Type-I cascaded quadratic soliton compression in lithium niobate: Compressing femtosecond pulses from high-power fiber lasers

The output pulses of a commercial high-power femtosecond fiber laser or amplifier are typically around 300–500 fs with wavelengths of approximately 1030 nm and tens of microjoules of pulse energy. Here, we present a numerical study of cascaded quadratic soliton compression of such pulses in LiNbO3 using second-harmonic generation in a type-I phase-matching configuration. We find that because of competing cubic material nonlinearities, compression can only occur in the nonstationary regime, where group-velocity-mismatch–induced Raman-like nonlocal effects prevent compression to less than 100 fs. However, the strong group-velocity dispersion implies that the pulses can achieve moderate compression to durations of less than 130 fs in available crystal lengths. Most of the pulse energy is conserved because the compression is moderate. The effects of diffraction and spatial walk-off are addressed, and in particular the latter could become an issue when compressing such long crystals (around 10 cm long). We finally show that the second harmonic contains a short pulse locked to the pump and a long multi-picosecond red-shifted detrimental component. The latter is caused by the nonlocal effects in the nonstationary regime, but because it is strongly red-shifted to a position that can be predicted, we show that it can be removed using a bandpass filter, leaving a visible component of less than 100 fs at λ=515 nm with excellent pulse quality.
