## BOOK REVIEW*

EDDINGTON'S search for a FUNDAMENTAL THEORY: A key to the universe C. W. Kilmister, Cambridge University Press, 1994

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This book, by one of the founders of ANPA, explores a mystery in the history of science. Sir Arthur Eddington was a brilliant astrophysicist and one of the leaders of British science in the 1920's. He was one of the most important figures who brought Einstein's work on general relativity to the attention of the British scientific community. He was responsible for organizing the solar eclipse expedition whose observations gave dramatic evidence for the prediction of the bending light as it passes close to the sun. His book, Mathematical Theory of Relativity, published in 1923, was recognized at the time as the definitive textbook in English on the subject. It was a model of lucid presentation. In 1936 he published Relativistic Theory of Protons and Electrons (RTEP), which most readers found obscure and unhelpful; some felt it was completely on the wrong track. His last book Fundamental Theory (FT) - essentially complete before his death, but published posthumously in 1946 - went even further toward destroying his reputation with most physicists.

The mystery is attacked by Clive Kilmister by asking and answering three questions about these two controversial books:

[^0]1. What made Eddington write RTPE (and then FT) ?
2. Why is RTPE (and also FT) obscure?
3. What important and valuable aspects does each work have?

Since a reviewer is not supposed to reveal the plot of a mystery story, I will not summarize the answers here. I urge you to learn for yourselves by reading this delightfully written volume which clarifies an important piece of scientific history in non-technical language.

This work is, of course, required reading for anyone interested in ANPA. Ted Bastin and Clive Kilmister met originally because of their common interest in Eddington's theory, and in the early 50's started the collaboration which has continued to this day. ANPA was originally founded in 1979 in order to attract more attention to their efforts to forge a new foundation for physics. As Clive remarks, "For all its faults, RTPE remains, because of its wealth of revolutionary ideas, one of the most important scientific books of the first half of the twentieth century. It puts at the head of its statement of purpose the outstanding problem of physics the establishment of a sensible relationship between general relativity and quantum mechanics. An enormous amount of work on somewhat more orthodox lines than Eddington's toward quantum gravity in some sense of the words has still left this problem unsolved. This suggests that perhaps the wrong question is being asked."

As those who have attended recent meetings of ANPA in Cambridge, England know, there is as yet no consensus within ANPA as to what is the right question, let alone how to ask it! How to formulate the problem of quantum gravity is a matter of lively debate among us, and not just in the community at large. This debate will certainly continue at the next meeting [ANPA 17, Sept. 7-10, 1995]. As background for understanding the fireworks, which should provide considerable entertainment in September, I suggest that you read the masterful outline of the situation as Clive sees it as quoted in the APPENDIX.
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## APPENDIX

Excerpts from C.W.Kilmister, Eddington's search for a fundamental theory: A key to the universe, Cambridge, 1994, quoted with kind permission from the author.
pp. 216-217
If the scale constants are prior, it is necessary to show how the appearance of other numbers can be understood. Eddington did not get so far as that problem, but he unconsciously anticipated the way ahead. For the triumphal conclusion of RTPE quoted in the last chapter, though it overstates its case, does so in this way:
"There is nothing in the whole system of laws of physics that cannot be deduced unambiguously from epistemological considerations."
[CWK's italics]. Now if one considers Eddington's claim careful, it becomes clear that, if there is anything in it, questions of epistemology cannot be simply pasted afterwards onto a theory like physics which exists independently of them. If Eddington is right in seeing his theory as epistemological, and it is hard to see it in any other way, then this fact needs to be part of the theory from the beginning. The resulting theory cannot be a physical theory in the usual sense, but a theory of how physical knowledge is gained. The process of gaining physical knowledge must be part of the subject matter of the theory. Such a theory has been formulated in recent years by Bastin, Noyes and others.* It is beyond the scope of the present book to examine it in detail merely because it arises in response to Eddington's difficulties. Suffice it to say that the theory has no obvious connection with Clifford algebras but it gives, like Eddington's, 137 as a first approximation to a scale constant. Its strength lies in its being able to use this numerical value to identify the scale constant with the fine-structure constant and to carry this identification forward to the finding of the next approximation. This further step gives $137.035 \ldots$ as a second approximation. The theory also gives good reason for the dimensions of space to be three and it generates in a natural way the scale constant $2^{127}=10^{38}$. To describe these achievements of the new theory must not
be seen as denigrating in any way the achievements of RTPE. Rather, it is from the basic idea of the scale constants as prior, with its inevitable consequences, that the new theory is generated, so that it can be seen as a logical development from RTPE.
pp 219-222

* Much of this work is not yet published so a summary is given here. The basic idea is to study the process of increase of information about the world. The model of this chosen is that involved in division between that part of the world that is known and what remains unknown. Entities may change from being in the unknown part (when nothing can be said about them) into the known part. They then show up as new mathematical elements and the frequency of appearance of such an element is the one source of information about the world. The process is autonomous, so that the requirement of quantum mechanics of 'incorporating the observer' is satisfied without the need to make an untenable distinction between observation and other operations and without the temptation to ascribe properties to human observers.

