N-users optimal resource-sharing with entangled photons

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Photonics is at the core of many technologies based on quantum physics, such as quantum computing [1] or quantum cryptography [2]. The strong technological development behind the production, tuning, transmission, and detection of single photons in recent years has made it a targeted interest for many computing and telecommunication applications, from artificial intelligence algorithms using quantum information processing to secure random qubit generation between distant users.

In this context, our team has specifically studied the interest of using quantum states of photons directly to solve algorithms such as the Multi-Arm Bandit problem, a typical situation associated with reinforcement learning [3]. We have extended this work to the Competitive Multi-Armed Bandit problem (CMAB) [4], where several users have to compete to get resources from limited, probabilistic choices. As a collective strategy is needed, polarization-entangled photon pairs have been shown to optimally resolve this problem for two users facing two choices with limited intercommunication and individual interests.

More recently, we have extended this study to the case of CMAB with $N > 2$ users [5]. Specific entangled N-photon states have been successfully obtained for up to 5 users that guarantee a maximal total cumulated outcome, fair repartition between users, and optimal individual outcome, as well as making a cooperative strategy be in the best interest of each user. Moreover, in cases where polarization bases would be misaligned among users, a simple, scalable and efficient realignment algorithm is demonstrated and provide a straightforward error correction protocol without direct communication between players.

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