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A Book Review by the Editor, Cynthia Whitney

Zero to Infinity: The Foundations of Physics

by Peter Rowlands, University of Liverpool, United Kingdom

2007, World Scientific: New Jersey, London, Singapore, Beijing, Shanghai, Hong Kong, Taipei, Chennai

This is a very big, very deep, book about a proper foundation for mathematical physics. It is a wonderful book, with much information, some of which you may have encountered before in a fragmented way, but can now appreciate much better as part of a coherent whole, presented in this book.

The book is about physics, but is not about any sort of model-dependent physical theory; for example, fluid dynamic aether theory, or quark-based elementary particle theory, or electromagnetic, or gravitational, or quantum, field theory. It does not buy into any sort of detail-dependent origin for physical laws, as in Big Bang theory.

The book is about a process for the construction of a mathematical edifice that embraces much that we know to be needed in physics, and leaves little to be chosen arbitrarily among too many options. In fact, it leaves nothing important to be chosen arbitrarily. Contrast that to current string theory!

The basic premise here is that "physics is the inherent creator of mathematics." (p. 47) I can't really agree on that. Some of mathematics, such as the part discussed in this book, may be about physical reality, but a lot of it is about other things, such as probability, actuarial science, game theory, gambling, financial engineering, and other potentially destructive human activities! But that doesn't matter; the book has inherent value.

The book does not start with the usual concepts that have always been considered 'fundamental' in mathematics, like counting by integers. Such counting actually presupposes quite a lot. On p. 83, Rowlands suggests that the premature adoption of the integers may lead to the system-incompleteness problems identified by Gödel. Interesting thought! I hope to find some response to it from A.A. Nassikas, [author of "Electromagnetic Space-Time-Ether", pp. 180-182, and of earlier NPA papers as well, and of the book Minimum Contradictions Everything, available at the 2009 NPA conference, and ever after from Hadronic Press].

There are also other NPA authors who may tell us something interesting in response to Rowland's book. I look to Zbigniew Oziewicz, who invited me in on "Electric and Magnetic Fields According to Hermann Minkowski", p. 183-194. And I

look to D.E. Matthieu-Laudet, author of "Special Relativity and the Theory of Four-Vectors", pp. 137-154, and to Diego Saá, author of "Four-Vectors in Electromagnetism", pp. 218-233.

And I hope that Rowlands will in turn look at and interact with all these authors and these works. Rowlands is not overly infatuated with group structures, and he knows about groupoids, so what might he say to Oziewicz and me? And he knows of problems like those recounted by Matthieu-Laudet, and he knows historical details like those recounted by Diego Saá.

Anyway, Rowlands doesn't start with the troublesome unit '1'; he starts with the benign nothing, '0'. His approach is not based on 'counting'; it is based on 'computing'. The difference is that 'counting', by integers, presumes so much, whereas 'computing' means thinking like a computer scientist thinks, in terms of a 'Universal Rewrite System'. Unfortunately, I am not a computer scientist; I am a physicist. Iam not confident that I know what the term 'Universal Rewrite System' means. Here is an opportunity for Rowlands to expand his audience: for more clarity in communicating to the uninitiated, he can explicitly define all such specialized terminology.

Notation is an issue too. It seems to me that if it is worth showing some notation, then it is worth revealing how to read it. On page 6, we see the expressions

(subalphabet) (alphabet) $\rightarrow$
(alphabet) *i.e.* there is nothing new

(alphabet) (alphabet) $\Rightarrow$
(new alphabet) *i.e.* the zero totality is not unique

The $\rightarrow$ and the $\Rightarrow$ are explained, but the meaning of proximity, (…)(…) escapes me. I don't know how to read these expressions as English language sentences, like I can generally read ordinary mathematical equations.

And once in a while there are things so important that they appear in a Section title, but yet they are explained only rather obliquely, without direct quotes. I think of Noether's theorem in this category. Page 37 says what it allows us to do, page 40 says more or less what it is, and page 54 promotes it into a Section title, but still we haven't seen a sentence in quotes stating it explicitly, with a reference.

It seems to me that, just as we ought not presume too much before moving on with the mathematical construction (*i.e.* presume to start with integers instead of starting with zero), we ought not presume too much before more moving on with the writintg of the text!

But all that can be forgiven, because the book is so good anyway.

Characterizing his book, Rowlands says on p. xi "...there is no challenge here to the bases of quantum mechanics, classical physics, particle physics, or anything else now universally accepted." Note that Special Relativity Theory (SRT) is not on that list. The reason why is that Rowlands does not buy into the SRT understanding of

‘spacetime’ as a unified thing with all its constituents of like kind. The SRT understanding really mixes ‘apples and oranges’, because time really is different from space. In Rowlands’ formalism, time corresponds to a real scalar, without dimension or measurability, and with a definite physical direction, whereas space is a triad of imaginary quaternion units representing three dimensionality and measurability of space, and its physical symmetry with respect to direction reversal.

Imagine that one starts with an empty vacuum and starts filling it with mathematical objects, always in pairs that cancel each other, leaving a total zero. The cancellation works by some type of mathematical combination operation, such as addition or multiplication. The creation of cancelling duals is a kind os ‘splitting’.

