

# The deeper hidden message in Maxwell's equations

by Ivor Catt

## Why have Maxwell's Equations survived for so long?

In November's article<sup>1</sup> I investigated Maxwell's Equations, generally regarded as the greatest mathematical achievement in science.\*

In the 1830s, Faraday discovered electromagnetic induction, thus closing the loop between electricity and magnetism. This discovery paved the way toward the rapid growth of electricity-based industrialization and the high technology which shapes today's world.

By making the key discoveries of their era, uneducated technicians like Michael Faraday and James Watt threatened the scholastic myth, that all progress, including scientific progress, needs must use the rigour and discipline controlled and celebrated by academics in places like Cambridge University. The ultimate in scientific rigour (*rigor mortis?*) was held to be mathematics. Biography and History of Science writings spawned in academia present the thesis that, lacking mathematics, Faraday could not and did not really effect his discovery of electromagnetic induction. Rather, he stumbled into it, but it could only be properly exploited decades later, after Professor Maxwell had placed a mathematical structure upon Faraday's fumbling, unscholarly ideas. Thus, according to the Platonic interpretation of history, Professor Maxwell, not Faraday the technician, paved the way for massive exploitation of electromagnet-

ism in transformers, motors and generators. The deeper hidden message in Maxwell's Equations is that, do what they will, the local yokels will not replace mathematical academia as the fount of knowledge and progress.

In a previous article<sup>1</sup> I posed two questions:

Do Maxwell's Equations contain any information about the nature of electromagnetism?

Why do academics and practitioners generally think that Maxwell's Equations are useful?

I am sure you will have found my answers unsatisfactory. The reason is that they were based on certain assumptions, and failed to dig deeply enough into the underlying motivation, psychoses and myopia within contemporary science.

The underlying battle for the soul of science is between the practical engineer on the one hand and the Platonic pure mathematician on the other.<sup>2</sup> For his part, the mathematician sees this battle as more important than search after truth or technology-fuelled search after new sources of wealth. For him, the important thing is Form; the purity and beauty of his world, and his ability to control and manipulate it intellectually. (The profane aspect of this idea is the desire to impose a structure onto any 'discipline' such that it is easy to teach and, more importantly, easy to set exam questions on). One FRS told me that physical reality was composed of sine waves, and this encapsulates the

mathematician's attitude to our world.

A good example of an academic with the mathematician's attitude is Sir James Jeans. He was highly regarded in the 1930s both as a Cambridge academic and as a populist, much like Sir Fred Hoyle in the 1950s. In his book "The Mysterious Universe",<sup>3</sup> Jeans gives a clear view of the

well's Equations for such a long time.

Jeans then goes on helpfully to point out the flaw in his argument:

"This [last] statement can hardly hope to escape challenge on the ground that we are merely moulding nature to our pre-conceived ideas. The musician, it will be said, may be so engrossed in music that he

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attitude of the Platonic mathematician discussed in the last paragraph.

"By 'pure mathematics' is meant those departments of mathematics which are creations of pure thought, of reason operating solely within her own sphere, as contrasted with 'applied mathematics' which reasons about the external world, after first asking some supposed property of the external world as its raw material"

On the next page, Jeans goes on to write,

"... the universe appears to have been designed by a pure mathematician."

The important thing is not to ponder over the possible contradiction between these two statements, but to grasp the mentality underlying them. This mentality, usually in a better camouflaged and less grotesque form, is what made possible the survival of mathematical absurdities like Max-

would contrive to interpret every piece of mechanism as a musical instrument; the habit of thinking of all intervals as musical intervals may be so ingrained in him that if he fell downstairs and bumped on stairs numbered 1, 5, 8 and 13 he would see music in his fall. In the same way, a cubist painter can see nothing but cubes in the indescribable richness of nature - and the unreality of his pictures shows how far he is from understanding nature; his cubist spectacles are mere blinkers which prevent his seeing more than a minute fraction of the great world around him. So, it may be suggested, the mathematician only sees nature through the mathematical blinkers he has fashioned for himself. We may be reminded that Kant, discussing the various modes of perception by which the human mind apprehends nature, concluded that it is specially prone to see nature through mathematical spectacles. Just as a man wearing blue spectacles would see only a blue world, so Kant thought

\*And if mathematics is the highest flowering of science, then Maxwell's Equations become the greatest achievement in all science.

# MAXWELL'S EQUATIONS

that, with our mental bias, we tend to see only a mathematical world. Does our argument merely exemplify this old pitfall, if such it is?

