Vortex penetration into type-II superconductors with pinning centers

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In the vortex-glass regime at the temperature T close to the melting curve $T_m(B)$, the superconductor response becomes substantially nonlinear because the parameter $\alpha \sim U(j)/T \to \infty$ as $j \to 0$. In this case, we have the continuity equation [1] $b_t = -[vb]_x$. The activation barrier has the form $U(j) = U_0 \ln(j_c/j)$ and the vortex velocity can be represented as $v = v_0 \exp(-U(j)/T) = v_0 J|J|^\sigma$, $(J = j/j_c)$. Then the equation can be reduced to $b_t = \nabla(\nabla b|\nabla b|^\sigma)$. Here, $\sigma = U_0/T, x \mapsto x/d_p, t \mapsto tv_o/d_p, d_p = cB_0/4\pi j_c$, and j_c is the critical current density. Let us solve equation with the boundary conditions $b(0,t) = b_0(1-t)^m$, $0 < t < 1$, $m < 0$. In the case $m = -1/\sigma$, the problem has the solution [2, 3] $b_A(x,t) = b_0(1-t)^{-1/\sigma}(1 - x/x_0)_+^{(\sigma+2)/\sigma}$, where $x_0 = ((\sigma+2)/\sigma)\big[2\sigma(\sigma+1)/(\sigma+2)\big]^{1/(\sigma+2)} b_0^{\sigma/(\sigma+2)}$. The solution is a magnetic wave with an immobile point at the front localization within $0 < x < x_0$. An analysis of the structure of the self-similar solutions shows that the blow-up regime is not localized for $m < -1/\sigma$ [2], that is $x_f \sim (1-t)^{(1+m\sigma)/(\sigma+2)} \to \infty$ for $t \to 1^-$, where x_f is the coordinate of the magnetic wave front.

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