Coherent Control of Pulse Propagation in a Multimode Fiber

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Multimode optical fibers have recently attracted growing attentions in various fields such as optical communication, biomedical imaging, spectroscopy and fiber amplifiers. In most of the applications, ultrashort optical pulses are employed to deliver energy. A serious issue associated with pulse propagation is that the output pulse is significantly distorted and broadened by modal dispersion. How to deliver the pulse power at arbitrarily selected time as efficiently as possible remains an unsolved problem.

In this work, we discover long-range spatio-temporal correlations in MMFs with strong random mode mixing. The correlations play a crucial role in the coherent control of short pulses transmitting through an MMF. The positive correlations among spatial channels enable a global enhancement of transmitted energy at a selected arrival time by shaping the incident wavefront. Our results show that the maximal power that can be delivered through an MMF at a well-defined time is much higher than what is achievable without long-range correlations. This discovery is important to MMF applications such as telecommunication, fluorescence endoscopy, nonlinear microscopy and fiber amplifiers, in which ultrashort pulses are deployed for energy delivery.