(for example in the context of cholinergic, aminergic and other sites) this implies a degree of specificity and affinity which is at variance with the characteristics of fibronectin in mediating interaction with collagen. This is, however, a small criticism of a paper that invites a major reassessment of attitudes in this field of research. □

Proposed optical Stern–Gerlach experiment

from Peter Knight

THE atomic beam work of Otto Stern and his colleagues in Hamburg was published in a series of papers bearing the subtitle 'Investigations with the Molecular Beam Method' (*Untersuchungen zur Molekularstrahlmethode*). The thirtieth and last, in 1933 by R. Frisch, reported the observation of the deflection of an atomic beam by the momentum carried by photons (*Z. Physik*, **86**, 42; 1933); it closes with the remark: "It would certainly be possible to do more careful experiments. Unfortunately, for reasons beyond our control, the experiments had to be stopped prematurely". The phenomenon was revived by the work of Ashkin and his coworkers (most recently in *Phys. Rev. Lett.* **41**, 1361; 1978) who demonstrated a large enhancement of the radiation pressure effect using laser radiation. Since then photon deflection has been discussed for atomic trapping and cooling, for spectroscopy and for laser isotope separation (although the latter now seems an outsider in the separation stakes).

A recent paper by R. J. Cook presents a new and quite simple analysis of atomic motion in a resonant laser electromagnetic field (*Phys. Rev. Lett.* **41**, 1788; 1978). He shows how an atomic beam can be split by traversing an amplitude gradient of the resonant radiation in a fashion reminiscent of the old Stern–Gerlach demonstration of space quantisation. This splitting had been discussed earlier by Kazantsev (*Sov. Phys. JETP* **39**, 784; 1974) and aspects of the subject reviewed by Stenholm (*Phys. Rept.* **43**, 151; 1978). Photon deflection is produced by excitation and emission recoils, and by a force caused by the interaction of the induced dipole moment with the amplitude gradient of the radiation field. Cook's paper is concerned with the latter and his results are valid only if spontaneous emission can be neglected during the interaction time.

For an atom driven by a laser such that only two energy levels (with wave func-

Fig. 1 Focusing of atomic trajectories associated with the wavefunction u_- . (Cook op. cit.)

tions c_1 and c_2) are relevant, the analysis is particularly simple. The Schrödinger equation for the time-dependent wavefunction for the atom interacting with an incident field leads directly to two uncoupled equations of motion for the symmetric ($u_- = 2^{-1}(c_1 + c_2)$) and anti-symmetric superposition ($u_+ = 2^{-1}(c_1 - c_2)$) of states. These two combinations represent special 'eigen-waves' for the atomic trajectories which propagate independently. An atom initially in its ground state is equally likely to be in one or the other of these superpositions. The 'eigen-waves' obey similar Schrödinger equations except that the potential energy for the u_+ is of opposite sign to that for u_- . The forces acting on atoms in the two waves are thus in opposite directions so that an amplitude gradient will split a collimated ground-state atomic beam into two components: an optical analogue of the Stern–Gerlach experiment. A well-collimated beam of atoms intersecting a Gaussian laser beam at right angles will see the optical beam as a cylindrical lens which focuses u_- waves but defocuses u_+ waves. (Fig. 1 shows the focused trajectory.)

Cook estimates that a 1 W laser beam focused to a 50 μm beam waist (with waist intensity about 10^4 W cm^{-2}) will act as a lens of focal length approximately 1 cm for an atom of slow thermal speed and typical mass and transition dipole moment. An atomic beam centrally traversing such a cylindrical 'radiation lens' would have a cross-section flux at the focus as shown in Fig. 2 where the u_+ wave has been deflected out of the

Fig. 2 Total atomic flux J at the focus of the 'radiation lens' for a centrally positioned beam of atoms, in units of laser beam radii (Cook op. cit.).

centre and the u_- wave focused.

The lens effect is an interesting demonstration of the inversion of our usual ideas. A lens is normally made of a medium (consisting of polarisable dipole oscillators) shaped so that a collimated light beam is focused by the density gradient of polarisability. Here we have a collimated atomic beam focused (or defocused) by polarisability effects in a light beam shaped to give an electric field gradient. Experimental investigation of these ideas does not seem too difficult and is presumably under way. □

Complexities of cultural evidence in the Lower and Middle Pleistocene

from John A. J. Gowlett

For many years the study of human evolution became, in the words of Irving Hallowell, 'more and more restricted to biological problems dealt with by physical anthropologists'. The cultural evidence, which is essential to a study of the distinctiveness of man, and which is mainly the province of the archaeologist, was scarcely considered as an aspect of biological evolution. The splitting of the study of early man into separate disciplines of archaeology, physical anthropology, and to some extent evolutionary biology, has its roots in the 19th century, and although much has been achieved in the way of interdisciplinary studies since Hallowell was writing, the central importance of the cultural evidence is still sometimes overlooked.

Archaeological work has however built up a record of behavioural complexity of a cultural nature going back at least 2 million years. Man can therefore investigate the evolution of his present cognitive capacity through the permanence of the cultural record. Considering the clear evidence of humanity that is available, it is surprising first that philosophers have made

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