture images with exposure times as low as 50 nanoseconds. The system is capable of recording up to 700,000 frames per second, giving researchers a real-time look at how particles behave during an explosion. This dramatic increase in time resolution allows for far more detailed tracking of fast-moving objects, even in environments filled with dust, smoke, or other visual obstructions."

Prof Deshmukh said "At the core of this innovation is a high-frequency (HF) light source. This particular light source has been specifically chosen for its ability to penetrate the dense dust clouds. By incorporating the high-speed laser in the optics setup for illumination, our team has overcome one of the biggest limitations of previous methods: poor visibility in obscured environments. Now, even in the midst of dust and fire, the system can capture crisp, clear images of high-speed particles in motion."

The laser light system has adjustable pulse widths starting from as low as 10 nanoseconds. This flexibility allows researchers to adapt the system to various experimental setups, making it versatile enough for a wide range of high-speed events. Whether the task is studying the dynamics of a detonation or analyzing the impact of high-speed particles on materials, this technique provides a level of detail and accuracy that was previously unattainable.

The implications of this breakthrough extend far beyond the laboratory. In defence research, for example, the ability to clearly visualize and analyze the behaviour of fragments after an explosion can lead to improvements in both offensive and defensive technologies. This breakthrough is equally valuable to the aerospace industry, where high-speed imaging is essential for studying everything from fuel spray patterns to the impact of debris on spacecraft.

In industrial applications, the technique can be used to analyze high-speed processes like material cutting, spray formation, and fluid dynamics in manufacturing settings. The insights gained from such studies could lead to more efficient processes and higher-quality products, further demonstrating the versatility and far-reaching impact of this technology.

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