Review of: "Limitations of the Method of Integration in Astro- and Fundamental Physics"

Harish Parthasarathy[1]

1 Electronics and Communication Engg., Netaji Subhas Inst of Technology, India

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As I understand it, this paper is about the inadequacy of continuous integration methods in the physical sciences. After reading this paper, I felt that there was a certain plausibility in the author's arguments. He cites the example of Newton's third law of motion to illustrate this idea. After a particle hits another particle during a collision, its momentum instantly undergoes a change, and this is not reflected by continuity arguments. However, no matter how rigid the bodies are, there will still be a very small collision duration caused by the very small deformability of the bodies, and hence the momentum of either body will not change instantaneously. The author then gives the example of pair annihilation of electrons and positrons and conversely pair production out of photons in quantum electrodynamics as one of the primary phenomena in astrophysics. Now, the amplitude for the vacuum polarization process in which a photon propagates, disintegrates into an electron and a positron, and then recombines to produce a photon is usually computed by a one-loop Feynman diagram, which can be corrected further by the introduction of multiloop amplitudes based on the Dyson series expansion of the unitary evolution operator with the interaction Hamiltonian between the photon and the electron as prescribed by Dirac's relativistic wave equation. The process of computing these amplitudes is based on evaluating the Feynman diagrams using many standard tricks on integration over four-dimensional momentum space. When infinities creep into these computations due to ultraviolet and infrared divergence effects, we renormalize the fields and coupling constants in such a way that the infinite parts of the amplitude are eliminated and only finite answers come up. The mathematical justification for these techniques is not known even today, but they give the correct experimentally verifiable results, as Feynman pointed out. Although we use continuous integration methods in QED, we cannot justify them, and this suggests that there must be an alternate discrete method for evaluating these amplitudes. The fact that in string theory, we do not encounter infinities while evaluating Feynman diagrams suggests to us that the space-time manifold itself is composed on a minute scale of strings rather than points and that fields are not functions of space-time points but rather functions on the string worldsheet. This alternate view of physics has been shown to give all the correct results of general relativity with extra stringy corrections at the quantum level, thereby avoiding renormalization problems. The author is undoubtedly correct in that by treating space-time as a continuum of points, we lead to internal contradictions, but that does not mean that space-time should be completely discrete. The author then goes on to suggest that in set theory and number theory, we can find better explanations of physical laws, especially those involving randomness like the second law of thermodynamics and even the probabilities that are inherent in quantum theory. He cites the example of prime numbers, whose pattern is totally unpredictable. However, to date, we do not have a formula for the number of primes between two integers. We have only asymptotic formulae, so it would be premature at this stage to state that the fundamental laws of physics can be described using set theory or prime number theory. Of course, in string theory, for example, the number of states of the string having a fixed energy is given by the Hardy-Ramanujan theory of partition functions, i.e., the coefficient of z^n in the product of $1-z^k, k=1,2,.,…$ whole raised to the power 24. It is thus natural to believe that discrete methods in physics will soon replace the whole of continuum physics. Nevertheless, the paper is very interesting, and I hope that the author will pursue this line of work. I would also like to point out that in supersymmetry theory, the space-time manifold is replaced by super-space-time, having both Bosonic space-time variables and, in addition, Fermionic or Grassmannian anticommuting variables. The concept of a field is replaced by the concept of superfields, and the resulting supersymmetric Lagrangians constructed have not only from a purely mathematical viewpoint unified Boson-Fermion theories but have also been quite successful in unifying gravity as described by Einstein's general relativity with conventional elementary particle physics. I recommend publication after the author gives some stronger evidence in the form of examples of how structures in set theory and prime number theory can be integrated into particle physics.

When Planck's law of black body radiation replaced Wien's displacement law in order to get agreement with experiment, Planck's constant was created, and it led to the quantum revolution according to which energy comes in discrete wave packets and not in a continuum. This is the first example of how discrete methods replaced continuum methods.