



Sommerfeld Theory Colloquium

Prof. Jan Plefka

Humboldt University Berlin

High-precision gravitational wave physics from worldline quantum field theory

The gravitational two-body problem has been fundamental to physics since Newton's time. With the advent of gravitational wave astronomy and the anticipated third generation of gravitational wave detectors in the 2030s, there is an increasing need for high-precision predictions from Einstein's theory of gravity regarding the encounters of black holes and neutron stars in our universe. Fascinatingly, perturbative quantum field theory methods developed for high-precision predictions of elementary particle scattering at the LHC have proven remarkably efficient for this classical physics problem. This unexpected connection has led to inspiring synergies between collider and gravitational wave physics. In my talk, I will present our approach using a worldline quantum field theory inspired by string theory, which has emerged as the most efficient tool for quantifying the scattering of spinning black holes. We have achieved highest-precision perturbative results for the scattering angle, radiated energy, and recoil of such black hole encounters at the fifth order in Newton's gravitational coupling G . Our four-loop calculations have revealed a new class of mathematical functions related to Calabi-Yau manifolds, previously studied only in mathematics and string theory compactifications, appearing for the first time in a physical context: The radiated energy in gravitational waves at N⁴LO perturbation theory.

Wednesday, 27 May 2026, 16:15h, Room A348, Theresienstr. 37/III

Prof. Dieter Lust