Contribution ID: **2** Type: **not specified**

Unlocking higher spin effects in black hole and neutron star binaries with supersymmetry

Wednesday 5 November 2025 14:40 (40 minutes)

In this talk, I will present the recently introduced higher spin extension of the Wilson line approach to classical gravitational scattering. Wilson lines, abundant in theoretical physics, can be suitably generalized to subleading powers in the soft expansion to capture the soft dressing of asymptotic states in scattering amplitudes. By appropriately choosing the topology for these Wilson lines, the eikonal phase emerges as their correlator, which in turn enables the computation of observables in the scattering process from the eikonal.
Since Wilson lines can be derived from worldline actions, spin can be elegantly captured through worldline supersymmetry. While no-go theorems previously suggested limitations—specifically, that supersymmetry can not describe spin effects beyond second order—I will show that considering non-minimal coupling can overcome these limitations. This insight opens a rich framework for obtaining Hamiltonians and scattering amplitudes for spinning particles. To illustrate the potential of this approach, I will present two new solutions to the supersymmetry algebra: firstly, the supersymmetric action for Kerr black holes accurate to all orders in spin, and secondly, the cubic in spin action for neutron stars in d dimensions.

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