Orbital Angular Momentum Selection in FSO Communications under Atmospheric Turbulence

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Abstract: Propagating OAM modes through free space may be subject to atmospheric turbulence (AT) that causes modal crosstalk and power disparities. We propose a selection criterion for OAM modes to minimize the impact of AT and achieve a better error probability performance.

1. OAM mode selection

Orbital angular momentum (OAM) multiplexing is proposed as a versatile technique to transmit multiple signals over free space channels [1]. OAM modes are orthogonal which makes them suitable to co-propagate and carry independent data streams in free space. In the presence of atmospheric turbulence (AT), the power of a signal carried by a particular OAM mode is spread to other modes which results in modal crosstalk. The latter is mode dependent and engenders the break of orthogonality between OAM modes resulting in power imbalance known as mode-dependent loss (MDL) that causes performance degradations at the system level [2]. MDL can be measured by the ratio of the maximum to the minimum received powers. Different digital signal processing and adaptive optics techniques were proposed in order to mitigate the effect of AT in OAM FSO communication systems [2, 3]. In this work, we focus on the effect of MDL caused by atmospheric turbulence. We show that the amount of MDL dependents on the OAM modes considered for multiplexing. Therefore, the BER is improved by selecting the OAM modes that minimizes the MDL. At the receiver, a maximum likelihood (ML) detection is used for optimal decoding performance. The proposed selection method completely absorbs the signal to noise ratio (SNR) penalty in weak turbulence conditions. To have an insight on the proposed selection strategy, we consider an OAM FSO link of 1 km. Propagation in turbulent atmosphere is simulated by placing 50 random phase screens satisfying the Von Karman spectrum along the propagation path. In Fig. 1, MDL is shown for a 2×2 MIMO channel for different OAM mode combinations for weak turbulence. The minimum MDL is found for OAM modes having opposite topological charges (see anti-diagonal elements). Moreover, for OAM modes satisfying the previous condition, the MDL decreases as the topological charge increases. In Fig. 2, we show the BER as a function of SNR for different OAM sets where in each set modes with different topological charges are considered. From the figure, we notice that as the topological charge increases, the BER decreases. Consequently, the choice of an optimal OAM sets is relevant to improve the performance of OAM FSO systems impaired by atmospheric turbulence.

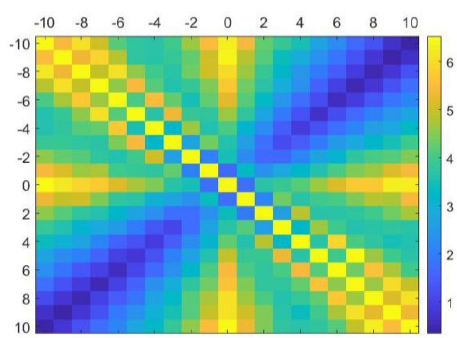

Fig.1: MDL for different sets of OAM modes

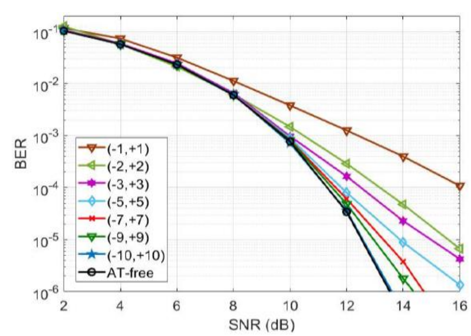

Fig.2: BER vs SNR for different sets of OAMs modes

2. References

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[3] H. Huang, et al, ``Crosstalk mitigation in a free-space orbital angular momentum multiplexed communication link using 4x4 MIMO equalization," Opt. Lett., vol. 39, pp. 4360--4363, 2014.