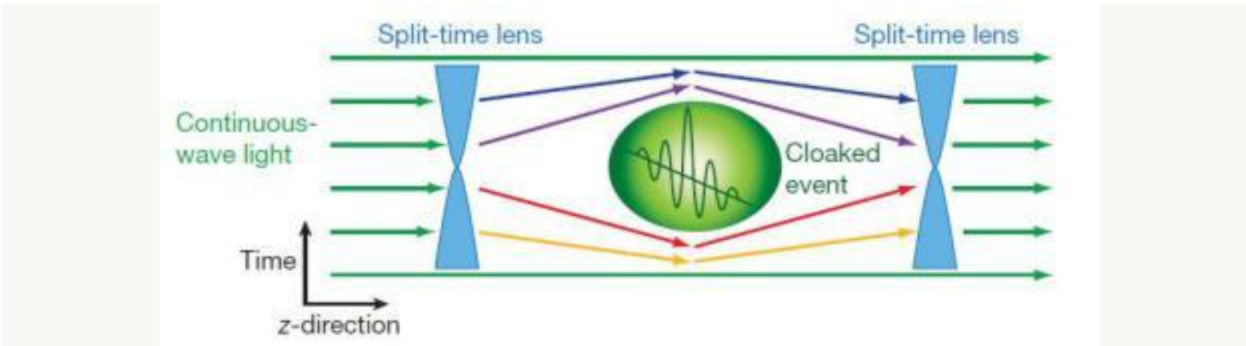
THE CLOAK THAT HIDES EVENTS IN TIME



The temporal cloak. A light beam of a single colour is directed at a split-time lens (STL) that converts it into different colours. As the beam then propagates through an optical fibre, the blue light components travel faster than the red ones (the vertical axis shows time), so that eventually a brief gap is formed in the travelling beam during which there is no light present. Therefore, any even taking place during that temporal gap will be concealed from the beam. Afterwards, a reverse process restores the original beam so that an observer does not notice the cloaking device. Reprinted by permission from Macmillan Publishers Ltd. Nature (2012). doi:10.1038/nature10695

Devices that conceal objects from an observer are called cloaks. Conceptually, the idea of cloaking devices has its roots in science fiction, but such devices have indeed been demonstrated in the past few years. These cloaks are based on tiny structures that are able to bend light on predetermined paths as it passes through the structure. This is like a lens, but consisting of manmade materials, and much more versatile and powerful.

A very different type of cloak has now been published in *Nature* by Alexander Gaetaand colleagues from Cornell University. Following earlier theoretical proposals, they have now demonstrated the first temporal cloak where events are hidden in time, not in space so that an event is concealed from a light beam travelling through the same space for a certain amount of time. To understand the difference of a temporal to a spatial cloak, Robert Boyd and Zhimin Shi from the University of Rochester make a very good comparison in their News and Views article on the paper:

"The distinction between temporal and spatial cloaking can be understood in terms of a metaphor involving automobile traffic. A spatial cloak acts like a junction in the form of a 'cloverleaf' interchange or flyover, in which the traffic is guided (by slip roads) to bend around a certain region of space. After passing through the junction, the traffic continues in the same direction as if the junction did not exist. By contrast, a temporal cloak behaves like a railway crossing. Traffic is stopped when a train passes, forming a gap in the traffic. After the train has passed the crossing, the stopped cars speed up until they catch up with the traffic in front of them, and the fact that a train has crossed the intersection cannot be deduced by observing the traffic flow."

The realization of such a cloak requires a number of steps. First of all, it isn't easy to completely halt the propagation of light and then carry on as before in a way similar to traffic at a crossing. But what is possible is to create a gap in the traffic whilst it is flowing by making some of the cars go slower and others go faster.

In the actual device, cloaking starts when a beam of a single colour is directed at a so-called split-time lens (STL), which basically broadens the colour range of the original beam. For example, a green light beam would be converted into blue and red colours. This is a key step for the device, because it is relatively easy to make the beam components with different colours go either faster or slower – this kind of manipulation is routinely done in optical fibres. Here, in the optical fibre blue rays are made to travel faster and red ones slower. Eventually, the blue ones race far enough ahead so that the red ones can't keep up and a gap forms in the middle of the beam where there is no light. Any event happening within this gap is going to be unnoticed by the light beam. Afterwards, once the zone of interest it passed, an inverse process first brings the different colours back together and then reinstates the original, single-colour light beam. The temporal cloaking is complete.

However, before we get too excited here (and I imagine that these cloaks will get quite some attention in the media), here are a few things that the device as demonstrated here does not do: first of all, it only works for a single colour. Also, it only works for a short moment – about 110 picoseconds (around a ten billionth of a second), although temporal gaps ten times longer should be feasible. And finally, the cloak only works for a small volume in a complicated experimental setup. This is nothing to carry around, so it won't make anyone disappear for certain amounts of time, and it certainly isn't a time-machine either and never will be.

With these caveats out of the way, scientifically this is certainly an intriguing demonstration because not only complement temporal cloaks nicely the spatial ones and realize a new concept of light manipulation, but they also could find some real-world applications – even if these probably will be less head-line grabbing. For example, the in initial operation of the STL needs to be triggered by a short optical pulse. This possibility to control the operation of the cloak can be used in optical communications and data processing to selectively turn the cloak on and off so that light pulses carrying data are either processed (cloak off) or left alone (cloak on). But this is certainly something left for future research. As with any new research field, we don't really know where these cloaks will take us, and certainly this is the exciting part.

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