How to keep coherent control under control

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Pulse shaping has been and still is one essential ingredient in coherent control experiments. It is long known that standard 4f pulse shapers introduce space-time coupling but it has never been analyzed in detail as to what extent space-time coupling does influence the outcome of coherent control experiments. Moreover, most theoretical work in coherent control assumes a perfectly modulated pulse, whose electric field depends on time or frequency only. Some experimental demonstrations seem to agree well with those theoretical predictions, suggesting that the influence of space-time coupling is not overwhelmingly important. Here, we try to answer the question why the effects of space-time coupling are hardly seen in certain types of quantum control experiments while having a considerable influence in others. We begin with a summary of the Fourier optical description of pulse shaping and present experimental results. After that, we proceed with investigating the influence of space-time coupling on three different nonlinear effects. For a relatively simple nonlinear interaction, namely, second harmonic generation, we compare experimental results with simulations. Based on simulations only, we then evaluate the effects of space-time coupling on the interaction of laser pulses with a resonant atomic three-level system and a resonant diatomic molecule. We conclude the talk with new experiments on coherent control of the population distribution in a multiplet of Stark levels of rare earth ions embedded in a crystalline matrix and show that feedback-controlled optimization can be well understood if the effects of space-time coupling are minimized.