Response to "Comment on 'Forced magnetic reconnection in the inviscid Taylor problem' " [Phys. Plasmas 11, 5734 (2004)]

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We agree with the Comment that the final result obtained by Ishizawa and Tokuda is extremely implausible. However, Ishizawa and Tokuda's central claim—that Hahm and Kulsrud improperly used the constant-ψ approximation to obtain their results—cannot be lightly dismissed, since in their calculation Hahm and Kulsrud do not make a proper distinction between the reconnected magnetic flux at the center of the layer ψ_{in} and the asymptotic flux for the external solution ψ_{out}. Hence, it seems to us that a publication redoing Hahm and Kulsrud's analysis but retaining the vitally important distinction between ψ_{in} and ψ_{out}, and then verifying the analysis by careful comparison with numerical simulations, is warranted.

We cannot agree with the remainder of the Comment. The condition to be satisfied for the validity of the constant-ψ approximation is

$$|\psi_{\rm out} - \psi_{\rm in}| \ll \psi_{\rm out}, \tag{1}$$

not

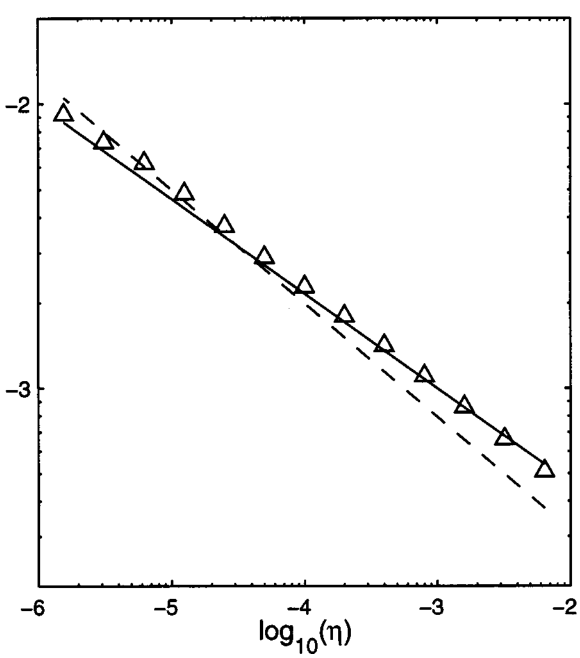

FIG. 1.

$$|\psi_{\rm out} - \psi_{\rm in}| \ll \psi_{\rm in}, \tag{2}$$

as asserted in the Comment. In a non-constant-ψ regime, there is a big difference between these two conditions. The inequality (1) can be written more succinctly as

$$|\Delta|\delta \ll 1, \tag{3}$$

where Δ is the usual layer matching parameter, and δ the layer thickness.

Let us adopt the normalization scheme used in our original paper. In the inertial regime, which holds for $t \ll \eta^{-1/3}$, we have $\Delta = -\pi k/g$ and $\delta \sim g/k$, where $g \sim t^{-1}$ is the Laplace transform variable. Hence, $|\Delta|\delta \sim \mathrm{O}(1)$ throughout the whole of the inertial regime. In other words, the inertial regime is a *non-constant-ψ* regime. Moreover, this regime breaks down at $t \sim \eta^{-1/3}$ because resistivity can no longer be ignored in the layer. The reconnection rate $J = \eta^{-1} d\psi_0/dt$ (which is equivalent to the perturbed current density at the center of the layer) in the inertial regime scales as $J \propto t$, and therefore *increases* in time. Here ψ_0 is the reconnected magnetic flux.

In the resistive-inertial regime, which holds for $t \gg \eta^{-1/3}$ (or $g \ll \eta^{-1/3}$), we have $\Delta \sim g^{5/4}/\eta^{3/4}$ and $\delta \sim g^{1/4}\eta^{1/4}$. Hence, $|\Delta|\delta \sim (g/\eta^{1/3})^{3/2} \ll 1$. In other words, the resistive-inertial regime is a *constant-ψ* regime. Moreover, the reconnection rate in the resistive-inertial regime *decreases* in time.

The scenario outlined in the above two paragraphs is illustrated and verified in Figs. 1–3 of our paper. It is quite clear from Figs. 1 and 2 of our paper that the inertial regime holds for $t \ll \eta^{-1/3}$, whereas the resistive-inertial regime holds for $t \gg \eta^{-1/3}$. (Note that $\tau_1 \sim \eta^{-1/3}$ and $\tau_{ri} \sim \eta^{-3/5}$ in these figures.) The reconnection rate (perturbed current density) J can be seen to increase for $t \ll \eta^{-1/3}$ and to decrease for $t \gg \eta^{-1/3}$, peaking at $t \sim \eta^{-1/3}$ (not at $t \sim \eta^{-3/5}$, as suggested in the Comment—see Fig. 2 of our paper). As illustrated in Fig. 3 of our paper, and Fig. 1 of this Response, the peak reconnection rate (perturbed current density) scales as $J_{\rm max} \sim \eta^{-1/3}$ (not $J_{\rm max} \sim \eta^{-2/5}$, as suggested in the Comment). Finally, it is quite clear from Figs. 1 and 2 of our paper that J does not increase like $t^{1/4}$ in the time interval $\eta^{-1/3} \ll t \ll \eta^{-3/5}$, as suggested in the Comment.

