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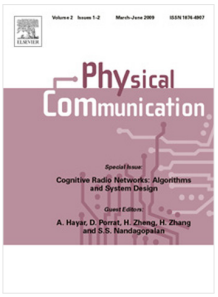

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Intra-group principal modes in graded-index multimode fibers used for mode group division multiplexing transmission

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Abstract By considering very strong intra-group mixing while neglecting inter-group mixing in mode group division multiplexing (MGDM) transmission, we theoretically introduce and describe the physical model of intra-group principal modes (IGPMs) in graded-index (GI) multimode fibers (MMFs), from the view of fiber transmission matrices for both cases of one- and dual-polarization. Proof-of-concept numerical calculations for an exemplary mode-group-channel with the two lowest-order degenerate mode groups (namely the three lowest-order fiber eigenmodes) show that IGPMs can exhibit potential possibilities of the MGDM channel with minimal mode mixing/dispersion-induced signal distortion over a GI MMF.

Keywords Graded-index Multimode fiber; Mode group division multiplexing

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1. Introduction

Graded-index (GI) multimode fibers (MMFs) have been widely used as short-reach, in-building transmission media due to its ease of installation and low assembly cost, as well as the availability of cost-effective transceivers. Driven by the rapid increase in data-based services and the ongoing standardization of Ethernet beyond 100G, there is a growing demand for bandwidth in short-reach applications, which MMF systems must handle [1]. From an information theory viewpoint, MMF has a much larger information transport capacity than single-mode fiber (SMF) since the capacity of each guiding mode in a MMF basically equals to that of a SMF. Therefore, the utilization of higher-order modes (HOMs) is of interest for capacity enhancement of multimode fiber (MMF) transmission links through mode group division multiplexing (MGDM), in which independent channels of information are propagated via different mode groups [2]. These selectively excited mode groups in GI MMFs are in a spread of adjacent degenerate mode groups (DMGs) [3], the fiber modes of which nearly share the same phase constant and group delay (GD) [4]. Considering low inter-group mixing in MGDM transmission, mode groups propagate nearly independently and can be separated by spatially resolved receivers, partly in combination with multiple-input multiple-output (MIMO) signal processing [5]. On the other hand, if a higher transmission bandwidth is required, the differential mode delay of each mode-group-channel should be reduced, due to the fact that the mode dispersion within a mode group is the main limiting factor of the transmission capacity [6].

Recently, instead of using the eigenmodes of unperturbed MMFs as carriers, principal modes,