Contribution ID: **32** Type: **oral presentation**

Emergence of High-Purity Spin-Triplet States and Quantum Entanglement in Proton–Proton Scattering

Tuesday 26 August 2025 16:40 (12 minutes)

Entanglement is a unique feature of quantum mechanics that remains relatively unexplored in the context of nuclear physics. In this work, we investigate spin entanglement in elastic proton-proton scattering with unpolarized beams. By analyzing the final spin density matrix from the scattering amplitude, we find two regimes where the outgoing spin state has near-maximal purity: a known low-energy S-wave singlet-dominated region, and a new intermediate-energy region at $E_{\text{lab}} \approx 151$ MeV and $\theta_{\text{c.m.}} \approx 90^\circ$, with a highly pure spin-triplet configuration. We show that the triplet-dominated final state exhibits strong nonclassical correlations, violating the Bell inequality with substantial potential. Furthermore, we quantify the entanglement using concurrence and entanglement power, both of which peak in the same kinematic domain. These results demonstrate that unpolarized pp scattering can serve as a practical source of entangled triplet spin states, offering a new platform for experimental tests of quantum nonlocality and to investigate the spin structure of the nuclear force.

Research field of your presentation

Theoretical Low-energy nuclear physics

Authors: Prof. BAI, Dong (Hohai University); Prof. WANG, Simin (Fudan University); Prof. MA, Yugang (Fudan University); SHEN, zhaoxin (Fudan University)

Presenter: SHEN, zhaoxin (Fudan University)

Session Classification: Young Scientist Session 3