Divyadaan **33**/1 (2022) 123-128

QUANTUM ENTANGLEMENT AND EMERGENCE

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During the years 1971–1974, I was an undergraduate at University College Dublin (UCD), and unbeknownst to me at the time, I was essentially following the same mathematical itinerary as Philip McShane. However, unlike McShane, I was struggling with my senior course in quantum mechanics. It was also during that time period that I had a providential encounter with Fr. Brendan Purcell of the philosophy department, which was to profoundly change my life on many levels. It was (if I recall) February of 1974. We went for lunch together with some others after Brendan had given a lunchtime lecture to members of the Student Christian Movement. At a certain moment, I commented that I had a problem with objectivity in quantum mechanics. Brendan immediately suggested that I read Lonergan's *Insight.* My first reaction as an innate positivist was that this was not something to be taken seriously; after all, what would philosophers know about mathematics? Indeed, more than a year was to pass when through Brendan, I first heard mention of Philip McShane and of his mathematical and philosophical interests, and although I paid little attention to who he was at the time, that was soon to change.

I finished my M.Sc. degree in September of 1975 having specialized in general relativity and quantum mechanics, and a few weeks later Brendan gave me a gift of Bernard Lonergan's *Insight.* That evening I began to look through it and quickly realized that this was no bedtime reading, at least for the uninitiated. I struggled to understand both the introduction and preface. Chapter 1 (Elements) was a bit more accommodating but nevertheless hard work even for someone with an M.Sc. Degree in mathematics. Two things came out of that initial struggle with this text. Brendan referred me to McShane's article entitled 'The Foundation of Mathematics,' which had been published in *Modern Schoolman*.[1] It was my first encounter with McShane's thought, my first delving into the methodology of mathematics, my first encounter with an exceptionally gifted mind, my first encounter with someone who understood what my questions were or should be. It was also the first time that I realized that

[1] Philip McShane, "The Foundation of Mathematics," *Modern Schoolman* **40** (1963): 373–387.

we had similar interests. McShane had graduated from the Mathematical Science program at UCD as I did (although 19 years earlier) and, moreover, he was asking the same questions that I was, or more precisely, he was unlocking Lonergan's *Insight* for me by teaching me how to ask the correct questions. He was not the only one to do this, but certainly he was one of those who gave me a passion for metaphysics. Also, once I discovered that we had both graduated from the same program at UCD, I mentioned his name to Prof. J. R. Timoney, who was head of the mathematics department at the time. He replied that "[McShane] was second only to O'Raifeartaigh[2] but left mathematics for the bliss of philosophy."

My second encounter with the thought of Philip McShane was through his book *Randomness, Statistics and Emergence*. I knew that his Ph.D. dissertation was related to Lonergan's methodology applied to biology. However, being that my interests were still in mathematical-physics, I did not feel any urge to acquire it so to speak, until one day in August of 1977, while perusing books in McGills in Upper O'Connell Street, Dublin, there it was in front of me. As it turned out, I did not have sufficient money with me to purchase it, but I came back a week later and did so. If 'The Foundation of Mathematics' article was seminal for me in that it helped me to understand the nature of scientific methodology, then this book was even more so. I had already made my first attempt to read *Insight*, gleaning as much as I could and trying to also understand my own cognitional structure through self-appropriation with more than a little help from Brendan Purcell. I was particularly impressed with Chapter 4 and Lonergan's treatment of emergent probability, but it was also equally clear to me that the move to higher schemes of recurrence and generic higher viewpoints, if it were to be grasped scientifically, required a move from description to explanation that could only come through hard work and a detailed explanatory knowledge of how actual schemes emerge and function in the real world. It is not enough to grasp Lonergan's formal argument, rather it seemed to me that if the evolutionary process is a sequence of generic higher viewpoints, then it would be necessary to delineate the processes that enabled the move from physics to chemistry, from chemistry to biology and so on.

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[2] O'Raifeartaigh was Senior Professor of Theoretical Physics at the Dublin Institute of Advanced Studies and classmate of Philip McShane. He died on November 18, 2000.

Moreover, I was convinced that part of my initial problems with objectivity in quantum mechanics were related not only to wave-particle duality but also to being better able to distinguish physics from chemistry. I felt that I could and indeed should perhaps work on this latter problem at some later date, but never quite knew how it might happen. On reading *Randomness, Statistics and Emergence,* I was able for the first time to fully appreciate the distinction between classical and statistical methods and also complement my understanding of chapters 2–4 of *Insight*. Ironically, one can study probability theory for many years and overlook that its intelligibility rests on the non-systematic nature of events. One can consider probability theory as a special case of the theory of finite measures without having the certainty that it implicitly involves a paradigm shift from the formal question to the question of reflection, from explanation to existence. Indeed, it is quite possible in mathematics departments to emphasize pure probability theory over statistics by relegating statistics to some type of first cousin to mathematics. In other words, most mathematicians are aware that there is a difference between the two but do not think it through.

