Adaptive Boson Sampling: validation and exploitation

Fabio Sciarrino
Quantum Lab, Dipartimento di Fisica, Sapienza Università di Roma

Universal photon-based quantum computing fundamentally requires optical nonlinearities, which can be induced through intermediate measurements and adaptive feedback applied to linear-optical elements. A critical near-term question is whether non-linear dynamics can be accessed with limited experimental resources. While recent theoretical work establishes fundamental bounds on the photonic states accessible via linear optics alone, practical methods to quantify the emergence of non-linear behavior remain underdeveloped. This presentation addresses this gap by analyzing Adaptive Boson Sampling, a measurement-feedback architecture in which the optical transformation is progressively adapted based on real-time measurement outcomes. We develop practical nonlinearity witnesses that quantify deviations from linear-optical bounds, deriving these witnesses directly from properties of the underlying linear evolution. We experimentally validate our framework on a state-of-the-art integrated photonic platform, implementing both genuine real-time adaptive protocols and emulated adaptive schemes via post-selection for more complex configurations. Our results demonstrate experimentally that limited adaptivity can access non-linear regimes provably inaccessible to static linear optics, establishing adaptive photonic architectures as a versatile platform for exploring novel quantum dynamics with near-term resources.