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Ground Reflection Effect on OAM Multiplexing System with Radial Uniform Circular Array Antennas

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Since it was reported that the orbital angular momentum (OAM) can be used in radio frequency band, the communication link and channel capacity of an OAM wireless system have been intensively studied. Until now, free-space channel characteristics have been mainly studied, but the ground reflection should be considered in a real channel environment. In a real channel environment, the received wave is a superposition of direct and ground-reflected waves. Since the reflected OAM wave is off-axis, it is not orthogonal with the direct OAM wave, and causes severe inter-channel crosstalk at the receiver.

This paper investigates the ground reflection effect on an OAM multiplexing system using radial uniform circular arrays (UCAs). Fig. 1(a) shows an OAM transmission link over the flat ground. Two radial UCAs are located at a distance d from each other, and at height h above the ground. There are two signal paths (direct and reflected). The channel capacity of the OAM multiplexing system with three OAM modes (l = 0, ±1) is analyzed, and compared with that of a single channel system using linear UCAs with l = 0. Fig. 1(b) shows the OAM multiplexing channel capacity and single channel capacity as a function of d. The single channel capacity is hardly affected by the ground reflected signal. However, the OAM multiplexing channel capacity is significantly degraded by the ground reflected signal, and even lower than the single channel capacity as d increases.

Increasing the directivity (D_0) of the UCA elements can mitigate the ground reflection effect. Fig. 1(c) shows the channel capacity variations when D_0 changes from 6 to 18 dBi. As D_0 increases, the OAM multiplexing channel capacity increases significantly, while the single channel capacity is only slightly improved. In addition, increasing the UCA radius (R) and the UCA height (h) above the ground can help to reduce the ground reflection effect and increase the channel capacity.

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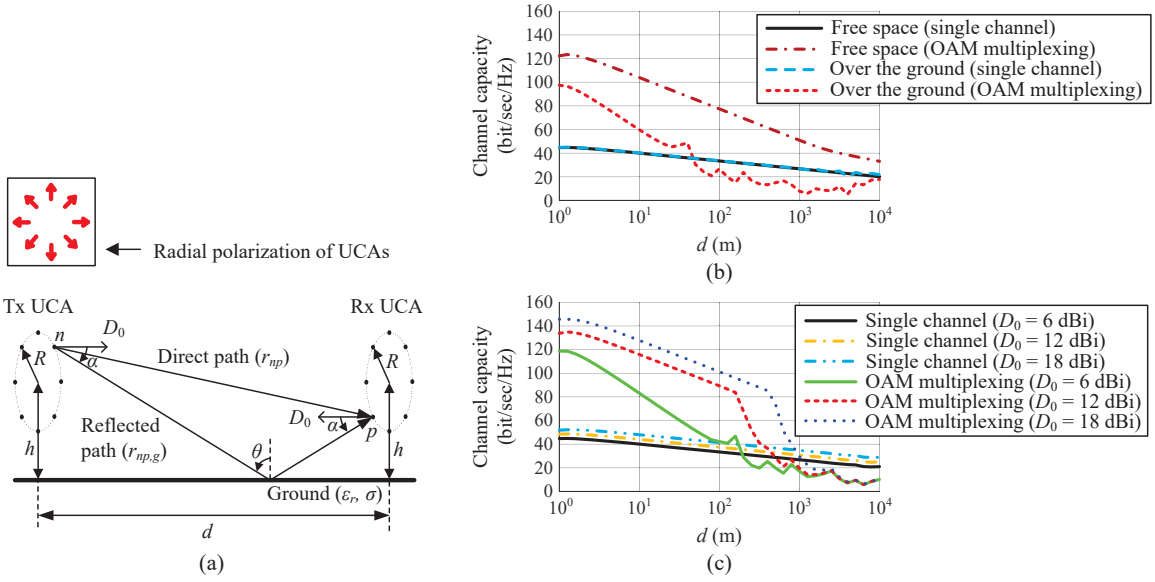

Figure 1. OAM system with radial UCAs. (a) OAM transmission link over the flat ground. (b) Channel capacities of an OAM multiplexing channel and a single channel in free space and over the ground. (c) Channel capacity vs. the directivity of UCA elements over the ground.