Cluster of Excellence Precision Physics, Fundamental Interactions and Structure of Matter
PRISMA

Mainz Institute for Theoretical Physics

Amplitudes: practical and theoretical developments

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Scattering amplitudes are a fascinating and rapidly developing subject of current research, in supersymmetric quantum field theories and for applications to collider physics. At the same time, there are many connections to mathematics. This interplay between the different research communities is very productive. The two-week MITP scientific program ``Amplitudes: practical and theoretical developments'' brought together about thirty-five physicists and mathematicians in the intersection from the fields of high energy physics, mathematics and string theory. The main emphasis of the program was on scattering amplitudes, a fascinating topic relevant to precision calculations in particle physics and enjoying remarkable mathematical properties. The scientific program was carried out in a stimulating and productive atmosphere, with one talk usually scheduled in the morning and another talk scheduled in the afternoon. But the most important parts of the scientific program were the discussions among the participants during and after the talks.

Scattering amplitudes in particle physics are related to the probability with which a certain scattering process occurs. Perturbative quantum field theory offers – in theory at least – a systematic way to calculate the scattering amplitudes through Feynman diagrams. However, any practitioner in the field soon realizes that an approach based on Feynman diagrams is feasible only for the simplest processes. The complexity of the calculation increases with the number of external particles and with the number of internal loops. Often the final answer is much shorter than any intermediate expression. This indicates that not all structures and symmetries of the problem have been identified. Furthermore, scattering amplitudes in Yang-Mills theory show a close connection to scattering amplitudes in perturbative gravity. Recent years have shown great progress in this area and have given rise to an active interaction between high energy physics, mathematics and string theory.

The scientific program started in medias res with a talk by David Broadhurst, who reported on impressive results for specific 18 loops diagrams, which he related to particular values of Dirichlet L-functions. This was followed in the afternoon by a talk of Lorenzo Tancredi who related maximal cuts of Feynman diagrams to solutions of the corresponding homogeneous differential equations. Jacob Bourjaily challenged the audience with an “integration polemics” on unitarity methods. Leonardo Vernazza reported on progress on two-parton scattering in the high-energy limit. Dmitrii Chicherin

talked on the duality of Wilson form factors, Harald Ita on numerical unitarity at two-loop.

There was an afternoon session on elliptic generalizations of polylogarithms with expositions by Pierre Vanhove, Matt Kerr and Christian Bogner, followed by a general discussion on this topic on the next day. Dario Consoli reported on simplifying one-loop amplitudes in superstring theory. At the end of the first week Claude Duhr taught the audience about defining a co-action on one-loop graphs. The second week started with an overview on perturbative calculations by Kirill Melnikov. Simon Badger spoke on mass renormalization and unitarity cuts. Henrik Johansson presented new and simple formulas for Einstein-Yang-Mills amplitudes, Carlos Cardona reported on S-matrix singularities and CFT correlation functions.

These talks often triggered discussions which were continued in the coffee room. In this way the MITP scientific program “Amplitudes - practical and theoretical developments” was very successful and it is not unlikely that several new collaborations and research projects grow out of this scientific program.