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Brian G Wybourne: Innovator

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We will hear much during this conference on Brian Wybourne's contributions to science. I wish to bring attention to another aspect of his role in science and science statesmanship by relating a personal story based on the discovery and development of the properties of quaternions during the 1844–45 period by Hamilton and Cayley. Brian Wybourne will enter in the middle of my presentation.

In the collection of reprints *Theory of Angular Momentum*, Ed., L.C. Biedenharn and H. Van Dam, Academic Press, 1965, there appears two paragraphs on the geometrical objects called 'turns.' It is described there in succinct descriptive terms how this concept is the generalization of the addition of geometrical vectors (directed line segments) in the plane, using the usual 'head-to-tail' rule and the equality of geometrical vectors under parallel transport, the generalization being the addition of directed line segments belonging to great circles of the unit sphere with parallel transport being the equivalence of two such 'directed arcs' of the same length belonging to the same great circle. It is remarked that for infinitesimal turns the commutation rules $\mathbf{J}\times\mathbf{J} = i\mathbf{J}$ are implied. These are, of course, the Lie algebra relations for the quantum theory of angular momentum, discovered some fifty years later by mathematicians (Poincaré, Cartan, Lie) in a purely mathematical context, and some ninety years later by physicists in the context of quantum theory. Many of us, including Brian, have spent years dedicated to the application of these relations and their generalizations to other symmetries, and the consequences for physical theory.

I first visited Larry Biedenharn at Duke University in 1968, and he gave me a copy of his book with Van Dam. It was a very valuable asset for me, and I was caught-up by the concept of turns. It was such a nice problem to visualize that I worked out the principal properties for my own enjoyment. (In fact, the concept does not appear directly in the work of Hamilton and Cayley.) Larry liked it very much, and tuned it greatly. I invite each of you to undertake the same enjoyable task before consulting the very detailed treatment in L. C. Biedenharn and J. D. Louck, *Angular Momentum in Quantum Physics,* in: Encyl. Math. and Its Applications (Ed. G.-C. Rota) Cambridge Univ., 1981, where the full apparatus of the group representation theory of angular momentum through the use of left and right translations, etc. is developed.

The essence of the treatment is presented [1] in Figures 1–3 which illustrate, respectively, the definition of a turn as a directed arc length on a great circle, the rule of addition for turns belonging to different great

[1] Thanks are expressed to Cambridge University Press for permission to reprint Figures 1–3.

circles and the noncommutivity of this addition rule, and finally the associativity of this addition rule.

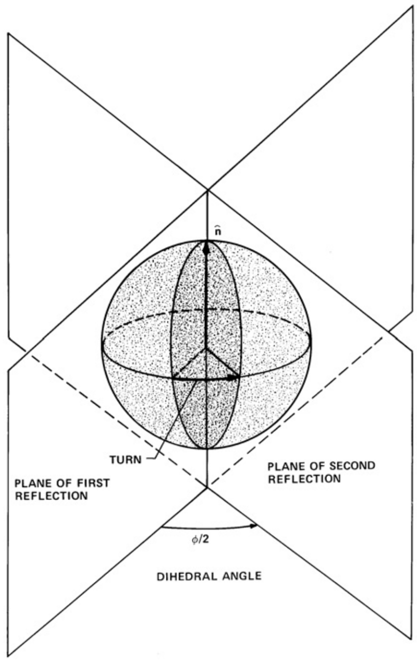

Figure 1. A turn is an ordered pair of points shown here, geometrically, as a directed arc length of a great circle. Each turn defines a rotation by specifying two intersecting planes.

The seeds of Lie algebra and group representation theory, going beyond the substitution (symmetric) group of Galois, were already present in the work of Hamilton and Cayley. Such developments in physics were to await the foundational work of Weyl, Wigner, and Racah. But we must also include here Brian Wybourne for his capacity and talent for bringing these concepts into forms suitable for real calculations in his books, publications, and computer programs.

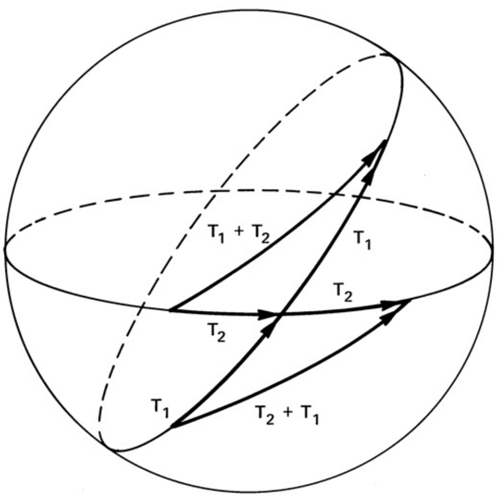

Figure 2. Addition of turns is noncommutative.

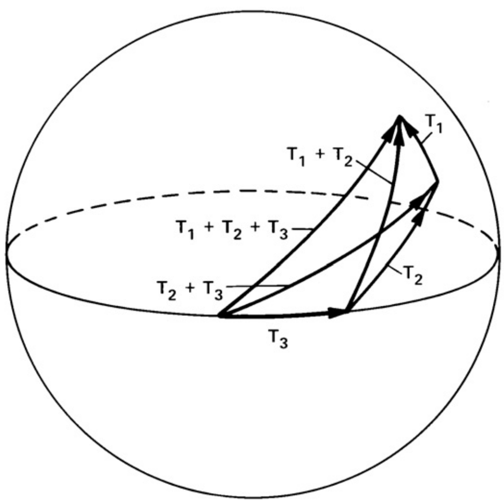

Figure 3. Addition of turns is associative.

It was but a few years later that Brian Wybourne entered my career in an indirect, but memorable way. Brian Wybourne was principally, if not solely, responsible for a series of lectures given at the University of Canterbury on basic advances in the spectroscopy of complex systems, using methods of symmetry groups. Brian Judd, Johns Hopkins University, and J. P. Elliott, University of Sussex, were the first Visiting Erskine Fellows at the University of Canterbury, where they delivered some very famous lectures published in: Topics in Atomic and Nuclear Physics, University of Canterbury, 1969. I expect that he met Larry Biedenharn at about the same time, perhaps, somewhat earlier, at the famous Moshinsky conferences in Mexico. In any case, he invited Larry to Canterbury to give the next Erskine Lecture in 1974. While Larry was already well-known for his independent discovery of the Biedenharn-Elliott identities for Racah coefficients, he chose to speak on the theory of turns. The lectures were never published, but the event is documented in the Biedenharn-Louck volumes with my name included. I was, of course, very pleased and honored to have had a small part in those lectures. (I also learned just today that Ron King was an Erskine Fellow, which initiated a long and fruitful collaboration that you will hear about soon.)

This personal story is intended to show Brian in his broader role in science as the communicator and innovator of ideas by bringing colleagues together; by his intense interest and insights into the foundations of a subject; by his extraordinary insight into what is important; and by the inspiring conversations he generated at informal meetings with colleagues and friends. And not least, the confidence he instilled in others such as me to do research. It has been a great privilege to share in this at the meetings of the Lulek SSPCM conferences, extending over fifteen years, and continuing today in his honor.