Comment on "Self-Compression of High-Intensity Femtosecond Optical Pulses and Spatiotemporal Soliton Generation"

In a recent Letter, Koprinkov *et al.* [1] investigated the spatial and temporal behavior of an ultrashort laser pulse undergoing self-focusing in several gases. They claim to have observed novel behavior in this interaction including self-compression, filamentation, and the generation of spatiotemporal solitons (STSs). The use of highly chirped initial pulses complicates the experiment, but we believe that the first two phenomena are consistent with well-known properties of self-focusing. In addition, the claim of STS generation is inappropriate given that the propagation distances in their experiments are a small fraction of that required to observe any temporal broadening as a result of dispersion.

The main claim emphasized by Koprinkov *et al.* [1] is the observation of temporal self-compression. Pulses from a regenerative amplifier underwent highly nonlinear and dispersive propagation in the cell windows before entering the gas. As a consequence, the initial pulse duration was 280 fs (240 fs) in experiments on CH_4 (Ar). The spectral bandwidth of the initial pulse was approximately $\Delta\nu = 7$ THz, which corresponds to a temporal pulse width of $\tau_p = 0.315/\Delta\nu = 45$ fs for a transform-limited hyperbolic-secant pulse. Thus, the experiments were performed using pulses with large and unknown phase distortion and thus excess bandwidth. Koprinkov *et al.* did not account for this significant experimental fact in the interpretation of their experiments. The duration (40–50 fs) of the output pulses from the cell was close to the transform-limited value. True pulse compression requires an increase in spectral bandwidth. In contrast, only a relatively small increase ($<1.5\times$) in spectral bandwidth was produced in the experiments. The authors also appear to be unaware of the fact that temporal compression inherently accompanies the self-focusing process [2] with transform-limited input pulses, and this may partly explain their observations.

Spatial compression and filamentation of femtosecond light pulses in gases has been observed [3] by a number of groups. In these experiments, the proposed explanation for the observed filamentation over distances of many meters is the generation of plasma that occurs in the gas when the pulse undergoes self-focusing collapse and reaches an intensity of approximately 10^{14} W/cm^2. The nonlinearity associated with the generated plasma leads to an effective defocusing contribution which compensates to some degree for the positive self-focusing nonlinearity associated with the highly nonresonant $\chi^{(3)}$ electronic nonlinearity of the gas. We believe that this mechanism could also be responsible for the filamentation observed by Koprinkov *et al.* [1].

Finally, we address the claim that STSs were generated and observed. In the experiments carried out in CH_4 and Ar, the generation of a STS would be surprising since at the incident wavelength of 800 nm the group-velocity dispersion (GVD) β_2 is normal. Any plausible demonstration of soliton formation in the time domain requires propagation over distances of at least several dispersion lengths ($L_{DS} = \tau_p^2/|\beta_2|$) to ensure that the pulse does in fact exhibit negligible temporal broadening. However, in all the experiments performed in gases, the dispersion length was significantly longer than the 80 cm cell length. For example, with Ar at the highest pressures (20 atm), the GVD is $\beta_2 = +2$ fs^2/cm [4]; for a pulse 40 fs in duration the dispersion length is $L_{DS} = 800$ cm, which is 10 times the cell length. As a result, no appreciable pulse broadening is expected, and the claimed observation of a STS remains unsubstantiated. A related point is that the absence of temporal pulse splitting [5] at the lower pressures is not surprising since it intrinsically requires non-negligible dispersion.

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