AERIALS AT SEA

Regarding Wiseman's articles on marine radio, it is unfair to compare Soviet merchant practice with the West's since all Soviet ships are quasi-military and under strict government control, hence "proper" aerials.

I agree that some of the installations are quite appallingly bad and have been neglected, but the root cause is the short aerial, and lack of radiation resistance. Since we cannot emulate the BBC's "big T" at Droitwich within the confines of a ship another solution must be found, and I suggest that the helically loaded glass-fibre whip is the answer. Glass-fibre poles are freely available (pole vaulters use them). Such poles are about twenty feet long and would accommodate around one hundred metres of 16 s.w.g. copper wire. Since these aerials could be manufactured to have a driving-point impedance equal to that of the feeder, insulation losses would be minimal.

Regarding the durability of glass-reinforced plastics, cheap g.r.p. is based on polyester resin, which is hygroscopic and does deteriorate in the space of a few years. G.r.p. reinforced with epoxy resin does not appear to suffer in this way although it is more costly.

Finally if anyone is enterprising enough to make such an aerial, he must be sure to avoid a carbon fibre reinforced pole.

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HERETICS GUIDE TO MODERN PHYSICS

I would have thought that authors prepared to advertise their Ph.D., B.Sc., and so on would show a more up-to-date knowledge and greater scientific integrity than that displayed in October 1982 *WW* by Dr Scott Murray.

The 'Photon' article revolves round and leads to a conclusion that a special test experiment on counting single photons should be done, and the author confidently predicts the result that individual photons passing through an apparatus would not show interference. I'm afraid that Scott Murray is out of date by 50 years or more; the experiment has been done many times, since photon counters (able to detect single photons) have been available for a long time. And the result – individual photons produce interference fringes just as more intense light does.

I cannot offer an explanation, since apart from using quantum mechanics (which is a mathematical description) there is no explanation in mechanistic terms of what happens. The problem strains our imagination to its limits, but explanation or not, it is a hard experimental fact. I do not think that this can be passed off as a subjective assessment as implied by John W. T. Smith, September, 1982 *WW* letters), since the photomultiplier either does, or does not register photons at certain position along the interference fringe pattern. This experiment has been repeated by many workers, since the topic is of great significance, yet always the same result.

I think therefore Scott Murray should review the contents of any subsequent articles on this theme if they rely on his incorrect anticipation of the photon experiment. A good description of this experiment occurs in Richard Feynman's Book – The Character of Physical Law (BBC Publications 1966).

To further confound Scott Murray, electrons also show wave/particle duality and give interference fringes too; this is also described in Feynman's book.

One further point, articles of a scientific nature, whether 'heretical' or not, are improved by less use of emotive terms like 'dogma', 'mysticism' 'doctrine'. It would seem that the only person with a dogmatic view is Scott Murray himself who has decided to shun the facts and invent his own 'nature'.

B. J. C. Burrows
Benson
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In the article from the series by Dr Murray which appeared in the December issue he refers to Compton's calculation of the way in which the energy of a gamma ray scattered by a free electron varies with the angle of scattering, though for some reason he describes the scattered gamma ray as a second gamma radiated from the point of impact. He claims correctly that Compton's calculation was based on the model of a billiard ball collision between the gamma ray photon and the electron, but neglects to mention that this model is quite unable to account for the experimental observations of the angular distribution of the scattered photons about the direction of the incident photons. Eventually Klein and Nishina succeeded in deriving an expression for this distribution which is accurate up to and beyond energies of 10 MeV, but they made use of wave mechanics. So much for his assertion that there is 'no indication of wavelike properties of either electrons or photons'.

He goes on to discuss the photo-electric effect. This effect, in which an incoming gamma ray is completely absorbed by a single atom, which then emits a single electron carrying the excess energy, has been studied for many years. Characteristically the electron has a distribution about the direction of the gamma ray which extends over a wide range of angles, and an energy which falls short of that of the gamma ray by an amount which has a series of discrete values determined by the atom from which it is ejected[1]. Thus the process observed experimentally bears little resemblance to the results of Dr Murray's calculation, since according to him 'the direction of the electron's motion must be at right angles to the incident photon's path to within a few hundredths of an angular degree'. Even if one were to take Dr Murray's calculations at their face value, and to accept that they would apply to the photons associated with electromagnetic waves, a 'Murray photon' hitting a vertical dipole aerial would be equally likely to eject an electron from its parent atom so that it moved towards the top, bottom, or sides of the aerial rod, giving zero net induced current!

In general a photon will interact collectively with electrons in an area of the wave front with linear dimensions of at least one wavelength. For the optical photo-effect, in which a photon of visible light ejects a single electron from a suitably prepared surface, the wavelength is some tens of interatomic spacings, so that despite the end result the effect cannot be explained in terms of the interaction of the photon with an isolated electron or atom. A 300 MHz photon, whose energy is some 10^{-9} eV only, would interact collectively with electrons over the whole length of a dipole aerial tuned to that frequency, though I doubt whether individual quantum phenomena as such have been observed at frequencies below 300 GHz. This is hardly the behaviour of a classical particle, and it is not surprising that Dr Murray turned his discussion rather quickly from photons and electromagnetic waves to the consideration of much higher energy photons.

