as fast as present day electronic storage. Because they will be small and manufactured by the proposed submillimetre machines, they will be inherently cheap.

In the paper by Conrad Schneider (which has a copious list of references), it is argued that the development of simple artificial replicating microtechnology devices should be possible this century. Most of the tools used are not new, but draw from many different scientific disciplines. It is interesting to note that there wasn’t anything by way of components in the Eniac computer of the late 1940s that wasn’t previously available for 10 to 15 years. Again, the construction of the acoustic phonograph did not rely on any technologies that weren’t available centuries earlier. J. de Rivas Truro Cornwall

WHAT’S IN A THEORY?

Our Ivor Catt always makes cheerful light reading, especially when he points out the obviousness of some physical statements which are usually mentioned with bated breath. Typically, in E&W for November 1985 he reminded us that only uniquely electromagnetic information contained in the two Maxwell equations relating E and H in vacuum lies in the theoretical artefacts μ₀, ε₀ from them one can extrapolate to derive “the impedance of free space” as Z₀=Vμ₀ε₀ and “the universal velocity of light” as C = 1/√μ₀ε₀. The phenomenon is by no means confined to electromagnetic theory. Some of your readers might care to try the following unconventional derivation in the wave theory of matter:

A completely general expression for 3-dimensional waves in any linear, continuous medium is provided by

\[ \mathbf{\nabla} \times \mathbf{u} = (\frac{2\pi}{\lambda})^2 \mathbf{u} = 0. \]  

(1)

where \( \mathbf{u} \) (psi) is “whatever it is that oscillates” in the waves and \( \mathbf{u}, \mathbf{x} \) are the wave velocity and frequency respectively. The last are classed as “unobservables” by the theory, so we will simply eliminate them by means of the wave axiom (self-evident truth) \( \mathbf{u} = \mathbf{m} \), obtaining

\[ \mathbf{\nabla} \times \mathbf{m} = (\frac{2\pi}{\lambda})^2 \mathbf{m} = 0. \]  

(2)

Next, on the apparent evidence of experiment we assume these matter-waves obey the momentum precept \( \mathbf{p} = \mathbf{m} \times \mathbf{u} \), so that

\[ \mathbf{\nabla} \times \mathbf{p} = (\frac{2\pi}{\lambda})^2 \mathbf{p} = 0. \]  

(3)

Now the momentum \( \mathbf{p} \) is directly related to the particle’s kinetic energy \( K = \frac{1}{2} m \mathbf{u}^2 \) by the form \( \mathbf{p}^2 = 2mK \); substitution for \( \mathbf{p}^2 \) leads inexorably to

\[ \mathbf{\nabla} \times \mathbf{u} = \frac{2\pi}{\lambda} \mathbf{m} \times \mathbf{u} = 0. \]  

(4)

Finally, since the total dynamic energy of any particle is defined as \( W = (K + U) \), evidently \( K = (W - U) \) and therefore

\[ \mathbf{\nabla} \times \mathbf{u} + \frac{2\pi}{\lambda} \mathbf{m} \times (W - U) \mathbf{u} = 0. \]  

(5)

Here we have derived Schrödinger’s Wave Equation, that famous, basic statement of the Wave Mechanics which students may approach only with extreme reverence. Given two further assumptions it leads to Schrödinger’s mathematical model of the wave—represented as an infinite set of spherical harmonics—which is said to “explain” the atomic line spectra.

The derivation given above may be unfamiliar, but it is both simple and watertight. Step by numbered step it consists of the following physical assumptions:

1. Let us suppose that linear matter-waves exist;
2. Then these matter-waves must obey the wave axiom;
3. The matter-wavelength of a particle is related in this particular way to its mechanical momentum (de Broglie);
4. The laws of Newtonian mechanics are to apply; and,
5. A particle’s energy is part kinetic, part potential.

Given at (1) the idea of matter-waves and at (2) the axiom which must follow from that, the only remaining to be made to any properties of the waves, namely \( \mathbf{p} = \hbar \mathbf{u} \), occurs at (3). The derivation is in fact complete at this point, the other two steps being added to facilitate its conventional application. We note that the derivation, and therefore the wave equation itself, is invariant with respect to any definition of \( \mathbf{u} \), so that “any old waves will do” for the wave theory of matter. That is why a Wave Mechanician will give you an odd look if you ask him about the frequency of his matter-waves. Nor is any textbook willing to tell us whether these matter-waves are transverse or longitudinal. The theory doesn’t know about such things, and it gets along without caring about them either.

As Mr Catt has pointed out in the case of the electro-magnetic theory, so here in the case of the wave-mechanics, and so also as is well known in the case of special relativity, the key theoretical formulations are found to rest upon two, and only two, particular and radical physical assumptions. The rest is algebra.

W. A Scott Murray Kippford Galloway

HALL AND HOLES

To reply to R. Petzeratt (New), the “standard explanation” of a “free seat moving backwards” is more realistic if one imagines a cinema screen case (or any other) rather than a doctor’s waiting-room. The “hole” is now in a distinct minority; and I see a further analogy with the bubble in Ptolemy’s Accelerometer—if the acceleration is to the right, the bubble moves to the right—to the great delight of teachers who are fed up with tickers tapping— and everyone knows it is easily liquid which has moved to the left.

“Opposite” behaviour, depending on whether the charge carrier is in a minority or on roughly equal terms with the mob, also helps to explain the opposite effects of temperature on the resistivity of metals and of semiconductors. Consider a person trying to cross the town square, when it is densely packed. If the crowd is heated, it becomes more difficult to cross. But if the square contains just a few folk, and the charge carrier knows he (she?) must touch a different person (atom) before continuing, “heating” makes the journey easier.

May I suggest Dr J W Warren at Brunel University as being well qualified to say which of your many recent correspondents are blethering, and which are quite rightly attempting to pinpoint errors in existing theories? He has a long record of nailing failacies perpetrated by text writers. Bill Jarvis MA, CPhys, MInstP

Relativity

The idea that classical physics cannot account for the constancy of light velocity needs correction. The velocity will be constant if the fields of observers A and B, whose coordinates are related by the Galilean correspondence, both satisfy equations of Maxwell form. To express the fields of B in terms of those of A, let A change his coordinates tensorially with a valence band) with the metal strips (stalls, circle and balcony) rather directly related to the particle’s kinetic energy \( K = \frac{1}{2} m \mathbf{u}^2 \) by the form \( \mathbf{p}^2 = 2mK \); substitution for \( \mathbf{p}^2 \) leads inexorably to

\[ \mathbf{\nabla} \times \mathbf{u} = \frac{2\pi}{\lambda} \mathbf{m} \times \mathbf{u} = 0. \]  

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