Amplitude ambiguities in second-harmonic-generation frequency-resolved optical gating: comment

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The authors of an earlier paper [Opt. Lett. **32**, 3558 (2007)] reported two "ambiguities" in second-harmonic-generation frequency-resolved optical gating (FROG). One ambiguity is simply wrong—a miscalculation. The other is well known and easily avoided in simple well-known FROG variations. Finally, the authors' main conclusion—that autocorrelation can be more sensitive to pulse variations than FROG—is also wrong.

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All ultrashort-pulse measurement techniques have ambiguities. Fortunately, those in FROG are *trivial* (unimportant or easily removed). The authors of [1], however, claim to have found a *nontrivial* ambiguity in second-harmonic-generation frequency-resolved optical gating (SHG FROG): two different pulses (Figs. 3(a) and 3(b) in [1]) whose SHG FROG traces, the authors claim, are the same, having a tiny rms difference, $G=7\times10^{-6}$. Alas, this is wrong.

In fact, $G=2.4\times10^{-3}$. The authors' own plot [Fig. 3(e)] of the trace difference (~2% in a region comprising ~10% of the trace) clearly confirms this larger value. Also, in an erratum, Yellampalle *et al.* [2] later reported a rms error computed over only the nonzero area of the trace, $G'=8\times10^{-4}$. This is also wrong; in fact, $G'=0.026$. It appears that the authors neglected to take the square root when computing the rms. In any case, traces so different are easily distinguished in practice.

Simply quoting such differences is simplistic, however. That, of course, is all that autocorrelation (AC) allows. FROG, on the other hand, enjoys a powerful pulse-retrieval algorithm. Thus the issue is *not* the FROG-trace difference (G or G') but whether the *pulses retrieved from the traces* are wrong.

So we generated SHG FROG traces of the two "ambiguous" pulses and added up to 2% additive noise. We ran the usual FROG algorithm and, to attempt to fool it, we used the *other "ambiguous" pulse* as the initial guess in each case. Despite this deception, the algorithm quickly and accurately retrieved the correct pulse in all cases. Clearly, such pulses are not ambiguities in FROG.

Yellampalle *et al.* also reminded us of an SHG FROG trivial ambiguity, described earlier by Taylor and co-workers [3,4] and also by us [5,6]: pulses well separated in time (Fig. 1 in [1]). It's well known that relative phases, amplitudes, and directions of time of well-separated pulses or modes confuse most techniques [5–7]—but not XFROG [7]. Also, in our papers on the issue [5,6] (and not mentioned by the authors of [1]), we also showed how to remove *all* such ambiguities: using an *etalon* for the FROG beam splitter yields an easily measured train of overlapping pulses, which easily yields the individual pulse.

In conclusion, intensity and interferometric AC are *not* appealing alternatives to FROG. It is well known that the complexity of the mathematics prevents *any* pulse (including all those in [1]) from being retrieved from either type of AC trace, even when additional quantities (e.g., the spectrum) are included, unless arbitrary assumptions are made or the pulse is trivial [5,8]. Worse, as pulses become more complex, both types of AC badly blur the pulse structure [9], rendering pulse retrieval in AC *fundamentally impossible* [9]. FROG traces, on the other hand, grow more complex, thus retaining the necessary pulse-structure information. Indeed, FROG easily measures and retrieves even extremely complex pulses without ambiguity, even in the presence of significant noise [5,9].

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