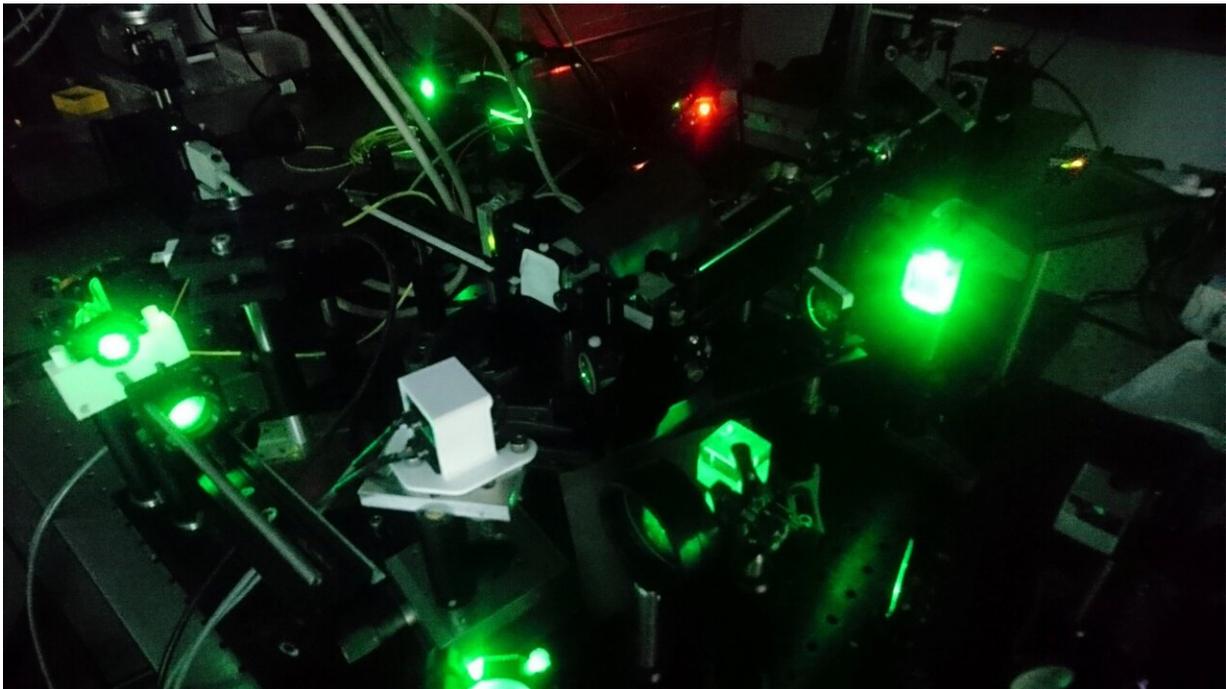


# Tiny lensless endoscope captures 3-D images of objects smaller than a cell

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Researchers have developed a new self-calibrating endoscope that produces 3D images of objects smaller than a single cell. Credit: J. Czarske, TU Dresden, Germany

Researchers have developed a new self-calibrating endoscope that produces 3-D images of objects smaller than a single cell. Without a lens or any optical, electrical or mechanical components, the tip of the endoscope measures just 200 microns across, about the width of a few

human hairs twisted together.

As a minimally invasive tool for imaging features inside living tissues, the extremely thin endoscope could enable a variety of research and medical applications. The research will be presented at the [Frontiers in Optics + Laser Science \(FIO + LS\)](#) conference, held September 15-19 in Washington, D.C., U.S.A.

According to Juergen W. Czarske, Director and C4-Professor at TU Dresden, Germany and lead author on the paper: "The lensless fiber endoscope is approximately the size of a needle, allowing it to have minimally invasive access and high-contrast imaging as well as stimulation with a robust calibration against bending or twisting of the fiber." The endoscope is likely to be especially useful for optogenetics—research approaches that use light to stimulate cellular activity. It also could prove useful for monitoring cells and tissues during medical procedures as well as for technical inspections.

## **A self-calibrating system**

Conventional endoscopes use cameras and lights to capture images inside the body. In recent years researchers have developed alternative ways to capture images through optical fibers, eliminating the need for bulky cameras and other bulky components, allowing for significantly thinner [endoscopes](#). Despite their promise, however, these technologies suffer from limitations such as an inability to tolerate temperature fluctuations or bending and twisting of the fiber.

A major hurdle to making these technologies practical is that they require complicated calibration processes, in many cases while the fiber is collecting images. To address this, the researchers added a thin glass plate, just 150 microns thick, to the tip of a coherent fiber bundle, a type of [optical fiber](#) that is commonly used in endoscopy applications. The

coherent fiber bundle used in the experiment was about 350 microns wide and consisted of 10,000 cores.

When the central fiber core is illuminated, it emits a beam that is reflected back into the fiber bundle and serves as a virtual guide star for measuring how the light is being transmitted, known as the optical transfer function. The optical transfer function provides crucial data the system uses to [calibrate itself on the fly](#).

## **Keeping the view in focus**

A key component of the new setup is a [spatial light modulator](#), which is used to manipulate the direction of the light and enable remote focusing. The spatial light modulator compensates the optical transfer function and images onto the fiber bundle. The back-reflected light from the fiber bundle is captured on the camera and superposed with a reference wave to measure the [light's](#) phase.

The position of the virtual guide star determines the instrument's focus, with a minimal focus diameter of approximately one micron. The researchers used an adaptive lens and a 2-D galvometer mirror to shift the focus and enable scanning at different depths.

## **Demonstrating 3-D imaging**

The team tested their device by using it to image a 3-D specimen under a 140-micron thick cover slip. Scanning the image plane in 13 steps over 400 microns with an image rate of 4 cycles per second, the device successfully imaged particles at the top and bottom of the 3-D specimen. However, its focus deteriorated as the galvometer mirror's angle increased. The researchers suggest future work could address this limitation. In addition, using a galvometer scanner with a higher frame

rate could allow faster image acquisition.

"The novel approach enables both real-time calibration and imaging with minimal invasiveness, important for in-situ 3-D imaging, lab-on-a-chip-based mechanical cell manipulation, deep tissue in vivo optogenetics, and key-hole technical inspections," said Czarske.

**More information:** "Fast 3D Imaging with Lensless Holographic Endoscopy Employing Coherent Fiber Bundles," by Juergen W. Czarske, Elias Scharf, and Robert Kuschmierz, will be presented Monday, 16 September 2019, at 11:15 a.m. EDT in Room Washington 6 of the Marriott Wardman Park hotel in Washington, D.C. [fio-  
ls2019.abstractcentral.com/s/u/8R1Y9w8UtAo](https://phys.org/news/2019-08-tiny-lensless-endoscope-captures-d.html)

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