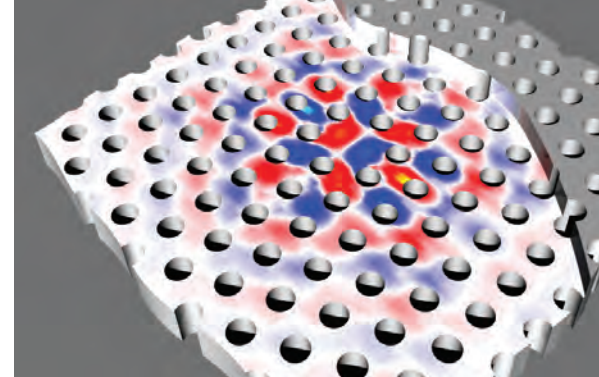
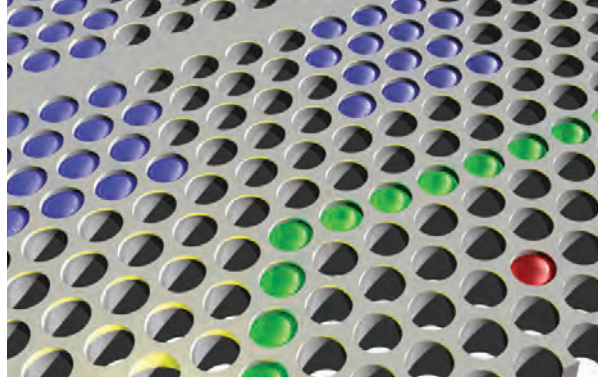




# SLOWING THE FASTEST THING IN THE UNIVERSE

IN AUSTRALIA, PHOTONICS RESEARCHERS ARE SLOWING LIGHT IN ORDER TO SPEED UP THE INTERNET

So that the internet and modern telecommunications may go a hundred or a thousand times faster, light itself must be slowed and made to perform all sorts of tricks it is not naturally inclined to.



With the aid of the NCI supercomputer researchers from CUDOS, the ARC Centre of Excellence for Ultrahigh-bandwidth Devices for Optical Systems—embodying six of Australia's leading research universities in the art of photonics—are devising new ways if not to break, then at least to bend, the laws of nature a little in the service of human communication.

While optical fibres have already transformed long-distance communications on a global scale, the full revolution of the Light Age still lies just beyond the technological horizon. The 'holy grail' of CUDOS research is the optical switch, a device for controlling packets of light in much the same way as today's electronic chips control electrons to make the signals which power our phones, TVs and computers. In pursuit of this elusive goal the team must make effective use of strange, new materials which actually change how they control light as light itself passes through them.

Known as chalcogenides, these ultra-dense, glassy solids—based on elements such as sulphur, selenium and tellurium—have curious properties when it comes to light. "They are highly non-linear, meaning that as you apply more light it alters the refractive index of the material slightly—so light passing in will change the qualities of the light that passes out," explains Dr Chris Poulton of CUDOS and the University of Technology Sydney. The optical properties of these materials can be made more curious still by the subtle placement of arrays of voids within them, thereby forming a "photonic crystal", the optical equivalent of a semiconductor. This special structure causes the photons to depart radically from their usual behaviour.

The voids act in concert to form resonators, trapping the photons within the glass for fragments of time: thus light may be made to flow in a certain direction, around corners or even be retarded 10- or 100-fold in its headlong flight through the universe. All these minor changes add up to one thing: the power to control light with precision so that it may be charged with countless human messages and duties, the makings of a tiny optical switch.

"Designing these devices isn't easy," Dr Poulton explains. "And designing the whole systems that connect them together is even harder. To do it we need to be able to model how they may perform at the smallest scale—at or below the wavelength of light itself—how particles of light will interact with particles of matter, to explore their potential, to try out new things. It takes vast computational power to do this, which is why we need the NCI supercomputer."

In 2008 the team announced the development of an optical switching device capable of multiplying the fastest internet speeds today 100-fold. More recently they have demonstrated how to slow light itself, trapping its photons momentarily in the photonic crystal structure. These 'slow-light wave-guides' open the way for extremely precise control over the optical signals flowing in and out of the device, which in turn hold the key to much faster communication, Dr Poulton says.

"We are also investigating novel 'woodpile' photonic structures. These consist of rods of high-index glass, stacked evenly in rows like a pile of wood. They are extremely difficult to model, however they have the unique property of possessing a full 3D photonic bandgap, which opens up the possibility of important new light sources, such as low threshold lasers and high-efficiency nanoscale LEDs," he says.

The CUDOS team is also exploring the strange powers of metamaterials, man-made substances which do not occur in nature, which can both admit and deny access to light. These materials may one day be used for super-lensing and electromagnetic cloaking, but also raise important questions about the fundamental physics of electromagnetism. The team is investigating the potential properties of compound devices made from metamaterials and normal dielectric materials.

"Australia is very, very competitive in photonics science," says Dr Poulton. "Our particular niche, in world terms, is solving the switching challenge in highly non-linear glasses. The problem is that light is so very fast. Unlike electrons, it is extremely hard to make it do things it doesn't want to do. But we're at the leading edge when it comes to doing that."

#### Research Support:

- ARC Grants: LE0883030, DP0665627, DP0987571, DP0881396, LE0775668, CE0348259, LX0666877, LP0883926, DP0774658, DP0556781, LE0668490, DP0665923, LE0668467, LE0667994 and DP0773984  
- Other Grants: NA300002, NA300001, NA300003, NA400001, NA500001, A500002, NA200001 and NA200002  
- NCI Grant: D91