High-dimensional fiber based quantum key distribution with twisted photons

Quantum key distribution (QKD), a branch of Quantum Communications (QCs), provides ultimate security based on quantum mechanics laws [1,2]. Essential challenges of most QKD systems are the relatively short propagation distances and the low transmittable bit rates. A fundamental way to overcome these issues is represented by high-dimensional (HiD) quantum states, which allow increased information capacity and higher robustness against channel noise. This higher information efficiency has the benefit of increasing the robustness to channel noise, resulting in an increased error threshold [3–5]. The generation, transmission and detection of high-dimensional quantum states is very challenging and only a few experimental realizations have been achieved for Hi-D QC protocols [6,12]. Using the orbital angular momentum (OAM) of light is promising, as it provides a natural discrete Hi-D basis for quantum states [13]. However, OAM fiber transmission with more than two modes has only been used for classical communication so far [14]. We experimentally demonstrate the first transmission of Hi-D quantum states, encoded in four OAM modes and their superposition, over a 1.2 km long OAM fiber, by implementing a real-time decoy-state Hi-D QKD protocol, demonstrating the highest secret key rate and the longest transmission distance presented to date [15].

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