Comment on "Interaction of Shear Waves and Propagating Cracks"

In a recent Letter Bonamy and Ravi-Chandar [1] generated markings on fracture surfaces (known as "Wallner lines") by the interaction of crack fronts with plane shear waves launched either across or normal to the fracture plane. The apparent similarity of these markings with those generated by locally perturbing a crack front prompted the authors to suggest that the "front waves" (FW) observed in [2,3] were essentially Wallner lines.

FW are waves of coherent velocity fluctuations that are generated when translational invariance in the direction along the crack front, z, is broken and gradients $dG(z)/dz$ of the energy flux $G(z)$ driving the crack, are formed. Analytical and numerical [4] work predicts FW propagation along the crack front at a velocity V_{FW}, close to the Rayleigh wave speed, V_R. Experimentally [2,3], interactions of a crack front with localized perturbations were shown to generate fracture surface markings exhibiting: (a) Initial exponential decay (with the decay length proportional to the size W of the perturbation), followed by persistent propagation at $V_{FW} \sim V_R$ with negligible decay over large distances ($\gg W$). (b) A nonlinear character; exhibiting either self-focusing for strong perturbations or dispersion for "weak" ones. (c) Strong correlation of the surface markings with large local velocity fluctuations [3], in accordance with predictions.

The Wallner lines generated by Bonamy and Ravi-Chandar had the following properties: (i) The surface markings created by waves propagating normal to the fracture plane did not persist beyond the passage time of the wave front. (ii) The decay of the amplitude of the surface markings generated by the passage of shear waves across the fracture surface echoed the decay amplitude of the waves themselves.

They then argue that both the visual "similarity" of the surface markings and their lack of "persistence" when shear waves are not present, suggest that tracks generated by local perturbations (as in [2,3]) are Wallner lines and not FW.

We strongly disagree with this suggestion. Regarding (i), a plane wave propagating *normal* to the fracture plane will *not* break the translational invariance of the front, since only negligible gradients in G are induced (these may result from either transducer misalignment or crack front curvature). Hence, FW would not be expected and, indeed, no persistent waves were observed. The decay described in point (ii) is an expected characteristic of Wallner lines. As noted in [2,4], this situation is qualitatively different from a FW generated by a *local* perturbation, where FW amplitudes are *dynamically* determined.

In what sense are the markings supposedly similar? Qualitatively, both FW markings and Wallner lines will appear similar. However, when the front is curved, the added arc length makes it possible to differentiate between the two. A FW is constrained to travel *along* the front at V_R, whereas a shear wave propagates in a straight line through the material at the shear wave velocity. Our analysis (using intersecting tracks, as in [2], to determine the front velocity), shows that tracks in Fig. 5b of [1] can be well described by a FW propagating at V_R along the curved crack front.

Another key difference between Wallner lines and the tracks that we associate with FW, is the evolution of their amplitudes. Both the amplitude decay and observed persistence of the tracks presented in Fig. 5b of [1] are not consistent with the expected $1/r^2$ decay of Wallner lines. The measured decay can be well described by an exponential decay (with a decay width of W), as in [2,3]. Subsequent, persistent FW propagation explains the long (at least 15 mm in length) visible tracks in Fig. 5b. These tracks would not be visible for a $1/r^2$ decay having a characteristic length (see the inset of Fig. 5b of [1]) of $\sim$1 mm. We have routinely observed such persistent pulses with steady state amplitudes a factor of 5 greater than the *initial* amplitude of the pulse in Fig. 5b of [1].

An important distinction between FW and Wallner lines is the observation that *strong* velocity fluctuations [3], on the order of the *mean* front velocity, are highly correlated with the "small" amplitude surface markings generated by a localized perturbation. These velocity fluctuations cannot be accounted for by Wallner lines.

In summary, the above arguments show that, in contrast to the suggestions in [1], the measurements in [1] actually support the idea that pulses generated from local perturbations are *not* Wallner lines but result from front wave propagation.

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Received 15 January 2004; published 26 August 2004
DOI: 10.1103/PhysRevLett.93.099601
PACS numbers: 46.50.+a, 62.20.Mk, 68.35.Ct

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