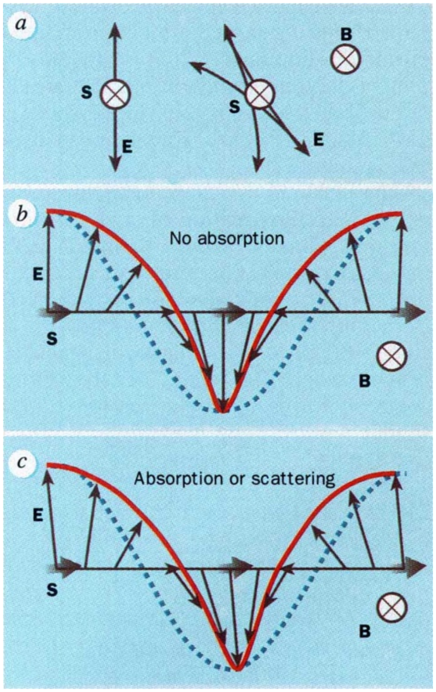

The Faraday effect and beam walk-off. The thin arrows are the electric field vectors of light, **E**, and the thick arrows show the Poynting vector **S** (denoting the direction of energy flow); an externally applied magnetic field **B** points into the plane of drawing in each case. *a*, Light moving parallel to **B** has its plane of polarization rotated. *b*, Moving perpendicular to **B**, a longitudinal wobble is induced in the electric field. *c*, In an absorbing medium this produces a transverse flux of energy because the wobble and the main component of **E** are no longer perfectly out of phase.

gling in the plane of the drawing, perpendicular to the external magnetic field. So the Faraday effect induces an electric field in the direction of the wave, but one that is much smaller than the original perpendicular component.

The two components of the electric field are exactly out of phase with one another. The accompanying Poynting vector will also wiggle, but on average, over a full cycle, it will point in the same direction as the wave vector. In order for beam walk-off to occur, the medium must be absorptive, as in part *c*. Because of the presence of absorption the two components are no longer completely out of phase. At those positions where the amplitude of the electric field is largest (the positions which contribute the most to the average energy flow) the Poynting vector is not parallel to the wave vector. Now the external field points into the plane of drawing, the wave vector points to the right, and the Poynting vector has a deviation perpendicular to both.

The phenomenon observed by Rikken and van Tiggelen happens in an inhomogeneous, isotropic medium without absorption. In view of the above this seems quite surprising. The effect is a result of the presence of scatterers[2]. The similarity between absorption and scattering can be made plausible by the notion that both give rise to an exponentially decaying intensity for the directly transmitted part of the light.

For a high enough concentration of scatterers, the intensity distribution of the scattered light can be described by a diffusion equation. This is similar to the diffusion process of molecules in a gas, although in the case of photons the total number of particles is not constant. For a mixture of a polyatomic gas with a noble gas, transverse diffusion has been observed experimentally[3]. The explanation of this effect runs as follows: in a diffusing gas there is a particle flow in which non-spherical molecules line up to reduce their collision probability. This is analogous to the alignment of tree trunks thrown into a flowing river. The magnetic field then causes the magnetic moment of the molecules to rotate around the field. This precession will change the collision cross-section, and consequently alter the diffusive flow of the molecules. In the same way, stirring the river will decrease the throughput and will also make some of the trunks end up on the river banks.

In the case of the diffusion of light, an external magnetic field will change the refractive index of the scatterers and thereby alter the scattering process, which in turn will give rise to a different diffusion constant. Rotational symmetry around the external field axis and time-reversal symmetry arguments demand that changing the sign of the magnetic field reverses the transverse diffusion, as verified by Rikken and van Tiggelen[1].

The Faraday effect is large near an optical resonance and changes sign there, so two frequency components either side of a resonance should be partially separated. A further test would be to verify the change in the forward and backward light flux induced by a magnetic field.

It is too early to say whether there will be applications of the phenomena described above. One should bear in mind, however, that optical gain plays exactly the same symmetry-breaking role as absorption or scattering. Consequently, lasers in an external perpendicular magnetic field will also cause beam walk-off in the third direction, and here the effect may be a big one. □

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DAEDALUS

Good neighbours

GROWING old is a melancholy fate. All the systems of the body start to 'go downhill'; joints degrade, arteries harden, tissue loses its elasticity, metabolism slows. But the body doesn't simply wear out like a bicycle or a car. It ages by the failure of its self-repair mechanism. Every now and again, some random error in the DNA of a cell evades this mechanism. Deprived of a gene, the cell becomes slightly less efficient. When it divides, its daughters inherit the inefficiency. If the error is in the DNA-repair machinery itself, that line of cells is likely to get very bad indeed. And less than 1 per cent of bad cells can be fatal. You will probably reach your deathbed with over 99 per cent of your cells in perfectly good shape.

Daedalus has a way out. His idea is for the many good cells to repair the few bad ones. Suppose, he says, that a defective cell could be fused to one of its neighbours. As in normal heredity, the defect will be recessive. The good cell will supply the gene missing from the bad one, and the fused product will function perfectly. Even if that gene is not missing, but present, damaged and actively mischievous, all is not lost. Let the bad cell be fused with two or three good neighbours, and they will outvote the aberration. The joint venture will still divide normally; it and its daughters will be good cells.

To work this trick, Daedalus is adapting his scheme of last week for fusing fat cells together in the body. This puts a high-frequency alternating field from a diathermy machine across the whole body, and concentrates its action in a small region by means of a phase-locked focused beam of ultrasound at the same frequency. This combination can fuse cells fairly efficiently. But how to target the few aberrant cells? Daedalus points out that they must differ slightly from their neighbours, in size, shape or conductivity. Electrical breakdown always concentrates at such anomalies and discontinuities. So with the right electric and ultrasonic intensities, Daedalus's gadget will concentrate its energy on the cellular aberrations. It will fuse them to their neighbours, while ignoring the mass of good cells. By sweeping the ultrasonic focus around the body, bad cells everywhere could be fused and reclaimed.

Thus the decrepitudes of age will be averted. A periodic 'sweep' of bad cells will keep you young, spry and active for ever — well, not quite ever. One day in late age, the cell-death programmed into your cells, at least the good ones, will begin to bite. On that day, only bad cells will survive. And there won't be enough of them.

David Jones