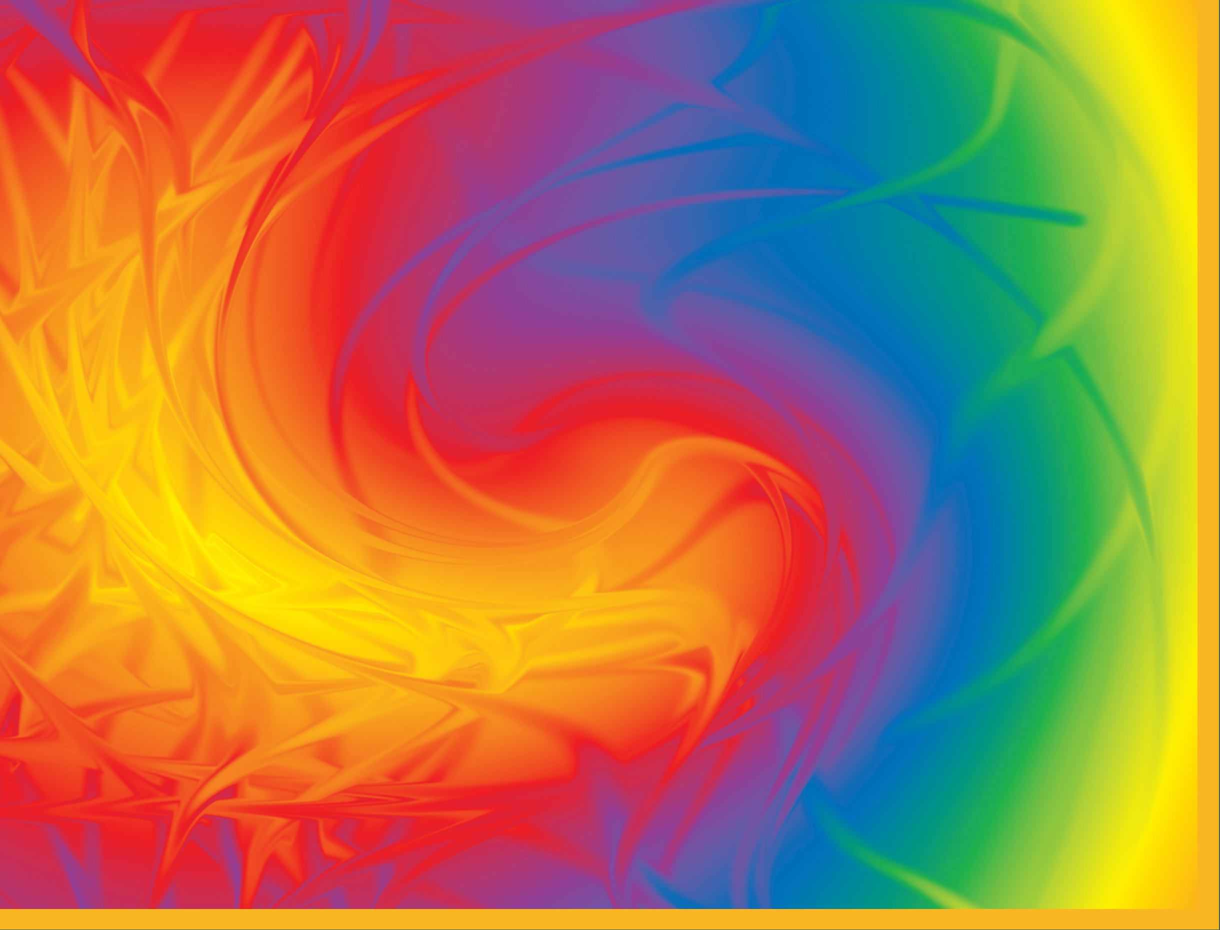

Discovery Days 2006

Allan Gillespie

Chair of Photonics

The photons are not coloured... but the photonics is colourful

Context

Basically, photonics is the science of light ....what we are working with is often (but not always) laser light, simply because that often gives us the greatest control over its properties. I have selected three typical activities from our portfolio at the Division of Electronic Engineering & Physics – chosen from a broad range of applications in order to demonstrate the versatility of these photonic techniques.

Examples

Number 1 is a very topical biomedical application – the combined use of lasers and ultrasonic waves to rupture biological cells. Paul Campbell leads a group from several institutions which studies the interaction of ultrasound with microbubbles in a fluid with the aim of disrupting cells via jet-induced tissue damage. In layman's terms, the ultrasound can cause the miniature bubbles to collapse (or cavitate) when close to a cell, in such a way that it may be possible, in the future, to "inject" molecular material through the cell membrane. This could, in principle, open up a new way of treating certain cancers without invasive procedures, a very exciting prospect.

Number 2 is a "big science" application, based on advanced light sources used primarily for fundamental biomedical and other scientific research work. One example is 4GLS, a planned UK fourth-generation light source with a world-leading specification. A key problem is the generation of electron pulses as short as 100 femtoseconds (10^{-13}s) – much too short to be measured by electronic techniques.

Allan Gillespie's group has solved this challenging problem using an electro-optic technique. Pulses from an ultrafast Ti:S laser are used with a nonlinear crystal to "encode" the electron bunch length on to the laser beam, then analysed using polarization to extract the profile of the femtosecond electron bunch. By this means very short bunches - around 200 fs - have been measured at several major international accelerator facilities within the last two years.

Number 3 involves the development of ultra-compact lasers based on *nanostructures* (quantum dots) which generate picosecond or femtosecond sources, making them suitable for widespread use in communication, sensing, machining or medical applications. Edik Rafailov's work, carried out with Wilson Sibbett and colleagues at the University of St Andrews, includes the development of highly efficient visible-light (490nm) sources that are potentially portable, and the generation of femtosecond pulses with applications in biology and photomedicine. These devices could lead to more compact data storage in CD, DVD and other systems.