Experimental Single-Photon Quantum Key Distribution Surpassing the Fundamental Weak Coherent-State Rate Limit

YANG ZHANG

University of Science and Technology of China, China

zy0@mail.ustc.edu.cn

Quantum key distribution (QKD) offers a secure means of communication based on the laws of quantum physics. Despite its remarkable advancements, the current reliance of QKD on attenuated coherent (laser) light sources has imposed a fundamental limit on the secure key rate (SKR) per channel use. This constraint stems from the scarcity of single-photon components within coherent light, inherently bounded by a maximum of $1/e$. Here, we report comprehensive demonstrations of single-photon-source-based high-rate QKD, surpassing the fundamental SKR limit imposed by the weak coherent light. By employing an on-demand, bright single-photon source with an efficiency of 0.71(2), coupled with narrow-bandwidth filtering and random polarization modulation, we demonstrated a field QKD trial over a 14.6(1.1) dB-loss free-space urban channel, achieving a SKR of 1.08×10−3 bits per pulse. This SKR surpasses the practical limit of weak coherent-light-based QKD by 79%. These findings unequivocally demonstrate the superior performance of single-photon sources over weak coherent light for QKD applications, marking a pivotal stride towards realizing a global quantum internet.