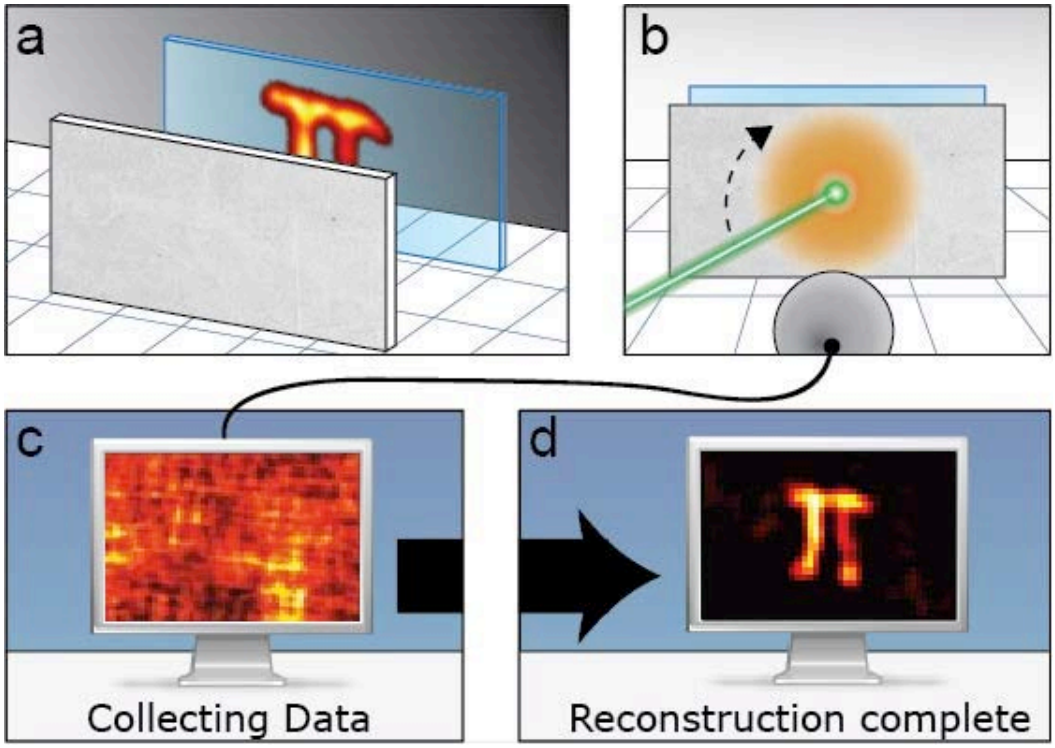
Prestigious publication by nanotechnology group from the Netherlands

Looking through an opaque material

A team of researchers from the Netherlands and Italy has succeeded in making sharp pictures of objects hidden behind an opaque screen. This breakthrough in research has been published in the world-leading research journal *Nature*.

Looking through an opaque material



(a) The test object used was the Greek letter "π", written in fluorescent ink and 100x smaller than the one printed here. The test object was covered by a strongly scattering ground-glass diffuser that completely hid it from view.
(b) A laser beam was then scanned in angle, always hitting the diffuser in the same spot. The test object only yielded a diffuse glow of fluorescent light.
(c) The intensity of this fluorescence was measured versus the angle of the laser beam and recorded by a computer. The seemingly random pattern bears no resemblance to the test object.
(d) The computer then searched for similarities in the measured pattern which are used to calculate the true shape of the test object.

Materials such as skin, paper and ground glass appear opaque because they scatter light. In such materials light does not move in a straight line, but travels along an unpredictable and erratic path. As a result, it is impossible to get a clear view of objects hidden behind such materials. Powerful methods have been developed to retrieve images through materials in which a small fraction of the light follows a straight path. To date, however, it has not been possible to resolve an image from light that has been completely scattered.

A team from the MESA+ Institute for nanotechnology at the University of Twente in the Netherlands has now succeeded in doing just this. The researchers, led by Dr. Allard Mosk, scanned the angle of a laser beam that illuminated an opaque diffuser. At the same time, a computer recorded the amount of fluorescent light that was returned by a tiny object hidden behind the diffuser. Dr. Mosk point out that: "While the measured intensity of the light cannot be used to form an image of the object directly, the information needed to do so is in there, but in a scrambled form. The two young scientists who are the

first authors of this paper had the brilliant idea to find out whether that scrambled information is sufficient to reconstruct the image – and they found a way to do so." Their method involves a computer program that initially guesses the missing information, and then tests and refines the guess. They succeeded in making an image of a hidden fluorescent object just 50 micrometers across – the size of a typical cell.

The researchers expect their work to lead to new microscopy methods capable of forming razor sharp images in a strongly scattering environment. Allard Mosk notes that: "This will be very useful in nanotechnology. We would like to bring structures to light that are hidden inside a complex environments like computer chips". They also dream of extending their method to examine objects under the human skin. "But for the moment", says Dr. Mosk, "our method is too slow for that."

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Details of the paper:

The Research Letter "Non-invasive imaging through opaque scattering layers" was authored by Jacopo Bertolotti, Elbert .G. van Putten, Christian Blum, Ad Lagendijk, Willem L. Vos and Allard P. Mosk, of the Complex Photonic Systems (COPS) research group of the MESA+ Institute for Nanotechnology at the University of Twente in the Netherlands. Jacopo Bertolotti is also affiliated to the University of Florence and Ad Lagendijk is also affiliated to the FOM-institute AMOLF in Amsterdam. Christian Blum is affiliated to the Nanobiophysics (NBP) research group of the MESA+ Institute for Nanotechnology at the University of Twente in the Netherlands. Elbert van Putten and Jacopo Bertolotti contributed equally to this work.

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