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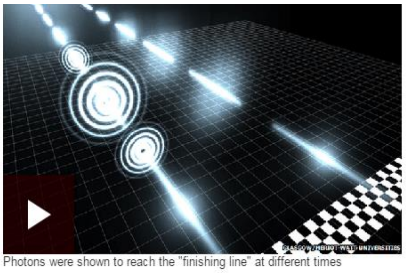
## Scientist slow the speed of light

A team of Scottish scientists has made light travel slower than the speed of light.

They sent photons - individual particles of light - through a special mask. It changed the photons' shape and slowed them to less than light speed.The photons remained travelling at the lower speed even when they returned to free space.The experiment is likely to alter how science looks at light.



Photons were shown to reach the "finishing line" at different times

The collaborators - from Glasgow and Heriot-Watt universities - are members of the Scottish Universities Physics Alliance. They have published their results in the journal Science Express. The speed of light is regarded as an absolute. It is 3.0 x $10^8$ metres per second in free space. Light propagates more slowly when passing through materials like water or glass but goes back to its higher velocity as soon as it returns to free space again.

Or at least it did until now. Two and a half years ago, the experimenters set out to see if they could slow down light just a little and keep it moving more slowly. In a laboratory at Glasgow university, Dr Jacquiline Romero, Dr Daniel Giovannini and colleagues built what amounts to a racetrack for photons, the individual particles of light.

### Photon race

Then they raced them in pairs. One photon they left in its normal state. The other photon was sent through a special mask.The mask forced the photon to change its shape and travel slower than the speed of light. Dr Romero explains: "After the mask, the photon is launched into a

sort of racetrack about a metre in length. Then we take the time in which the unshaped photon finishes the racetrack, and the shaped photon's time as well, and then compare the two times."

If they had both been travelling at the speed of light it would have been a dead heat. But the re-shaped photon came in second. Not by much - a few millionths of a metre but it showed that it had not just been slowed by the mask, but had continued to travel at less than light speed even after it had returned to free space. Light travelling at less than the speed of light. Whose bright idea was that? It grew from a conversation between Prof Daniele Faccio at Heriot-Watt University and Prof Miles Padgett at Glasgow.

Prof Padgett says the crucial component is the mask - a software controlled liquid crystal device: "That mask looks a little bit like a bull's-eye target. And that mask patterns the light
beam, and we show that it's the patterning of the light beam that slows it down. But once that pattern has been imposed - even now the light is no longer in the mask, it's just propagating in free space - the speed is still slow." But hang on a minute. If a photon is a particle, how is it possible to impose a pattern on it?

It's because photons exist in the exotic and rather wonderful quantum realm, where the rules of the reassuringly solid world in which we live tend to lose their grip. They exhibit what physicists call "wave-particle duality": they behave like both a wave and a particle. So you can send them round a racetrack two by two like particles, yet change the shape of one of them as if it was a wave.

**Peloton – the main bunch of riders**

Complicated? Oh yes. Which is why the researchers say it might help to think of a bicycle race. The peloton - the main bunch of riders - may be moving at a constant speed. But within the bunch an individual rider may be moving more slowly, dropping back for a rest or a drink.

Meanwhile other riders in the bunch are moving faster to get to the front. The bunch is a beam of light, travelling at - yes - the speed of light. The riders are photons, travelling at their individual speeds. For Dr Giovannini it's been a satisfying intellectual and experimental challenge: "It mostly comes from a question we asked ourselves two and a half years ago. We just kept working on it. It's really, really interesting. It's just one of those big, fundamental questions you may want to ask yourself at some point in the pub one night. And if you follow through and you actually measure it it's quite amazing, isn't it?"

Prof Padgett says: "What makes our experiment different and what has brought clarity to this, is that rather than looking at a light pulse which contains many, many, many photons we've reduced the experiment down to a single photon. So we measure the speed of a single photon as it propagates and we find it's actually being slowed below the speed of light." There are some practical implications. Light is used to make extremely precise measurements such as how far the Moon is from Earth. The good news is that we are not in for any nasty surprises on that scale. But researchers using large aperture lenses to accurately measure very short distances may be forced to take a second look for tardy photons. Beyond that, Dr Giovannini says practical, everyday uses for the discovery are possible. Although he concedes the physics is more fundamental than applied right now.
"But," he says, "who knows?"