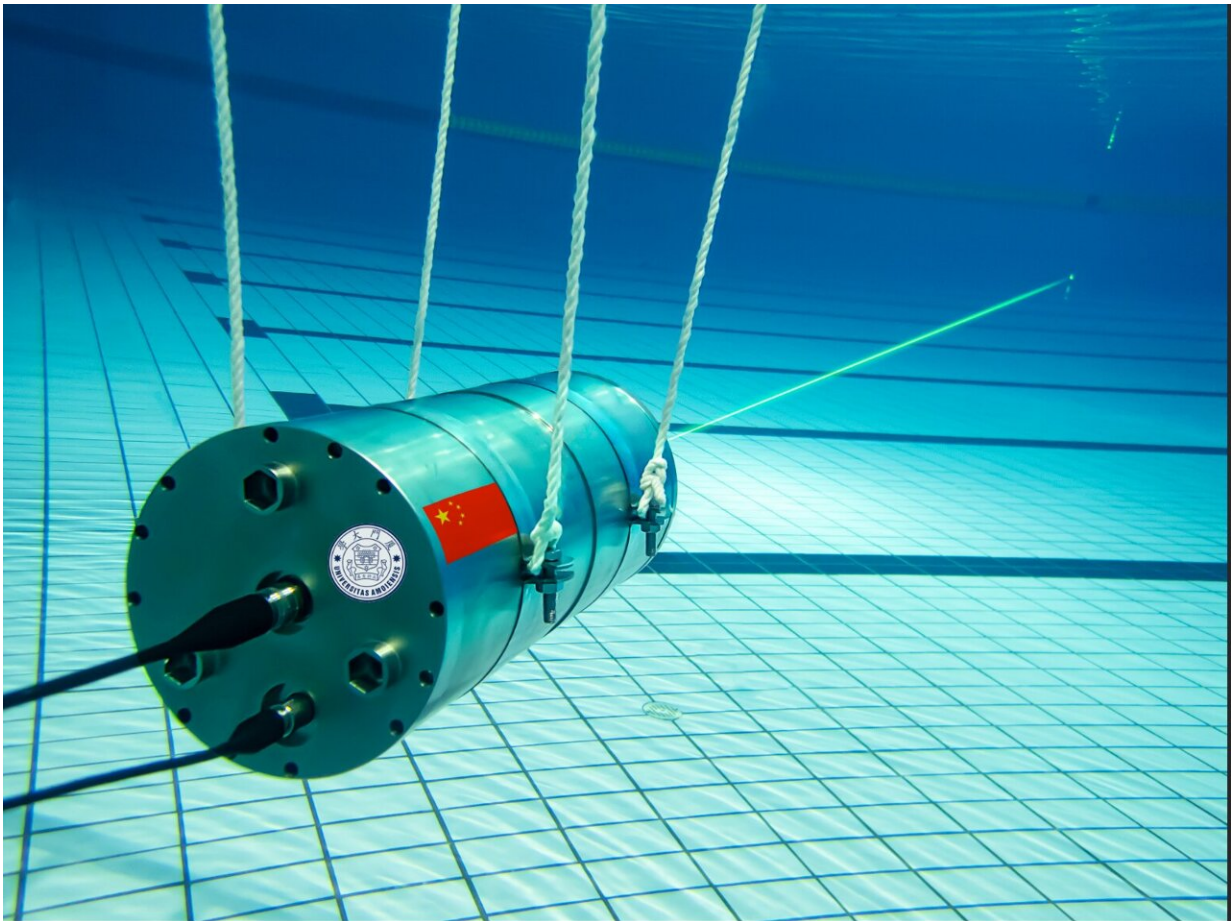


New single-photon Raman lidar is practical for underwater applications

June 29 2023



Researchers developed a single-photon Raman lidar system that operates underwater and can remotely distinguish various substances. They demonstrated the system by using it to detect varying thicknesses of gasoline oil in a quartz cell that was 12 meters away from the system in a large pool. Credit: Mingjia Shangguan, Xiamen University

Researchers report a new single-photon Raman lidar system that operates underwater and can remotely distinguish various substances. They also show that the new system can detect the thickness of the oil underwater up to 12 m away, which could be useful for detecting oil spills.

"Differentiating substances in water and detecting their distribution characteristics in the ocean are of great significance for marine monitoring and [scientific research](#)," said research team leader Mingjia Shangguan from Xiamen University in China. "For instance, the remote sensing of underwater oil that we demonstrated could be useful for monitoring leaks in underwater oil pipelines."

Although lidar approaches based on Raman signals have been previously used for detection of underwater substances, existing systems are impractical because they are bulky and require large amounts of power.

In the journal *Applied Optics*, the researchers describe their new lidar system, which uses just 1 μJ of pulse energy and 22.4 mm of receiver aperture. The entire lidar system is 40 cm long with a diameter of 20 cm and can be operated up to 1 km underwater. To boost sensitivity, the researchers incorporated single-photon detection into their compact underwater Raman lidar system.

"Mounting an underwater Raman lidar system on an [autonomous underwater vehicle](#) or remotely operated vehicle could enable monitoring for leaks in underwater oil pipelines," said Shangguan. "It could potentially also be used to explore oceanic resources or be applied in detecting seafloor sediment types, such as coral reefs."

Single-photon sensitivity in underwater lidar

Traditional lidar systems designed to operate above water on ships, aircraft or satellites can achieve large-scale ocean profiling, but their

detection depth is limited, especially during rough sea conditions. Raman lidar systems, however, can be used for analysis underwater at different depths without being affected by sea conditions.

Raman lidar works by emitting a pulse of green laser light into the water that interacts with substances such as oil. This excites inelastic Raman signals that can be used to identify substances. By measuring the intensity of Raman signals at specific wavelengths, lidar can provide information about the oil content in the water.

"Traditional Raman lidar systems rely on increasing laser power and telescope aperture to achieve remote sensing detection, which leads to a large system size and high-power consumption that make it difficult to integrate lidar systems onto underwater vehicles," said Shangguan. "The use of single-photon detection technology made this work possible by improving detection sensitivity to the level of single photons."

The researchers demonstrated their new lidar system by using it to detect varying thicknesses of gasoline oil in a quartz cell that was 12 m away from the system. Both the lidar system and the quartz cell were submerged at a depth of 0.6 m underwater in a large pool. The lidar system was able to detect and distinguish all thicknesses of gasoline, which ranged from 1 mm to 15 mm.

The researchers are now working to increase the number of detection channels and the Raman spectral resolution of the single-photon [lidar](#) system to enhance its ability to distinguish different substances in water. This would allow it to be used to analyze underwater bubble types and to detect corals and manganese nodules.

More information: Mingjia Shangguan et al, Remote sensing oil in water with an all-fiber underwater single-photon Raman lidar, *Applied Optics* (2023). [DOI: 10.1364/AO.488872](https://doi.org/10.1364/AO.488872)

Provided by Optica

Citation: New single-photon Raman lidar is practical for underwater applications (2023, June 29)
retrieved 30 April 2024 from

<https://phys.org/news/2023-06-single-photon-raman-lidar-underwater-applications.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.