There are three kinds of ‘splitting’, termed ‘conjugation’, ‘complexxification’, and dimensionalization’. ‘Conjugation’ means splitting ±1. ‘Complexification means splitting $\pm\sqrt{-1}$, or $\pm i$ (familiar notation), or $\pm \boldsymbol{i}$ (quaternion notation). ‘Dimensionalization’ means splitting for a second quaternion direction $\pm \boldsymbol{j}$, which automatically carries with it a third quaternion direction $\pm \boldsymbol{k}$.

The book title is Zero to Infinity, but the book content actually appears to go from zero to 64. The 64 is 2^6, for six splittings. These splittings are spelled out on page 11. First 0 splits into +1 and –1, or two parts. Then each of those splits into real and imaginary, giving ±1 and $\pm i$ (familiar notation), or $\pm \boldsymbol{i}_1$ (quaternion notation), giving 4 parts. The quaternion notation then allows, not just the one quaternion imaginary $\boldsymbol{i}_1$, but also another, $\boldsymbol{j}_1$, which allows another split, giving 8 parts. The quaternion notation also allows another quaternion imaginary, $\boldsymbol{k}_1$, but it is redundant because $\boldsymbol{k}_1 = \boldsymbol{i}_1 \boldsymbol{j}_1$. So the next split requires a new imaginary unit $\boldsymbol{i}_2$. That brings us to 16 parts. And $\boldsymbol{j}_2$ brings us to 32 parts. Finally, yet another imaginary unit $\boldsymbol{i}_3$ brings us to 64 parts.

It is not necessary that this process stop at order 64. I believe it does so only because order 64 is sufficient to meet the requirements of the Dirac algebra. But always remember, the title of the book is Zero to Infinity, not Zero to 64!

The display on page 11 is blindingly confusing to look at, and

I definitely had a hard time comprehending it. For readers of this review, let me offer here a more abstract and less explicit display that I developed to explain the pattern to myself.

order 2 = ±1
order 4 = (±l, $\pm \boldsymbol{i}_1$) × order2
order 8 = (±1, $\pm \boldsymbol{j}_1$) × order 4
order 16 = (±l, $\pm \boldsymbol{i}_2$) × order 8
order 32 = (±1, $\pm \boldsymbol{j}_2$) × order 16
order 64 = (±1 $\pm \boldsymbol{i}_3$) × order 32

There is no need to expand this display out to show all its constituent parts explicitly, but if one does so, the most recently added imaginary unit always comes on the left end of any product. That doesn't happen in the original explicit format on p. 11, where one finds $\boldsymbol{i}_1\boldsymbol{j}_1$, but then $\boldsymbol{j}_2\boldsymbol{i}_2$. Confusing!

Evidently, this switch has something to do with ''internal group symmetry'. Perhaps it has to do with the imposition of $\boldsymbol{j}_1$ to create order 8. I have failed to achieve certainty about this.

Perhaps confusion is inevitable in a narrative that is as abstract as this one is. It may help to know that concrete mathematical objects that perform in the way quaternions are defined to perform can actually be written down in terms of something very familiar: matrices. Along with the 2 × 2 identity matrix

$$\sigma_0 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix},$$

the Pauli matrices σ_x , σ_y, , σ_z , spelled out on p. 30, and again on p. 113, as

$$\sigma_x = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, \quad \sigma_y = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}, \quad \sigma_z = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix},$$

do the trick.

But there is a technically significant typographical error on both pages 30 and 113:

$$\sigma_x\sigma_y = -\sigma_y\sigma_x = i\sigma_x \quad \text{should read} \quad \sigma_x\sigma_y = -\sigma_y\sigma_x = i\sigma_z \ .$$

There is also an inevitable confusion of notation.* Pauli matrices are also sometimes referred to by boldface letters, **i**, **j**, **k** (p. 13). The boldface letters in turn sometimes refer to familiar Hamilton three-space unit vectors (see p. 26), or to multivariate vectors (see p. 17). In case all that gets confusing, just remember upright **i**, **j**, and **k** always square to +1, whereas slouching ***i***, ***j***, and **k** always square to –1.

There is also a lesser typo on p. 70: the 8 basic units in the Dirac algebra given as

$$1, i, \mathbf{i}, \mathrm{j}, \mathbf{k}, \boldsymbol{i}, \boldsymbol{j}, \mathbf{k} \quad \text{should read} \quad 1, i, \mathbf{i}, \mathbf{j}, \mathbf{k}, \boldsymbol{i}, \boldsymbol{j}, \mathbf{k} \ .$$

But all of that is trivia. Here is a really important idea. Think of a quaternion whose four parts correspond to mass (always positive), and vector charge (always available in two signs), comprising electric charge, strong-nuclear-force charge, and weak-interaction charge (pp. 32, 43).

There is much to take to heart in this great book. Right now I am thinking back to a remark on p. 57 concerning 'boundary conditions', imposed to conclude the process of 'solving' the differential equations of physics. Rowlands points out that boundary conditions are equivalent to approximations. I do agree with that, and desire to remark even further. Physics often analyzes what it calls a 'closed system'. The enclosing boundary of such a system is where approximation conditions are imposed. But I believe that in Nature there is no such thing as a closed system. Closed systems only exist within the realm of closed minds. Don't ever let your own mind be one that is closed!

Cynthia K. Whitney

* *Note by author*. Correspondence between the author and reviewer has established that the symbolic convention employed on p. 26 is used only in describing the historical background, and is clearly distinguished from both modern conventions and the author's own symbolism.