"A moment's reflection will shew that this can hardly be the whole story. The new mathematical interpretation of nature cannot all be in our spectacles – in our subjective way of regarding the external world – since if it were we should have seen it long ago [my italics]. The human mind was the same in quality and mode of action a century ago as now; the recent great change in scientific outlook has resulted from a vast advance in scientific knowledge and not from any change in the human mind; we have found something new and hitherto unknown in the objective universe outside ourselves. Our remote ancestors tried to interpret nature in terms of anthropomorphic concepts of their own creation and failed. The efforts of our nearer ancestors to interpret nature on engineering lines proved equally inadequate. Nature refused to accommodate herself to either of these man-made moulds. On the other hand, our efforts to interpret nature in terms of the concepts of pure mathematics have, so far, proved brilliantly successful. It would now seem beyond dispute that in some way nature is more closely allied to the concepts of pure mathematics than to those of biology or of engineering, and even if the mathematical interpretation is only a third man-made mould, it at least fits objective nature incomparably better than the two previously tried."

Professor Einstein argued similarly in 1949<sup>4</sup>:

"... the approach to a more profound knowledge of the basic principles of physics is tied up with the most intricate of mathematical methods."<sup>5</sup>

I have put the weak point in Jeans' argument above in italics. The mathematicization of science developed with a vengeance as a result of the professionalization of education. Dr Ivor Grattan-Guinness once pointed out to me that the decline, or ossification, of science into 'maturity' was a necessary result of the in-

roduction of universal education in the mid-19th century, because it caused the growth of a powerful group with a vested interest in knowledge, the professional teachers.

Basil Bernstein<sup>5</sup> says that a body of knowledge is property, with its own market value and trading arrangements, to be protected by the social group which administers that body of knowledge.

If only those who lived off a body of knowledge could make that knowledge more secure, their careers and pensions would be protected. Two strategems were open to them<sup>6,7,8</sup>:

- to freeze the knowledge base so that it would not be a prey to the ebbs and flows of the real world, and
- to develop the thesis that any change in, or extension of, the knowledge base could only be properly effected by the professional 'knowledge magicians', 'knowledge doctors' or 'knowledge brokers', with their special, skilled, occult ways of pushing forward the boundaries of knowledge.'

***"One FRS told me that physical reality was composed of sine waves, and this encapsulates the mathematician's attitude to our world."***

It would of course be less effective for the professional group of knowledge brokers merely to bless or condemn influxes of new knowledge. (Admittedly they *do* do that. All my attempts to publish work on electromagnetic theory and on computer architecture (US patents 3913072 and 4333161) were blocked for more than ten years by learned journal referees, who are by definition knowledge brokers). The knowledge brokers' power would be greater if they required that new knowledge arise in their own prescribed style, preferably devised by one of their members, a knowledge professional. An early example of this in my own publications is that under threat of firing by my boss, who was also a Fellow of the IEEE, I was compelled<sup>9</sup> to include a ghastly, recondite, mathematical last section, written by someone else, in my 1967 IEEE paper<sup>10</sup>.

We have reached the following point in the argument. Under cover of claiming to maintain standards of scholarship, or to maintain rigour, knowledge brokers (1) block the ingress of new knowledge, particularly revolutionary knowledge in the Kuhnian sense<sup>11</sup>, and also (2) they make a last-ditch, bitter defence of old, discredited knowledge, like Maxwell's Equations.

"Unfortunately, however, when the body of knowledge is bigger and the rate of inflow of new knowledge is smaller, more and more of the activity within the knowledge [base] becomes 'celebration', more and more ceremonial rather than exercise in depth. As a result, a different calibre of person is attracted to that large knowledge, lacking the ability to understand and defend a body of knowledge with many levels of meaning. They are 'maintenance men' rather than 'builders'. The central body of knowledge ossifies, becomes brittle and then disintegrates."<sup>12</sup>

We need to realise that the cardinals who suppressed Galileo did not need to be competent theologians or scientists;

they only needed a much narrower competence, the ability to distinguish between the orthodox and the heretical, in both content and in style<sup>12</sup>. As to style, it is worth pointing out that possibly the ability to publish radically new, revolutionary<sup>11</sup> knowledge in the old accepted style would prove that after all the new knowledge was not truly revolutionary. So arguments about style, which are regularly lodged against my writing, including my last article,<sup>1</sup> create a beautiful Catch 22 situation where no new knowledge can be published.

