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CORRIGENDUM

Evolution of current sheets following the onset of enhanced resistivity

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Numerical solutions were obtained by Forbes, Priest & Hood (1982) for the resistive decay of a current sheet in an MHD fluid. To check the accuracy of the numerical solutions, a linear, analytical solution was also derived for the regime where diffusion is dominant. In a subsequent reinvestigation of this problem an error in the linear, analytical solution has been discovered. For the parameter values used in the numerical solution this error is too small ($\lesssim 2\%$) to produce any significant change in the previous test comparison between the numerical and analytical solutions. However, for parameter values much different from those used in the numerical solution, the error in the linear solution can be significant.

In the diffusive regime the momentum ρu is governed by the wave equation

$$(\rho u)_{tt} - c^2(\rho u)_{xx} = -(\tfrac{1}{2}B^2)_{xt}, \tag{1}$$

where c, the sound speed, is constant. The magnetic field, B, is

$$B = \operatorname{erf}(x/2\eta^{\frac{1}{2}}t^{\frac{1}{2}}),$$

where η is the magnetic diffusivity. The solution to (1) for the problem considered in Forbes *et al.* (1982) is

$$\rho u = (\rho u)_* + \tfrac{1}{2}c\rho_0,$$

where

$$\rho_0 = 1 + (1 - B^2)/2c^2$$

and

$$(\rho u)_* = \tfrac{1}{2}\pi^{-\frac{1}{2}}c^{-1}\left[\int_0^t \bar{t}^{-1}\tilde{y}_+ \exp(-\tilde{y}_+^2)\operatorname{erf}(\tilde{y}_+)\,d\bar{t} - \int_0^t \bar{t}^{-1}\tilde{y}_- \exp(-\tilde{y}_-^2)\operatorname{erf}(\tilde{y}_-)\,d\bar{t}\right], \tag{2}$$

with

$$\tilde{y}_\pm = (x \pm ct \mp c\bar{t})/(4\eta\bar{t})^{-\frac{1}{2}}.$$

To evaluate (2), the variable of integration is changed from $\bar{t}$ to $\tilde{y}_+$ in the first integral and $\tilde{y}_-$ in the second. The relationships between $\tilde{y}_\pm$ and $\bar{t}$ are multi-valued functions which depend upon both x and t. In the previous paper, an equation

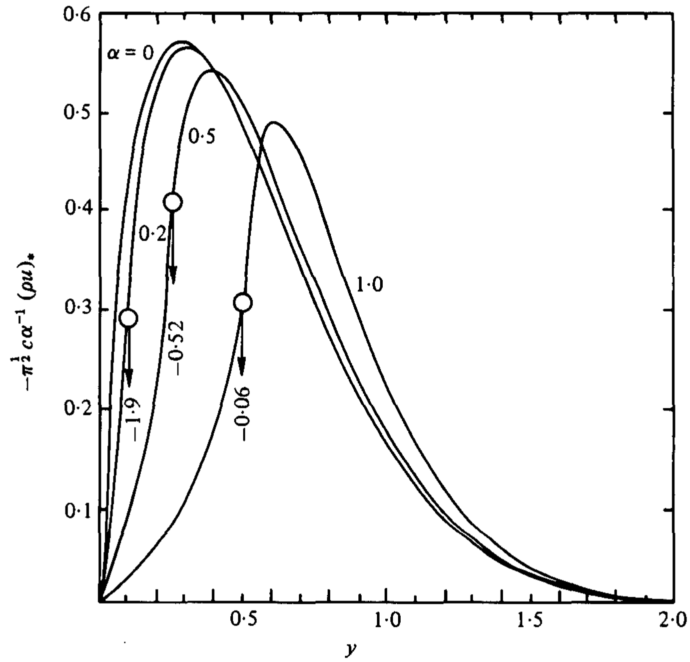

FIGURE 1. Replacing figure 5.

relating $\tilde{l}$ to y_- was used which was valid for only one of the branches of the multi-valued function. Because of this, the linear solution, which was assumed to be valid for all x and t, was in fact valid only for $x > 2ct$. The correct solution valid for all x and t is as follows.