Each new element has to be labeled say as $(a, n)$ where $a$ is the label of the element and $n$ is an integer stating how many times the element has occurred. The following discussion is concerned with $a$. It is argued that the method of carrying out labeling is immaterial, so that the process will have the same character as if it were systematically carried out with some fixed label alphabet, $L$. The particular alphabet $L=[1,2,3 \ldots]$ is adopted for analysis, as it can be without loss of generality. Here the symbols of $L$ are not cardinal numbers but they are used in an ordinal fashion with the obvious ordering. The labels are strings of symbols of $L$ or 'words in $L$ '. The labeling requires a test of whether an element is new or not. In whatever way the process actually operates, the effect is the same as if it operated thus: $S$ is the set of already labeled elements. The process relates $S$ and the not-yet-labeled element; the result is to 'signal' whether the new element is a member of $S$. The signal is a word in $L$ if the entity is in $S$. Otherwise it will
have a value outside $W(L)$ (the set of words in $L$ ) and this value can be taken as one fixed value and written as 0 . In all this it is the process that is taking place that is emphasized, rather than the objects taking part in it. Nothing is known about the background (by definition) and so at each stage all possibilities must be treated indifferently; and a consequence of this is that if the process continues long enough any possibility will in due course occur, which is thought of in the theory as a kind of primitive ergodic principle.

An analysis of the special case in which $S$ has only one element, $b$ say, so that the question of whether $a$ is in $S$ is that of whether $a$ is equivalent to $b$, shows that the requirement of an equivalence relation mean that: (i) Attention can be confined to a subset $R$ of $W(L)$, called the set of rows, of the form:

$$
r=r_{1} r_{2} r_{3} \ldots r_{k}, \quad r_{1}<r_{2}<r_{3}<\ldots r_{k}
$$

where the $r_{i}$ are symbols of $L$. (ii) There is a map

$$
\text { row : } \quad W(L) \rightarrow R
$$

constructed by removing any pair of occurrences of a symbol of $L$ and reordering the remainder. (iii) The signal generated for $a, f(a, b)$, can be written in terms of an associative and commutative operation,$+ f(a, b)=a+b$, where the operation $a+b$ is defined in terms of concatenation of rows by:

$$
a+b=\operatorname{row}(a \cdot b) .
$$

Because of the way in which the operation is used, it is called discrimination.
The general case in which $S$ has more elements cannot be treated simply by testing the new element against each in turn of the existing elements of $S$ since such a process would also need to ask, for each element, 'Has this element been tested before or not?' and so on in an infinite regress. The set $S$ has to be
treated as a whole. An analysis on the same lines as in the one-element case shows that: (i) an unambiguous labeling by this process arises only if the sets $s$ are discriminately closed (that is, such that $a+b$ is in $S$ for any two different $a, b$ in $S$ ); (ii) there is no loss of generality in taking the signalling process to be defined by a linear characteristic function (because of (i)) $S$ (using the same symbol for set and functional process). The value of $S(a)$ is in $R$ if $a$ is not in $S$ but is 0 otherwise. When such functions $S, T$ are defined, an operation $S+T$ is induced by the rule:

$$
(S+T)(x)=S(x)+T(x)
$$

for all $x$ in play up to the point reached. (Here + denotes discrimination on the right-hand side.) This operation between $S$ and $T$ also turns out to be discrimination operation but at a 'higher level'. It is therefore possible for the process to ascend to a higher level at which single elements stand for set of elements at the lower level. It need not do so since the process is self-organizing but the ergodic principle shows that eventually it will do so.

