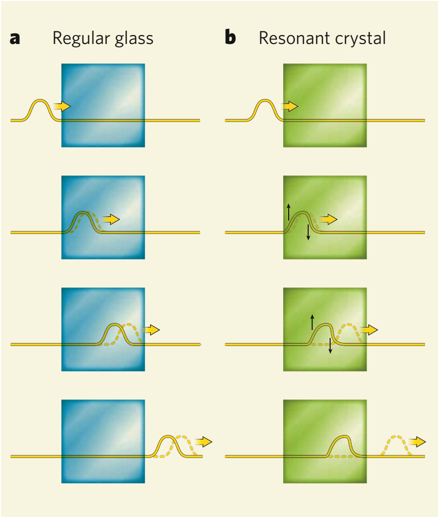

Figure 1 | Reshaping at light speed. a, When a pulse of light propagates through a block of a regular material with a constant refractive index — glass, for example — it is refracted and slightly delayed. **b,** In a strongly resonant material, by contrast, specific frequency components contained in the light pulse can be accelerated or delayed. As Shubina *et al.*[1] demonstrate in gallium nitride, if these changes act to suppress the leading edge (arrows) and increase the trailing part of the pulse, the maximum of the pulse envelope can be brought to a near standstill.

Controlling the speed of light is surrounded by many apparent mysteries and a fair sprinkling of misunderstandings. Admittedly, slowing light down until it stands still or even goes backwards does seem incredible. And, in the other direction, making light pulses travel faster than the speed of light in a vacuum is sometimes said to violate causality — wrongly, as it turns out.

Both effects are in fact intimately related. All one needs to do is bear in mind that a light pulse generally contains a superposition of light waves of different frequencies. The speed at which the whole envelope of the pulse is propagating is known as the group velocity[3]. Within this envelope, each individual frequency component of the pulse travels at its own phase velocity, which is determined by the refractive index of the material.

All one needs to do now is create a highly dispersive medium: that is, one whose refractive index depends strongly on the frequency of the passing light. On entering such a medium, different components of the pulse will begin to propagate at different phase velocities. The envelope of the pulse begins to change shape, and the top of the pulse might move forwards or backwards with respect to the rest (Fig. 1). In the first case, the pulse maximum seems to propagate at above vacuum light speed; in the second case, the effect can be so strong that the top of the pulse seems to stand still. But note that in the first case causality is not violated: the pulse itself, carrier of information, travels on as fast as ever.

A good way to achieve strong dispersion is by creating 'resonant' interactions that only affect light in a narrow frequency range. This can be achieved using a material with resonant microstructures, or one in which the constituent atoms or molecules have a resonant interaction with light of specific frequencies. This method has already been used to slow down light in crystals[4,5] and atomic gases[6], and Shubina *et al.*[1] now use it to put the brake on light in gallium nitride.

In crystals such as gallium nitride, light waves at specific frequencies can excite electrons, creating 'excitons' that temporarily store the optical energy[7]. This is strongly resonant behaviour — the interaction takes place only when the frequency of the light exactly matches that of the exciton — and thus strong dispersion is obtained[4]. When the authors shine a short light pulse with the right central frequency onto their sample, they observe a delay and elongation of the pulse, corresponding to a more than 100-fold reduction in velocity.

Shubina *et al.* discuss two possible mechanisms that might give rise to this effect, although they are not able to give a definitive picture of the physics behind their observations. First, the interaction of the light with the generated exciton might create an ' exciton–polariton' that delays the light's ballistic propagation through the material. Second, strong scattering effects around the exciton's resonant frequency could delay the light waves enormously[8]. Such effects have been observed in diffusive scattering from random distributions of uniform microspheres, and become enormous in cold atom clouds[9].

A further, much less intuitive delaying and trapping effect is that of optical localization[10]. Here, multiply-scattering light waves randomly create standing waves at points throughout the crystal. In strongly scattering semiconductors, the effect can become so strong that it brings diffusive propagation to a standstill[11]; it would be fascinating to see if it could be made to work in gallium nitride.

On a more immediately practical level, Shubina and colleagues' gallium nitride light 'brakers' could be applied in optical signal processing to produce delay lines for signal synchronization or to create short-lived optical memories[12]. This would require a method for tuning the resonance over a wider frequency window, not just at one specific exciton resonance frequency. Given gallium nitride's potential for integrating photonics and high-speed electronics, the effort would be worth while. One can imagine, for example, a photonic crystal created by periodically patterning a waveguide made of gallium nitride combined with other semiconductors, in which the gallium nitride would act both as a source of light and as delay components in a photonic circuit. ■

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50 & 100 YEARS AGO

50 YEARS AGO

Of the many craters on the Earth known to have been produced by fallen meteors, a few have left no signs of the meteor which caused them, apart from the huge holes created in the Earth's crust. Large meteorite fragments have been found in or near most craters. A possible explanation of the lack of meteorite fragments in the other cases is that the meteors concerned were of contraterrene constituency (anti-matter). In this case no traces of the meteors would remain, due to the annihilation process. One of these events, from which no fragments appear to have survived, has occurred in recent years. In 1908 a meteor, apparently of great size, was seen passing over western Russia; a few minutes later it crashed in the Siberian wastes with an explosion, effects of which were felt for hundreds of miles around, and seismographs thousands of miles away registered its impact ... No expedition to the site of its landing was undertaken until 1927, when the devastation found even at 40 miles from the site was almost inconceivable; but no fragments of the meteor were located despite the several huge though shallow craters which it had caused. If this meteor consisted of anti-matter an obvious explanation is at hand for the devastation found, the lack of meteoric material, and the great size reported in eye-witness accounts of its passage.
From *Nature* 26 April 1958.

100 YEARS AGO

At the London Institution on April 15, Mr Valdemar Poulsen lectured on "Telephoning without Wires."... The progress made in wireless telephony is shown by the fact that conversation has been carried on across Denmark from Lyngby to another wireless telephone exchange at Esberg, 170 miles distant. The reproduction of the voice was clear and distinct, and easy to recognise.
From *Nature* 23 April 1908.