$0 < y < \frac{1}{2}\alpha$:

$$(\rho u)_* = -\pi^{-\frac{1}{2}} c^{-1} \int_{\infty}^{y} F(\tilde{y})\,(\tilde{y}^2 + 2\alpha y + \alpha^2)^{-\frac{1}{2}}\, d\tilde{y} + \int_{-\infty}^{y} F(\tilde{y})\,(\tilde{y}^2 - 2\alpha y + \alpha^2)^{-\frac{1}{2}}\, d\tilde{y}; \tag{3a}$$

$y = \frac{1}{2}\alpha$:

$$(\rho u)_* = -\pi^{-\frac{1}{2}} c^{-1} \int_{\infty}^{\frac{1}{2}\alpha} F(\tilde{y})\,(\tilde{y}^2 + 2\alpha^2)^{-\frac{1}{2}}\, d\tilde{y} + (\tfrac{1}{4}\pi^{\frac{1}{2}})\,\mathrm{erf}^2(\tfrac{1}{2}\alpha); \tag{3b}$$

$\frac{1}{2}\alpha < y < \alpha$:

$$(\rho u)_* = -\pi^{-\frac{1}{2}} c^{-1} \int_{\infty}^{(2\alpha y - \alpha^2)^{\frac{1}{2}}} F(\tilde{y})\,[(\tilde{y}^2 + 2\alpha y + \alpha^2)^{-\frac{1}{2}} - (\tilde{y}^2 - 2\alpha y + \alpha^2)^{-\frac{1}{2}}]\, d\tilde{y}$$
$$+ \int_{(2\alpha y - \alpha^2)^{\frac{1}{2}}}^{y} F(\tilde{y})\,[(\tilde{y}^2 + 2\alpha y + \alpha^2)^{-\frac{1}{2}} + (\tilde{y}^2 - 2\alpha y + \alpha^2)^{-\frac{1}{2}}]\, d\tilde{y}; \tag{3c}$$

$y > \alpha$:

$$(\rho u)_* = -\pi^{-\frac{1}{2}} c^{-1} \int_{\infty}^{y} F(\tilde{y})\,[(\tilde{y}^2 + 2\alpha y + \alpha^2)^{-\frac{1}{2}} - (\tilde{y}^2 - 2\alpha y + \alpha^2)^{-\frac{1}{2}}]\, d\tilde{y}; \tag{3d}$$

where $$y = x/(4\eta t)^{\frac{1}{2}}, \quad \alpha = c(t/\eta)^{\frac{1}{2}}$$

and $$F(\tilde{y}) = \tilde{y}\,\mathrm{erf}(\tilde{y}) \exp(-\tilde{y}^2).$$

Equation (3), replaces (16) in Forbes *et al.* (1982). For $\alpha > 0$ and $y < \alpha$ the

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solution is different from the previous one. However, for $\alpha > 0$ or $y > \alpha$ it is identical. Figure 1 (which replaces the previous figure 5) shows the new solution as a function of y for selected values of α.

Previously, after the change of variables, expansions for $y < \alpha$ and $y > \alpha$ were derived in the limit $y \ll 1$ and $\alpha \ll 1$ (equations (22) and (24) in Forbes *et al.* (1982)). While the expansion for $y > \alpha$ (24) is still correct, the one for $y < \alpha$ (22) is not. By following procedures similar to those used before, the replacement for the expansion (22) is found to be

$$(\rho u)_* \simeq 2\pi^{-1} y \alpha c^{-1}[\tfrac{1}{2}\pi - \tfrac{8}{3} + \gamma + \ln(2\alpha^2)], \tag{4}$$

where $\gamma \approx 0{\cdot}577\,21$ is Euler's constant.

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