Researchers demonstrate for the first time how light squeezes through small holes

How does light pass through a tiny hole" For the first time, Dr Aurele Adam and Prof. Paul Planken of Delft University of Technology, in conjunction with two South Korean and one German research groups, have succeeded in mapping this process properly.

Their research also promises a significant improvement in Terahertz microscopy in the long term, a potentially interesting new imaging technique, and Terahertz microspectroscopy, a technique for identifying tiny quantities of substances using light. Their findings will be published in the scientific journal *Optics Express* this week.

We know from physics that it is particularly difficult to pass light through a hole smaller than half the wavelength of the light used. With the help of fellow scientists, researchers at Delft University of Technology have managed to provide insight into this process by conducting measurements using what is known as Terahertz radiation (THz radiation). This is far-infrared light with an approximate frequency of 1012 Hz.

This type of radiation allows the researchers to measure the force of the penetrating light's electrical field near the hole and not, as is usual, the intensity of the penetrating light. The electrical field's values reveal much more about how light behaves in such situations than intensity can. Measurement of the strength of the electrical field is done with great precision by measuring the refractive-index of a crystal near the hole using a laser beam.

The crystal's refractive index varies (very slightly) when in a variable electrical field. By measuring the variations in the refractive index, conclusions can be drawn on the strength of the light's electrical field near the hole.

'This process has never been mapped properly, mainly because the technology was not available to do so,' says Planken. The experiments largely confirm, for the first time, what is known as the Bouwkamp model, named after a Dutch researcher who worked at Philips and who in 1950 created a theoretical model for the way in which light passes through small holes. For instance, the strength of the electrical field, as predicted by Bouwkamp, is greatest at the edge of the holes and the field's strength indeed decreases in with decreasing frequency of the THz light used.

In their experiments, the researchers also discovered that even if the hole is up to fifty times smaller than the wavelength used, sufficient light can pass through to allow measurements near the hole; an extremely difficult task using other methods. This technique has also enabled the researchers to record the entire process, allowing them to observe, slowed down a thousand billion (1012) times, how the light exits the hole and subsequently how the light waves move outwards in the same way as ring-shaped ripples caused by a stone thrown into a pond.

The findings of Planken and his colleagues are not just significant from the point of view of fundamental science. They can help develop the use of Terahertz microscopy (THz). In the long term, Planken wishes to use the tiny holes as an improved source of THz light. The smaller these source holes become, the sharper the images that can be created using this technique and the easier it will be to measure small quantities of substances.

Terahertz radiation (with a frequency of about 1012 Hz) is a type of electromagnetic radiation which is

increasingly used to create images. After all, many materials, such as paper, plastics and clothing, are transparent to THz radiation, while they block visible light.

Terahertz microscopes do not yet provide such sharp images. The development of stronger and smaller sources and more sensitive detectors will improve the viability of creating images of, for example, biological cells using THz radiation.

Source: Delft University of Technology