The book *Randomness, Statistics and Emergence* is, as the title suggests, a book about those three topics and taken in that order. Chapters 1–4 treat the notion of randomness, chapters 5–8 treat the notion of statistics, chapters 9–11 treat the question of emergence, and finally chapter 12 recasts the book into the context of Lonergan's explicit metaphysics. I had read the book to help me deal with the problem of scientific reductionism. My religious faith told me that the evolutionary process had a higher meaning than Darwinian evolution and in attempting to understand the amoeba as described and explained by McShane gave me the first concrete methodological tools to overcome my own positivist leanings. When I first read it, I had not yet made the transition from latent to explicit metaphysics but was in that intermediatory stage of what Lonergan called the "problematic" phase of metaphysics in which "the need of a systematic effort for unification is felt" but my mind was still caught up "in the disarray of the positions and counter-positions that result from the polymorphic consciousness of man."[3] Therefore, while recognizing that McShane was moving in a higher context of metaphysics, I very much read the book to help me develop the language of emergent probability and to help me develop a top-down approach to the question of

[3] Lonergan, *Insight*, CWL 3, 416.

emergence and evolution. Also in that same period, since I was not a biologist, I felt compelled more and more to do for chemistry what McShane had done for biology, in other words, to delineate the formal elements needed to explain chemistry as a higher systemization of the merely coincidental aggregate of quantum interactions on the level of physics. I had already grasped Lonergan's general arguments for emergence as specified in Chapter 4 of *Insight*, and therefore from a common sense (albeit a refined scientific common sense) point of view, I knew that there was a stratified hierarchy of things associated with an upward thrust from elementary particles, to atoms, to molecules, to living cells, to animals, to sentient beings, to humans, that could be explained by emergent probability. But at the same time, when I turned to the actual world as it was, the question remained as to how a molecule of water H_2O was systematized by the laws of chemistry and not by quantum physics alone.

On reading *Randomness, Statistics and Emergence* I felt challenged to undertake this task for my own personal intellectual development, while also advancing the program that McShane and others had begun. If metaphysics is to become fully explicit, it must reverse counter positions by orientating the sciences as given and by helping them move from description to full explanation, from mere images to concepts by pointing out that the intelligibilities constitutive of the higher viewpoint cannot be explained (systematized) from a reduced viewpoint. In other words, events which form a coincidental aggregate on one level are sublated by a higher system. McShane makes this distinction on numerous occasions throughout his thesis by distinguishing biochemical from biological laws. In hindsight, McShane also recasts the problem of emergence into a question of meaning when, in the last chapter of the book, he distinguishes the commonsense, the scientific, and the philosophical meanings associated with the question "What is water?"[4] and notes that from a philosophical viewpoint it "is a specification of the basic question, 'What is knowing?'"[5] which in turn grounds scientific and artistic responses to the same question.

Forty-five years have now passed since undertaking my initial studies of Lonergan and McShane, forty-five long years in which I set out on a quest for truth and meaning. It seems that my initial quest has come full

[4] McShane, *Randomness, Statistics and Emergence* (1st edition), 258.
[5] Ibid.

circle. Apart from my spiritual journey, I also did a Ph.D. in mathematics at UCLA (1990) and have spent many years teaching the subject, especially probability and statistics, at NEIU in Chicago, while delving more and more into the mathematical and epistemological consequences of the Einstein-Podolsky-Rosen paradox (EPR)[6]. While in Chicago, I also undertook theological studies at CTU and, thanks to another Lonergan scholar, Gene Ahner, I was able to appreciate Lonergan's post-*Insight* developments, especially his emphasis on the turn to the subject and conversion as the ground for *Method in Theology*. Ironically, in this new encounter with Lonergan and my participation in the various Lonergan workshops from 2010 onwards at Boston College, I surprisingly returned to the problem of higher viewpoints as it relates to chemistry and physics. For the best part of 30 years, I had been inquiring into the epistemological difficulties associated with EPR and to my pleasant surprise I understood after all these years that my studies of mathematics and of Lonergan, seen through the lens of McShane, enabled me to realize that the EPR paradox, properly understood, is what distinguishes chemistry from physics. If chemistry is reduced to mere physics, a paradox arises; but if seen as a higher viewpoint, then there is no EPR paradox but rather a higher system in which the terms define the EPR relation and the relation ground the terms. In that context when I gave my presentation in honor of Phil McShane during the 2021 workshop, I could not but be in awe of the journey I had taken in coming to know both Lonergan's and McShane's thoughts. I have been very much enriched by them. Indeed, as I reread the 'Foundations of Mathematics' in these days, I realize now that the key to resolving the EPR question was already implicitly present. His observation (based on Gödel) that "there are the three basic metamathematical questions regarding any axiom system:

(a) Are the axioms independent, or is one axiom derivable from the others?
(b) Is the system consistent? If I persevere long will I arrive at a contradiction, P and not-P?

[6] The EPR paradox arises when one presupposes that spin values of electrons are associated with a hidden variable that determines the observed experimental outcome. When this supposition is made, a mathematical contradiction ensues and is encapsulated in a theorem first discovered by Northern Ireland Physicist, John Bell. For a detailed discussion of the subject c.f.: Paul O'Hara, "The Einstein-Podolsky-Rosen paradox and SU(2) relativity," *J.Phys.:Conf. Ser.* **1239** 012021 (2019).

(c) Is the system complete; that is does the system enable me to prove one out of each two contradictory statements, R and not-R, legitimately expressed in the terminology of the system? "Legitimately" here means according to rules for the formation of formulae, rules, for example, which govern the distribution of parentheses,[7]

which, when cast into the context of EPR paradox, could be expressed as follows:

(1) Are quantum correlations a consequence of Bell's independent (separable) hidden variables or do they constitute a higher viewpoint?
(2) Is the hidden variable theory consistent? If so, then why does it allows the derivation of a mathematical contradiction (1>2) associated with Bell's inequality?
(3) If hidden variable theory is complete, then it should not allow it to affirm that 1<2 while proving that 1>2. Transposed into a theory of chemical bonding, chemistry is not reducible to mere physics without giving rise to paradoxes. Chemistry must necessarily require a higher viewpoint associated with the Pauli Exclusion Principle.

To conclude, on rereading McShane's work on the foundations of mathematics, I have returned to my starting point, now with more than forty-five years of inquiry, only to discover that I too have been changed in the process and that the change was the process that I began when I first read his article.

[7] McShane, "Foundations of Mathematics," 378–79.