KPS Pioneer session - Discovery of quantum entanglement in High Energy Physics

Report of Contributions

https://indico.cern.ch/e/1462807

Contribution ID: **1** Type: **not specified**

A brief introduction to quantum entanglement in high energy physics

Thursday 24 October 2024 14:25 (40 minutes)

Quantum entanglement is a mysterious phenomenon of quantum mechanics that appears not only in low-energy atomic physics, but also in high-energy collision physics. In recent years, the effects of quantum entanglement have been predicted or observed in some of the representative high-energy collisions, such as heavy ion collisions, the production of top quark pairs, and the decay of the Higgs boson, which have attracted increasing attention from the HEP community. In this talk, I will give a brief introduction to quantum entanglement in high-energy physics and summarize recent developments.

Presenter: PARK, Inkyu (University of Seoul, Department of Physics (KR))

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

Quantum Entanglement and the Higgs Boson at the LHC

Thursday 24 October 2024 15:15 (40 minutes)

Signatures involving the Higgs boson from quantum corrections and interference effects, can be precisely calculated using Quantum Field Theory (QFT) at the LHC.
These phenomena position the Higgs as a crucial tool for probing the fundamental nature of quantum physics in high-energy physics. In this talk, we will explore how one can understand the quantum formalism by rejecting the LHVM (local hidden variable model) in the high energy regime. This approach serves as a complementary method to previous Bell experiments with photons, offering a novel avenue to test the foundations of quantum physics within the framework of particle physics.

Presenter: Prof. PARK, Myeonghun (Seoultech)

Contribution ID: **3** Type: **not specified**

Quantum Entanglement discovery in top quark events and perspectives into future colliders

Thursday 24 October 2024 17:15 (40 minutes)

In quantum mechanics, a system is said to be entangled if its quantum state cannot be described as a simple superposition of the states of its constituents. If two particles are entangled, we cannot describe one of them independently of the other, even if the particles are separated by a very large distance. When we measure the quantum state of one of the two particles, we instantly know the state of the other. The information is not transmitted via any physical channel; it is encoded in the correlated two-particle system. The talk will discuss CMS results in the top quark production region with data provided by the Large Hadron Collider (LHC) at CERN. Results confirm the observation of entanglement in top quark events, even in presence of hypothetical top quark bound states, and providing a new quantum probe to the inner workings of the Standard Model. The talk concludes with an outlook on LHC perspectives into the 2040's and prospects at other proposed future colliders.

Presenter: JUNG, Andreas Werner (Purdue University (US))

Contribution ID: **4** Type: **not specified**

Entangled in Tops: How we turned ATLAS into the world's largest quantum information experiment

Thursday 24 October 2024 16:25 (40 minutes)

A new sub-field has exploded onto the particle physics scene: testing fundamental features of quantum mechanics in collider experiments. A prominent initial result is the ATLAS Collaboration's observation of quantum entanglement between top-quark pairs, the first measurement of entanglement between free quarks, and the highest energy lab-based quantum information experiment to date. Entanglement between top-quark pairs is shown to be observable through measurement of a single angular observable. This talk shall discuss the motivation for using ATLAS as a quantum information experiment, and the experimental challenges and ultimate result of the ATLAS measurement. Shortcomings in current simulation tools and future ATLAS prospects will also be discussed, and attention given to the similarities and differences between recent CMS observations of the same phenomenon.

Presenter: SIMPSON, Ethan Lewis (The University of Manchester (GB))