There is a limit to the extent of this self-organization and this limit is given by the construction of Parker-Rhodes: consider any set $S$ of $r$ elements. These generate a discriminately closed set of $2^{r}-1=r^{*}$ members. Arbitrary discriminations between them will yield one of them or zero; i.e. one of the $2^{r}$ cases. To specify a member means giving $r$ bits of information, or for shortness, each element carries $r$ bits. The number of discriminately closed subsets generated by subsets of $S$ is also $r^{*}$ and so, in level changes, any of the corresponding $r^{*}$ characteristic functions is specified by listing its effect on each member of $S-r$ bits for each of $r$ elements. Thus each function carries $r^{2}$ bits. A system of levels can therefore start like this so long as $r^{2} \geq r^{*}$, which limits $r$ to $2,3,4$. To subsume a second level under the previous construction, regard the $r^{*}$ elements as a subset of $r^{2}$ ones each carrying $r^{2}$ bits. Then a second level change is possible if $r^{4} \geq\left(r^{*}\right)^{*}$ and this limits $r$ to 2 (in which case a further level change is also possible). The bounding construction therefore begins with two elements. At the first stage they
define $2^{*}=3$ discriminately closed subsets with three corresponding characteristic functions each carrying four bits. These give rise to a further $3^{*}=7$ discriminately closed subsets, making 10 in all, and each corresponding function carries 16 bits and gives rise to 127 more discriminately closed subsets, bringing the total to 137. Now these 127 characteristic functions each carry 256 bits but give rise to $127^{*}=10^{38}$ more discriminately closed subsets, which terminates the construction because $r^{2}=65536<r^{*}=10^{38}$.

The theory argues that the three-fold basic characteristic of this hierarchy of levels corresponds to a three-fold structure of experience (since the process is that of increasing knowledge about the world) and so the bounding construction of ParkerRhodes demonstrates the three-dimensionality of space. The successive numbers $3,10,137,10^{38}$ are identified as scale constants in the sense used in the text and the numerical values of them then indicate that the third and fourth correspond to electromagnetism (the fine-structure constant) and gravitation respectively. This suggests an identification of the two others with strong interactions but this seems at present less clear.

Once 137 has been identified as a first approximation to $1 / \alpha$, the logical position changes. The particular scale constant is now known and better approximations to it can proceed as follows. Suppose the process is artificially constrained to be operating at the first three levels only and that these three levels have been filled. There are 137 elements and so, in subsequent operations of the process, subject to the constraint, there is a probability $1 / 137$ of any particular element arising again. This interprets the first approximation as a probability in the process. Now if all constraints about level are removed, so that when an element arises it is not determined whether it is at one level rather than another, then at the first level the four possibilities, of its being one of the three elements or being at a higher level, must all be given equal probability $1 / 4$. Similarly at the next level, $1 / 8$ and at the third $1 / 128$. The probability of being at none of these levels and therefore at the top level is $1 /(4 \times 8 \times 128)$. The probability of being any particular element at the first three levels is reduced accordingly and 137 is increased to 137.033 . This
second approximation is in error by only $0.002 \%$.
The strength of this argument appears, however, when it is realized that it is not quite correct and that correcting it further improves the agreement. The point is that there are 74088 possible set of characteristic functions for the 7 discriminately closed subsets at level 2 and of these only 61772 give rise to 127 such subsets at the next level. The remainder give rise to fewer. The factor $1 / 128$ therefore needs to be increased and a lengthy calculation shows that, to a good approximation, it should be replaced by $1 / 122.229$ giving rise to a corrected value of 137.03503 , in error by less than $0.001 \%$.

Only imperfect versions of this work have so far been published
(Bastin 1966 [Studia Philosophica Gandensia 4, 77],
Bastin et al. 1979 [Int. Journ. Theor. Phys. 18, 445],
Noyes \& McGoveran 1989 [Physics Essays 4, 115],
McGoveran \& Noyes 1991 [Physics Essays 2, 76],
Kilmister 1992 [Philosophica 50, 55]).
Work is proceeding very actively and the workers have formed an international group, the Alternative Natural Philosophy Association. Further details can be found in the annual Proceedings of the group's meetings (obtainable from Dr. F. Abdullah, City University, Northampton Square, London EC1V 0HB). The group is not monolithic. Some members, particularly in North America, have employed promising short cuts to derive a large number of physical constants. For example, to concentrate on one familiar to Eddington, they derive

$$
\frac{m_{p}}{m_{e}}=\frac{137 \pi}{K}, \text { where } K=\frac{3}{14} \frac{4}{5}\left(1+\frac{2}{7}+\frac{4}{49}\right),
$$

which agrees to better than $0.0001 \%$. Such individual agreements could perhaps be dismissed as numerology, but the large number of good agreements is a good defense against this. By contrast, the UK arm of the group is most concerned to clarify principle before embarking on numerical calculations and has also made considerable progress.


[^0]:    * Work supported by the Department of Energy, contract DE-AC03-76SF00515.