The articles in the series so far have either been written tongue in cheek, or betray a failure to grasp the basic ideas of quantum mechanics and a very limited knowledge of the experimental results which confirm some of its most radical predictions. It is rather unfortunate that *Wireless World* should be propagating this 'disinformation' at the very time when experiments are coming down solidly in favour of one of the most mind-blowing of these predictions, one which is at variance even with the simpler versions of Special Relativity[2].

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References

1. C. M. Davisson, 'Interaction of γ-Radiation with Matter', from 'Alpha-, Beta-, and Gamma-Ray Spectroscopy', Ed K. Siegbahn, North Holland, Amsterdam 1965.
2. A. Aspect, P. Grangier and C. Roger, *Phys. Rev. Letters* **47** (1981) 460. R. D. Mattuck, *Eur. Jrn. Phys.* **3** (1982) 107.

Dr Scott Murray (Quantization and quantization, Jan. 83) regards the idea that light seems to consist sometimes of waves and sometimes of particles to be mysticism of the most blatant kind. Indeed it would be if one believes that light 'consists' of waves and particles, since these two entities have mutually exclusive properties.

The idea that any physical phenomenon 'is' or 'consists' of either waves or particles is surely the root of the problem. The concept of wave and of particle are pure abstractions. They summon up in each case a set of mathematical relationships which define what we mean by these abstractions. A bullet or a billiard ball do not 'consist' of particles, nor do ripples on a pond or vibrations in a plank of wood 'consist' of waves. That the abstract set of ideas associated with waves is useful in describing and predicting certain physical events, like the movement of a violin string is true. Similarly, the set of ideas associated with particles is clearly of value in other areas. That light has some properties for which the wave concept is more useful, and other properties for which the particle concept is of greater value presents no contradiction. It simply demonstrates that we have yet to devise a unified, internally consistent set of ideas which are paralleled in the physical world by all of light's manifestations.

M. M. Gleave
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I have an increasing sense of bewilderment on reading Dr W. A. Scott Murray's series of articles so far.

I may be simple-minded, but I am unable to see that certain of Dr Murray's remarks have the remotest connexion with any physical phenomena (". . . prediction is foreign to Nature . . .", ". . . living matter . . . does this (build enzymes etc. for its own convenience) by decreasing entropy locally . . .").

Now Dr Murray unveils what seems to be his fundamental physical paradigm, of "discrete

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physical entities having real, free-standing existence independently of each other and of any observer, human or deputy." Such a paradigm fails to provide any account even of the simplest interactions between such "entities", and I am afraid it suffers the same fate as all other attempts to explain the obscure in terms of the more obscure.

Indeed, this must be the fate of all attempted explanations which may be produced in accordance with Dr Murray's own criterion of demarcation between physics and mysticism (physical phenomena to be physically explained). Thus, any such attempted physical explanation will involve physical phenomena; but the criterion demands that these be explained physically, and so we either end up with an infinite regress (or a circularity) of physical explanations, or finish after all with something that is not explained at all, or at least not physically! I think we need a better criterion than what Dr Murray has proposed!

In summary, I am afraid that Dr Murray seems to show basic confusion about what is and is not capable of being meant and explained by a physical theory. I am unable to say what is the essence of a better approach to making, using and understanding theories, but anybody who would like to arrive at such an approach could do very well, I believe, to consider the views of Sir Isaac Newton. I quote his refusal to speculate on the nature and origin of the interactions involved in the phenomena of universal gravitation, for which he had provided his celebrated mathematical account: (Concerning such matters) 'I frame no hypotheses; for whatever is not implied by the phenomena is to be called an hypothesis; and hypotheses, whether physical or metaphysical, whether of occult things or mechanical, have no place in experimental philosophy.'.

Newton's 'experimental philosophy' is none other than what we now call science. I suggest that 'hypotheses, whether physical or metaphysical . . .' also have no place in a scientific journal such as *Wireless World*.

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The author replies:

Readers' letters in response to the "Heretic's Guide" series so far have fallen into two categories: the interested and constructive ones have mostly been addressed to me privately and some of them have initiated encouraging correspondence, while the critical and sometimes personally-abusive ones have tended to be addressed to the Editor of *Wireless World* – occasionally even taking him to task too for allowing such nonsense to be published in his magazine! That pattern was predictable and I have no fault to find with it.

One of the recurring topics is the suggestion that the interference of light might disappear at a sufficiently low light level or photon density. What is a "low" photon density? How long is a photon? (A. H. Winterfield, Letters, January). I know of several standard "experimental" answers to that second question, all of them wrong in that they are in conflict with other experimental results. Mr B. J. C. Burrows' letter may be quoted as representing the majority view on this issue. He says that "Scott Murray is out of date by 50 years or more . . . individual photons produce interference fringes just as more intense light does . . . This experiment has been repeated by many workers, always with the same result."