In this penultimate paragraph I mention in passing The Lateral Arabesque, 'Arabesque' having the meaning ascribed to it by Dr Peter<sup>13</sup> rather than its dictionary meaning. In the engineering sense, the supposed situation where academia controlling a discipline – electromagnetic theory for example – maps onto the real subject, is

unstable. If at any moment the professors administering a discipline happen to be weak in one branch of it, they will tend not to examine their students in it, and so will tend to select those up and coming students who have that sub-discipline as their strength. Positive feedback down the generations of students will further the retreat from that particular sub-discipline. (Sir James Jeans and Einstein could be said to be telling us very wordily that academia have selected out budding scientists who showed a grasp of the physics, rather than the maths, of their subject.) Similarly, the whole of academia will move deeper and deeper into any misconception or aberration, and there is no corrective force. In my view, 'The Lateral Arabesque' makes it possible for an academic subject's content to end up with no overlap *at all* onto the real subject from whence that branch of academia sprang. I have just completed four years as Principal Lecturer in a College of Further Education, where I was struck by the lack of any significant link between the Higher TEC syllabuses that I taught and the real subject, electronic design, in which I had been earning my living in industry for the previous 20 years. As a minor example, academia evolved the myth that dissatisfaction among logic designers with the indeterminate state of an R-S bistable if driven on both its inputs at the same time led to the development of the J-K bistable; then that the instability of the J-K led to the development of the Master-Slave J-K, regarded in academia as the Rolls-Royce of bistables. A nice idea, but with no historical foundation.

A larger example would be academia's fixation on Quine-McCluskey, something not even heard of, let alone used, by engineers in the real world of logic design. Although I was in the best position possible to introduce or alter syllabuses, being on the County Committee, during my four years as a P.L. I failed to change one word of one syllabus. I struggled very hard to do so.

To sum up. Professionalization of knowledge leads to a vested interest in knowledge,

*Continued on page 75.*

<sup>4</sup>In passing, it is worth noting from page 62 of the same book, where Einstein writes: "The special theory of relativity owes its origin to Maxwell's equations of the electromagnetic field." In the literature we repeatedly come across assertions that Maxwell's Equations play a pivotal role in science.

LISTING OF "FUNGIN"

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10 REM: THIS PROGRAM DEMONSTRATES HOW DATA FOR TESTING THE
20 REM: "FITCOMP" PROGRAM CAN BE GENERATED. ANY CONGRUENT
30 REM: MATHEMATICAL EXPRESSION FOR A PERIODIC FUNCTION COULD
31 REM: BE USED, PREFERABLY WITH AN INTEGER NUMBER OF PERIODS
32 REM: FOR THE SAMPLING INTERVAL (TO AVOID "WINDOW" EFFECTS!)
33 REM: THE EXAMPLE SUGGESTED WILL GIVE 5 PERIODS OF A 5 Hz
40 REM: SINE-WAVE WITH SUITABLE AMPLITUDE, ASSUMING THAT THE
41 REM: TOTAL SAMPLING TIME REPRESENTS 1 SECOND.
50
60 REM: ANSWERING "45*5IN(5*X)+15*5IN(15*X)+9*5IN(25*X)" INSTEAD,
70 REM: WHEN ASKED FOR A FUNCTION, WOULD GIVE A COMPOSITE WAVE
80 REM: TRAIN, RESULTING IN FREQUENCY LINES AT 5Hz, 15Hz, 25Hz
90 REM: WITH AMPLITUDES IN THE RATIOS CORRESPONDING TO THE THREE
91 REM: FIRST FOURIER TERMS OF A 5 Hz SQUARE WAVE, ETC,ETC.
100
110 REM: EXAMPLES OF SUITABLE, PIECE-WISE CONTINUOUS FUNCTIONS
120 REM: (LIKE PERFECT SQUARE WAVE, SAW-TOOTH, ETC.) CAN BE
130 REM: GENERATED FROM SMALL BASIC PROGRAMS, TAILORED FOR THE
140 REM: PURPOSE! BY SUBDIVIDING THE ABSCISSA VALUES INTO GROUPS
150 REM: THAT CORRESPOND TO THE CONTINUOUS PORTIONS - WHERE THE
160 REM: VALUES OF THE FUNCTION CAN BE COMPUTED BY SIMPLE MATHE-
170 REM: MATICAL EXPRESSIONS -----
180
190 HODE 0
200 INPUTAB(10,10)"GIVE YOUR FILE A NAME,PLEASE! "55
210 X=0
220 DIM Y(255)
230 PRINT:PRINT
240 INPUTAB(5,10)"WRITE THE FUNCTION HERE (example: ""50*5IN(5*X)"" )"45
250 MOVE 0,400
260 FOR I=0 TO 255
270 Y(I)=EVAL(LAB)
280 DRAW X=50,Y(I)+400
290 X=X+PI/128
300 NEXT
310 R=DEPENDENT 55
320 PRINT 55
330 FOR I=0 TO 255
340 PRINT #R, Y(I)
350 NEXT
360 CLOSE #R

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necessary before running the program. As memory really is at a premium, this program is very skimpy on the text side, but it should be fairly self-explanatory.

