New Scientist "Describe Your Research" article (550-word limit)

X-rays meet Liquid Crystals

Hidden in the depths of the Cheshire countryside is a scientific establishment known as the *Synchrotron Radiation Source*. The site, lying between a wooded hillside and the Bridgewater canal, is home to about 500 permanent staff and dozens of visiting "users" from all over Europe. What the users come to *use* is the electromagnetic radiation emitted by high energy electrons as they whiz around a ring of 5m radius called a synchrotron. The radiation is transmitted in front of the electrons as they travel, sweeping around the ring like the beam from a lighthouse (figure 1). The beam is very intense and contains many wavelengths (infra-red, visible light, ultra-violet and X-rays). A user selects the particular wavelength he or she wants by blocking out the other wavelengths with suitable devices. The selected radiation is then used as a tool to probe the physical behaviour of any materials placed in its path. In my postgraduate work, I use X-rays from the synchrotron to look at liquid crystal displays (LCDs).

Liquid crystals are organic molecules that flow, just like liquids, but possess long-range orientational order typical of a solid. An LCD combines two features inherent in liquid crystal molecules—their ability to rotate in electric fields and their ability to transmit polarized light depending on the angle it makes to the molecules (i.e. *birefringence*). In an LCD, a thin layer of liquid crystal material is sandwiched between crossed polarisers whose inside surfaces have transparent conductive coatings. In the OFF state, the liquid crystal allows sunlight through the system. This is reflected from a mirror at the back and returns along the same path, reaching the viewer's eye. To turn the display ON (to generate a dark letter or number), a voltage is applied to the conductive coating at the relevant position. The electric field rotates the molecules into a direction that stops light from passing through the second polariser. Light no longer reaches the mirror and there is thus darkness. Such effects are seen by the naked eye with visible light and represent the combined response of millions of molecules. However, in order to see the molecules themselves, it is necessary to choose a wavelength similar to the size of the molecules. This is where X-rays come in…

When a beam of X-rays hits a group of molecules, the beam diffracts: The incident beam splits into others, which travel in different directions and with different percentages of the original beam intensity (figure 3). The directions and intensities of these beams depend on the structure of the molecules.

In my project, I observe the diffraction pattern produced when X-rays strike an LCD and work back to get an idea of the molecular structure that caused it. There have been many X-ray experiments on static LCDs, but mine are the first to observe real-time structural changes *during* the ON-OFF switching process! By taking a rapid succession of X-ray exposures, I observe the evolution of the of the diffraction pattern with time.

Early results have been promising; they have highlighted ways to speed up the switching process, one of the main concerns for flat wall-mounted televisions, and helped clear up a number of mysteries in the field of LCDs. And all this from the heart of rural Cheshire!