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Laudatio of Dr. Erik Panzer, 2020 Hermann Weyl Prize

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Abstract

Erik Panzer, from the University of Oxford, has been awarded the 2020 Hermann Weyl Prize of the International Colloquium on Group Theoretical Methods in Physics, for "his pioneering achievements in the calculation of amplitudes in gauge theories, for developing new mathematical structures that exploit the language of symmetries, and for his contribution to the description of important physical phenomena present in nature."

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Dear Colleagues,

It is a pleasure and an honor for me to introduce here today to Dr. Erik Panzer, who has been awarded de 2020 Hermann Weyl Prize for his "pioneering achievements in the calculations of amplitudes in gauge theories, for developing new mathematical structures that exploit the language of symmetries, and for his contribution to the description of important physical phenomena present in nature".

Erik is a brilliant mathematical physicist, working in the area of "Feynman amplitudes", which include quantum field theory, phenomenology related with the LHC experiments, string perturbation theory, algebraic geometry and number theory. It is only recently that the community started to realize that well posed mathematical questions are at the heart of the calculation of Feynman amplitudes. The area has been growing enormously in the last years and Erik, in spite of his youth, has become an indispensable reference in it.

His research is highly original and of exceptional quality. Besides, it is truly interdisciplinary, since he has made important contributions to both, mathematics and physics. He has generated entirely new problems in abstract mathematics which are of fundamental interest. On the other hand, he has succeeded in applying the most powerful tools in algebraic geometry to the solution of long standing problems in quantum field theory. These comprehend polylogarithms, iterated elliptic integrals, modular forms, K3 surfaces, Calabi-Yau manifolds etc. He has the rare skill of becoming a bridge between the two sectors of researchers interested in Feynman amplitudes, physicists and mathematicians.

I will talk only about a part of his work; perhaps the more representative.

Erik's earliest work, his doctoral thesis (2015), was groundbreaking and had a significant impact in the physics community. He brought the technique of parametric integration to a new level, showing rigorously how a certain class of Feynman integrals (previously inaccessible) are indeed multiple polylogarithms. This was a great progress in the analytic evaluation of Feynman periods, work that required a very careful study of the divergences of those functions. Moreover, his work has direct relevance in generating experimental predictions for the LHC. He even developed a versatile and efficient software for parametric integration, called "HyperInt", which is nowadays widely used in many applications. A large literature has emerged in this topic, and many claims on how to evaluate certain integrals are based in computational experimentation using Erik's software. In further work, he revealed Galois symmetries among the Feynman periods, in particular, he conjectured (with Schnetz) the possibility that the motivic periods of the Φ^4 theory are a comodule under the coaction of the Galois group. Multiple zeta values play an important role in the theory of periods and motives. This is one of the clearest examples of the "understanding physics through symmetries" principle, specially valued in the Weyl Prize.

In 1997 Kontsevich solved the long standing problem of the deformation quantization of Poisson manifolds. His formula is an expansion on polydifferential operators. Each operator is expressed in terms of a graph, weighted with certain universal coefficients, that is, coefficients that do not depend on the Poisson bracket. These are defined as integrals over configurations of points in the upper half-plane. The underlying techniques make heavy use of the theory of multiple polylogarithms on the moduli space of marked, genus 0 curves. Cataneo and Felder showed that these integrals correspond to the Feynman amplitudes of a topological string theory. Kontsevich conjectured that these integrals correspond indeed to integer linear combinations of multiple zeta values. Erik and collaborators (Banks and Pym) remarkably showed that this is indeed the case and that, appropriately normalized, they are integer numbers. Moreover, their proof included an algorithm to compute them and they created the first software for their symbolic calculation. This made, finally, Kontsevich's formula tractable, problem that had been standing for about 20 years. New avenues are opened for future research in this direction.

Erik's more recent work on tropical quantum field theory is the completely new study of the Feynman integral in terms of the Hep bound. The Hep bound is a simplified field theory that shares many symmetry properties with the original Feynmann integral, so it contains qualitative information about it. For example, it has the same asymptotic behavior than the original series. Another remarkable property of the perturbation series of the Hep bound is that it can actually be evaluated by numerical methods at large loop orders (Φ^4 theory). Being a bound, it is not the best approximation (it may be two orders of magnitude difference), but it correlates with the Feynmann integral in such a way that one can use it to predict numerically its value to a great degree of accuracy. In this way one can study properties of the summation of the original perturbation series, of which very few terms are exactly known. Moreover, Erik has advanced the radical conjecture that two Feynman integrals are equal if and only if their Hep bounds are equal. This has received numerical evidence to a large order of loops and then used to make interesting predictions at larger order. It implies the existence of a symmetry of the Feynman integrals that has eluded us so far.

Another of Erik's achievements was on the noncommutative Φ^4 theory in two dimensions, were he was able to resum a perturbation series and solve the nonlinear Dyson-Schwinger equation analytically, in terms of the Lambert W function. This is a remarkable achievement, which makes us hope to solve it in four dimensions.

Together with Bitoun, Bogner and Klaussen he studied the master integrals, that is, the Feynmann integrals that remain after applying the integration by parts procedure to reduce them. In this work, the number of such integrals is defined unambiguously as the dimension of a certain vector space. The amazing result of this study is that the number of master integrals is the Euler characteristic of the complement of a hypersurface, defined by a polynomial associated to each graph. This was proven using the theory of algebraic D-modules, and it is of central importance in its application to phenomenology problems.

Since he received the award, he has been very active and each new paper of his has been received with great expectation. In all his works, Erik reveals himself as a truly original and outstanding researcher, operating in the boundary between mathematical and theoretical physics. He works in different collaborations rather easily and he has made of the symmetries underlying Feynman integrals the leitmotiv of his work. This is particularly in accordance with the spirit of the Weyl Prize. As you have seen he is also an extraordinary speaker, of extreme clarity. This shows also in the big amount of seminars and conferences that he has given all around the world.

This year we had very competitive candidates for the Prize, but at the end he was elected unanimously by the Committee, who considered him as the most deserving recipient of the Prize. It is for all this that I invite you now to join me in recognizing the effort, intelligence and achievements of this young researcher by receiving him with a big applause.

Thank you very much.