Structures in Local Quantum Field Theories

Les Houches

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In recent years we have seen many new insights into the mathematical structure of renormalizable quantum field theories. Such theories still form the core of theoretical physics underwritten by either by their ability to predict the outcome of physics experiments, or by their hidden simplicity when augmented by sufficient supersmmetry, which allows them to be recasted in the framework of integrable models.

Progress was made in particular through understanding the mathematical structure of renormalization and the renormalization group. The identification of a Hopf algebra structure in renormalization by Kreimer in 1997, much elaborated on by Connes and Kreimer in the years 1998-2001, now leads to an understanding of the computational practice of perturbative quantum field theory in terms of algebraic geometry and mixed Hodge structures, starting with the work of Bloch-Esnault-Kreimer.

As a result, Francis Brown and collaborators were able to streamline the computational techniques in Feynman diagram computations and to explain the connection to mixed Tate motives recently which directly connects to the detailed analysis of multiple zeta values and polylogarithms and elliptic functions necessary in QFT computations. Brown, Bogner, Broadhurst, Doryn, Schnetz, Kreimer, Vanhove and Yeats will cover these developments in the school.

From string theory we obtain the AdS/CFT correpondence which led to many new insights on the interplay between quantum fields and string theory. In particular, the Britto-Cachazo- Feng-Witten recursion relations [11] led to spectacular progress in conformally invariant N=4 super YangMills theory, and many conjectures concerning the transcendental nature of Green functions in such theories were obtained by Beisert-Eden and Staudacher, by Korchemsky and many others. This led to new approaches recently to the computation of amplitudes focusing on Twistor methods and cluster coordinates. Drummond, Goncharov and Mason will present these developments.

Gracey, Magnea and van Suijlekom will cover up-to-date aspects of gauge theories, while Esnault and Müller-Stach will focus on relevant mathematical aspects.

In summary, at this moment, speakers who have agreed to lecture include

- S. Bloch
- C. Bogner
- D. Broadhurst
- F. Brown
- D. Doryn
- J. Drummond
- H. Esnault
- J. Gracey
- A. Goncharov
- D. Kreimer
- L. Magnea
- L. Mason
- S. Mueller-Stach
- O. Schnetz
- W. van Suijlekom
- P. Vanhove
- K. Yeats