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J. J. Sakurai Prize: Scattering Amplitudes - the Story of Loops and Legs

LANCE DIXON, SLAC - Natl Accelerator Lab

Scattering amplitudes are at the interface between quantum field theory and particle experiment. Precise predictions for reactions at energy frontier machines such as the Large Hadron Collider (LHC) rely on quantum corrections to scattering amplitudes involving multiple quarks and gluons, as well as other particles. For decades, theorists used Feynman diagrams for this job. However, Feynman diagrams are just too slow, even on fast computers, to allow adequate precision for complicated events with many jets of hadrons in the final state. Such events are produced copiously at the LHC, and constitute formidable backgrounds to many searches for new physics. Over the past two decades, alternative methods to Feynman diagrams have come to fruition. The new "on-shell" methods are based on the old principle of unitarity. They can be much more efficient because they exploit the underlying simplicity of scattering amplitudes, and recycle lower-loop information. The same methods have also enabled new insight into the structure of gauge theory and gravity at the quantum level, especially in highly supersymmetric theories where they maintain all of the symmetries. I'll give a brief motivation for and introduction to the new methods, which will be followed by descriptions of their phenomenological and formal applications by David Kosower and Zvi Bern.