

The energy spectral efficiency maximization (ESEM) problem of a multi-user, multi-relay, multi-cell system is considered, where all the network nodes are equipped with multi-antenna transceivers. To deal with the potentially excessive interference originating from a plethora of geographically distributed transmission sources, a pair of transmission protocols based on interference alignment (IA) are conceived. The first, termed the full-IA, avoids all intra-cell interference (ICI) and other-cell interference by finding the perfect interference-nulling receive beamforming matrices (RxBFMs). The second protocol, termed partial-IA, only attempts to null the ICI. Employing the RxBFMs computed by either of these protocols mathematically decomposes the channel into a multiplicity of non-interfering multiple-input-single-output channels, which we term as spatial multiplexing components (SMCs). The problem of finding the optimal SMCs as well as their power control variables for the ESEM problem considered is formally defined and converted into a convex optimization form with carefully selected variable relaxations and transformations. Thus, the optimal SMCs and power control variables can be distributively computed using both the classic dual decomposition and subgradient methods. Our results indicate that indeed, the ESEM algorithm performs better than the baseline equal power allocation algorithm in terms of its ESE. Furthermore, surprisingly the partial-IA outperforms the full-IA in all cases considered, which is because the partial-IA is less restrictive in terms of the number of available transmit dimensions at the transmitters. Given the typical cell sizes considered in this paper, the path-loss sufficiently attenuates the majority of the interference, and thus the full-IA over-compensates, when trying to avoid all possible sources of interference.