While I have been exclusively working with Basic 2 for a long time, it struck me that some readers might still have Basic1 in their machines. I have

therefore carried out tests to check the compatibility of the program with Basic1, and it turns out that it needs to have the word OPENIN inserted near the start of line 810. After that, it will run on both Basic versions. (The disc programs would also need the addition of the word OPENIN in line 810 to work with Basic1, of course.)

## The deeper hidden message

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which leads to the disintegration of competence among the knowledge professionals as well as the prevention of the ingress of new knowledge. Something like this syndrome is needed to explain the survival of Maxwell's Equations for so long.

Moving graphics help to illustrate the subtleties of electromagnetic theory. For information on the availability of videotapes, please write to Ivor Catt, 15 King Harry Lane, St Albans AL3 4AS.

### References

1. Catt, I., The hidden message in Maxwell's Equations. *Electronic & Wireless World*, Nov. 1985, p.35.
2. Catt, I., The new bureaucracy. *Wireless World*, Dec. 1982, p.47.
3. Jeans, J., The Mysterious Universe, CUP 1931, p.113.
4. ed., Schilpp, P.A., Albert Einstein, Philosopher-Scientist, Library

- of Living Philosophers, 1949, p.17.
5. Bernstein, B., Class, Codes and Control, vol. 1. R.K.P., 1971.
6. Catt, I., The rise and fall of bodies of knowledge. *The Information Scientist*, vol. 12, no. 4. Dec. 1978, p.137.
7. Catt, I., The scientific reception system as a servomechanism, *Journal of Information Science* vol. 2, 1980, p.307.
8. MacRoberts, M.H. and B.R., The scientific reception system, *Speculations in Science and Technology*, vol. 3, no. 5. 1980, p. 573.
9. Catt, I., Computer Worship. Pitman, 1973, p.64.
10. Catt, I., Crosstalk (noise) in digital systems. *IEEE Trans. Electron Computers*, vol. EC-16 1967, p.743.
11. Kuhn, T.S., The Structure of Scientific Revolutions. University of Chicago Press, 1962.
12. ref. 9, footnote, p.14.
13. Peter, L.J. and Hull R., The Peter Principle. Souvenir, 1969, p. 38.

# Equitable access to satellite communications

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cedures would be applied in the frequency bands where most FSS networks operate now, namely a bandwidth of 500MHz at 6 and 4GHz and another 500MHz bandwidth at 14 and 11GHz. There was discussion at WARC-ORB as to what changes should be made to the methods used in these bands. No decisions were taken, but the improvements are likely to be selected from among the following:

- (a) The present procedure, based on advance publication of an outline of the technical details of a planned system, followed by multiple bilateral coordination negotiations, is becoming cumbersome to operate. It may be replaced by multi-lateral negotiations which could take the form of a conference every couple of years attended by representatives of every country with an FSS satellite in orbit or with plans for launching within say five years.
- (b) The concept of spectrum segmentation may be developed for reducing the incompatibilities between different networks having satellites which are neighbours in orbit.
- (c) The technical principles of coordination may be simplified in order to make the process of harmonization more amenable to computation in a multi-lateral environment.
- (d) A stimulus might be given to cooperation between countries sharing an arc by the formulation of principles of burden-sharing.
- (e) A more systematic approach may be made to the periodical up-grading of technical standards.

The allotment plan is to be prepared and the new coordination procedures are to be agreed at the second session of the conference, in 1988. Extensive preparatory work will be necessary meanwhile.

## Broadcasting

While guaranteeing equitable access to the g.s.o. for all countries was the chief task of this Conference, its other activities, all related to satellite broadcasting, are also interesting. The frequency assignment plan for satellite broadcasting at 12GHz in North and South America was given formal approval, parameters for the links which will be used to feed programme material to satellites broadcasting in other parts of the world were discussed and agreed; a plan for these feeder links is to be drawn up at the 1988 conference. Proposals for sound broadcasting by satellite, suitable for reception on portable or car receivers, were considered; there is a major problem here in that it has not been possible yet to find a suitable frequency band that could be allocated for this purpose but the search continues and the 1988 conference will return to the matter.

Finally, WARC-85 discussed ways of providing for high definition television broadcasting by satellite. In two of the three Regions into which the ITU divides the world there is a frequency band for satellite broadcasting at 22GHz, but this does not include Europe. Now that the 12GHz direct broadcast band is planned world-wide for 625 and 525-line tv, there is a lot of interest, particularly in Japan and USA, in using the 22GHz band for high definition systems needing much more channel bandwidth. This enthusiasm is spreading to Europe and the feasibility of allocating a band at 22GHz world-wide will be discussed again in 1988 after further study of the problems posed by existing services already operating in the band.

David Withers is reporting WARC-85 in greater detail at OnLine's Satellite Communication 85 Conference, at the Tara Hotel, London, Dec 3/4. Proceedings are available from OnLine at 01-868 4466.