Self-generation scheme for heteronuclear compound states

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Soliton molecules are usually referred to soliton pairs propagating in waveguides with a fixed time delay, as observed, e.g., in dispersion-managed fibers [1]. Recently, a fundamentally different type of soliton molecule has been proposed [2] and successfully demonstrated in experiments [3]. Such kind of two-color compounds consists of two vastly separated subpulses in the frequency domain with similar group-velocities, enabled by suitable dispersion characteristics with at least two domains of anomalous dispersion (A1,A2) [Fig. 1(a-c)]. We have studied these compound states under perturbations [4] revealing very unique propagation dynamics due to strong entanglement between the individual subpulses. To generate two-color compounds, access to two incommensurable, group-velocity matched frequencies is required, which is difficult to realize experimentally. Here, we propose a self-generation scheme enabled by the Raman effect requiring only a one color pumping. The fiber design is optimized for commercially available wavelengths.

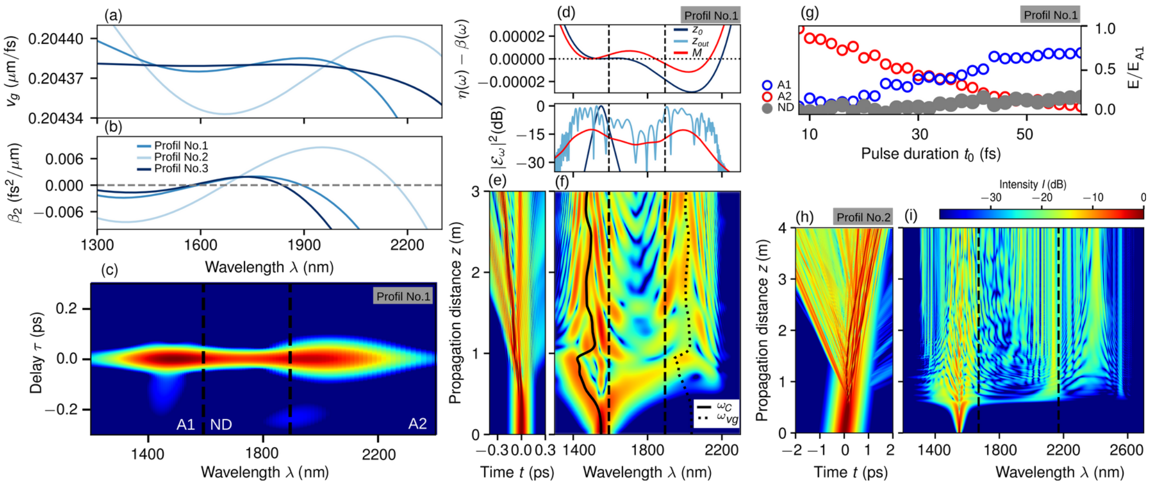

Fig. 1 Self-generation scheme. (a,b) Group-velocity and group-velocity dispersion. (c) Spectrogram of generated compound state. (d) Phase-matching analysis (top) and spectrum (bottom) of input, output, and filtered compound state denoted by dark blue, light blue, and red line, respectively. Propagation dynamics of self-generation process in temporal (e) and spectral (f) domain. (g) Parameter study for initial pulse durations. Supercontinuum generation in temporal (h) and spectral (i) domain.

Suitable group-velocity and group-velocity dispersion profiles are displayed in Fig. 1(a,b), respectively, for three different fiber designs. For the second fiber design a self generation scheme is presented in Fig. 1(d-f). The spectral broadening of an initial higher order soliton accompanied by the Raman-induced frequency down shift [5] initiates the population to a phase-matched component [6][Fig. 1(d); top panel] in A2 [Fig. 1(f)] by the spectral tunneling process [7] . With further propagation this mechanism leads to the build-up of a second group-velocity matched constituent (ω_{gv}) for a stable compound state. Our investigations show that the final energy distribution after a specific propagation distance depends on the initial properties of the soliton as displayed for the example of different pulse durations in Fig. 1(g). Our parameter study shows that we can tailor the process from a complete spectral tunneling to nearly no energy transfer between the regions. This process appears naturally in supercontinuum generation [Fig. 1(h,i)].

References

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