From Bell's inequalities to statistical physics models (and back)

Irénée FRÉROT

CNRS

irenee.frerot@protonmail.com

John Bell's celebrated inequalities (BI) constrain the *hidden-variable models* that Einstein had first envisioned to possibly complete the statistical predictions of quantum physics. The violation of BI by quantum-mechanical predictions imply that the latter are *non-local*. Most experiments have long focused on violating textbook BI, involving a pair of two-level systems. Yet, more recently, the investigation of BI in a many-body context has blossomed, motivated both by the fundamental understanding of the quantum / classical boundary when the complexity of the system increases ; as well as by the certification of genuine non-classical properties, such as quantum entanglement, in quantum-technology hardwares. In this talk, we first explain that Bell's local-hidden-variable models are nothing more than classical statistical physics models (namely, generalizations of Ising models). We use this insight to construct new algorithms that infer previously-unknown BI from correlation functions as measured in quantum many-body systems. These new BI are then analized to gain insight into the manifestations of many-body entanglement, and the certification of quantum properties.