Now the interesting point about this quote is that what Mr Burrows says, although straight down the centre of the established duality doctrine, is not in fact true. Two Russian experimenters, Dontsov and Baz' (Soviet Physics JETP, translated, 25, pp. 1-5, 1967) reported that "photons in light beams are correlated to a considerable degree and cannot be considered statistically independent as a rule . . . the impinging beams contained 'bunches' of photons"; and *after they had dealt with* this bunching (their choice of word, independently of mine), "the beam of statistically independent photons passed through the interferometer without producing an interference pattern."

One part of this experiment was quickly repeated by G. T. Reynolds of Princeton and reported at a symposium at Imperial College in 1969. Reynolds did *not* observe any deterioration of his interference fringes, but although he had attempted to reproduce the Russians' apparatus exactly he used a different kind of light source and his experiment was not performed in quite the same way. The most important difference was that Dontsov and Baz' had taken particular care to quantify photon bunching and to minimize its incidence, but Reynolds and his colleagues simply *assumed* that their photons were statistically independent at the light levels they used.

Therefore, despite Mr Burrows' disagreement, in view of this conflict of experimental findings I still feel that it would be worthwhile to perform at least one more experiment of this general type, taking special anti-bunching precautions and using photon-detection techniques effectively 100 times more sensitive than those of Dontsov and Baz', and Reynolds.

To reply fully to Mr C. F. Coleman would require a letter of at least article length, so instead let me pick out one representative passage for comment. In his third paragraph he says,
"In general a photon will interact collectively with electrons in an area of wave front with linear dimensions of at least one wavelength. For the optical photo-effect, in which a photon of visible light ejects a single electron from a suitably prepared surface, the wavelength is some tens of interatomic spacings, so that despite the end result the effect cannot be explained in terms of the interaction of the photon with an isolated electron or atom."

Once more this is *ex cathedra* doctrine, faithfully reproduced.

Comment one. The terms photon, wave-front and wavelength appear without differentiation in that single first sentence. Here we have Duality supreme: none of the "sometimes behaves like particles" and "sometimes behaves like a wave system" of the doctrine's more cautious apologists. Here light *is* both at the same time. Even among Copenhagen's adherents, not every one will support this extremist line in public.

Comment two. The photon is said to interact collectively with electrons over a linear dimension of at least 10 inter-atomic spacings; given one free electron per lattice atom there will be 100 of them per square wavelength, or up to 1000 of them would be involved if the photon were to penetrate into the material to a depth of just one wavelength. Now, if some 100 to 1000 electrons are interacting with one incoming photon, why is it that *only one* of these electrons is ejected by the photon's impact – and what physical mechanism determines *which* of the electrons is to be ejected? (Please don't tell me that it is ejected from the material by a "probability"!) This was the very argument that in Einstein's hands in 1905 denied the possibility of a statistical mechanism for the photoelectric effect and led directly to the photon hypothesis. Are we to go back on that hypothesis now? (I don't say we shouldn't – I just ask the question).

Comment three. The first sentence in the quotation makes a flat statement of what happens in a photon/photocell interaction, all cut and dried as if it were factually true. How wide is a photon, please? If we knew the answer to that we might be able to "explain the effect" in line with "the end result". Many answers have been proposed to that question, all different and mutually conflicting: it is conventional nowadays to regard the question as "improper" and refuse to recognise it. But in that case perhaps I may reasonably ask instead for a reference to the report of the experiment which measured the diameter of a photon and supports the statement that it is "at least one wavelength" across? I believe there is no such reference; that is one of the fundamental experiments that I have suggested ought now to be done.

Other comments could be made, but perhaps I have said enough. There are many things in the arena of modern physics that none of us understand, and it doesn't help progress for people to insist that we know it all when in fact we don't. It is more seemly to be humble when discussing such difficult problems. Several correspondents such as N. M. Gleave, John W. T. Smith and Professor D. A. Bell have written in a very civilized way on the theme that ". . . we have yet to devise a unified, internally consistent set of ideas which are paralleled in the physical world . . ." (with which I wholeheartedly agree), and that it may never prove possible to devise one because the scope of human thought-processes may be too limiting. There is as yet no evidence of this either way, but it suits my temperament to be optimistic. What I don't go along with is the idea that one should give up trying to understand such things simply because the Copenhagen School, having themselves failed to reach understanding of them, arrogantly pronounced them to be non-questions, unsuitable for the attention of physicists. It is just possible that the Copenhagen School and their followers may have been wrong on that point, as they have been on quite a few others.

I move that we should re-examine our current physical concepts carefully and conscientiously in the light of a few realistic principles ("acceptable paradigms", if you will, *pace* Mr Terry Stancliffe!), and go on trying.

SATELLITE TV SYSTEM

Dr Tomlinson, no doubt, will correct me if I am wrong but his "original method" of digital/analogue modulation (*WW* January 83, pp28,29) seems to me to be a development of the ADAM modem which Freddie Court of SRDE devised, in 1971/72, during his work on SKYNET.

Working from memory, I believe ADAM stood for "Amplitude, Dipolar Angle Modulation".

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