Moving interfaces in complex matter

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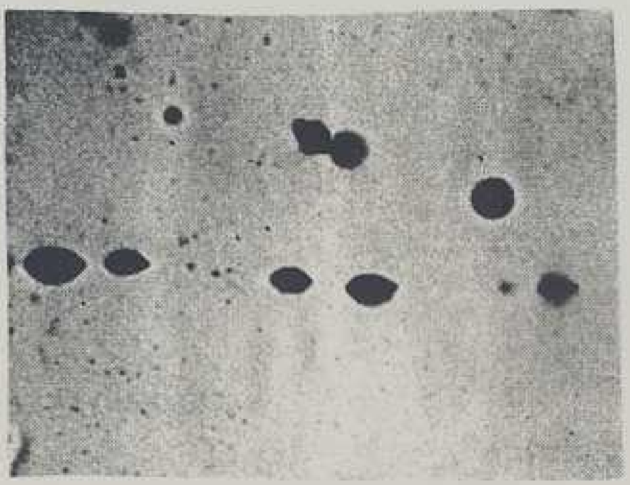
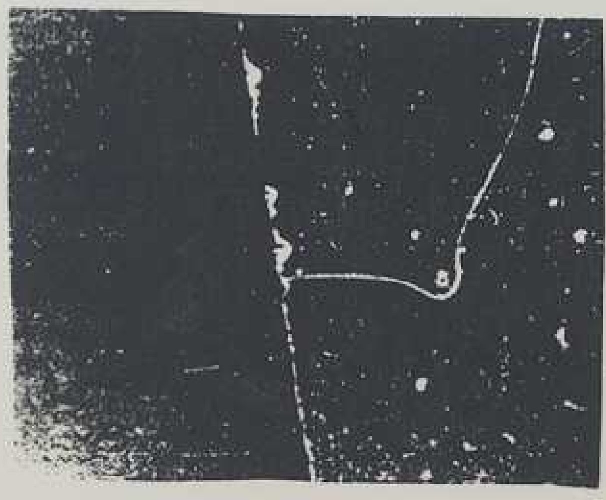
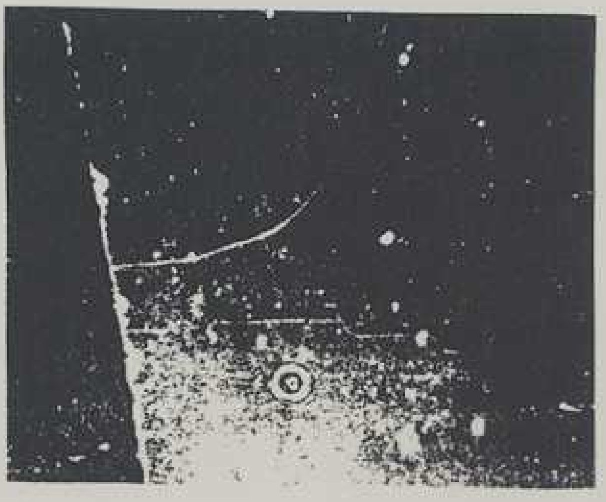


M. F. Ashby, J. Harper, L. Lewis





Phase-field model

$$H = \int d^3r \left\{ \frac{1}{2}(\nabla\phi)^2 + \mathcal{W}(\phi) + \frac{1}{2}[C - \mathcal{U}(\phi)]^2 \right\}$$

$$\partial_t \phi = -\Lambda\, \delta H / \delta\phi \quad , \quad \partial_t C = D\, \nabla^2 \delta H / \delta C$$

Stationary uniform motion

$$V \;=\; \Gamma\,[G + F]$$

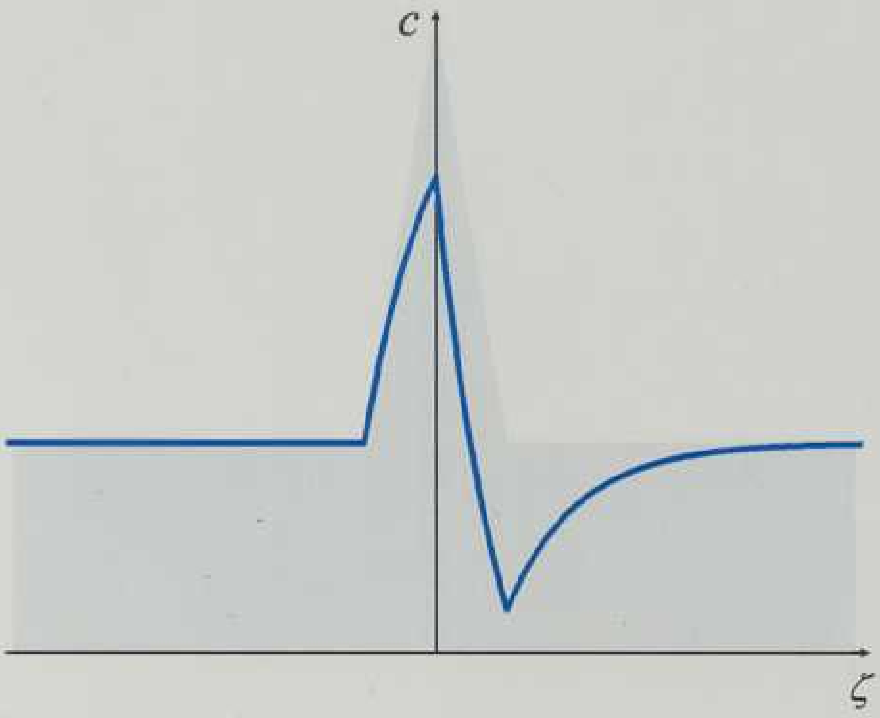
$$-V[C_s(\zeta) - C_0] \;=\; D[C_s'(\zeta) - U'(\zeta)]$$

Solute drag force

$$G = -\frac{V}{D} \int d\zeta\, [C_s(\zeta) - C_0]^2$$

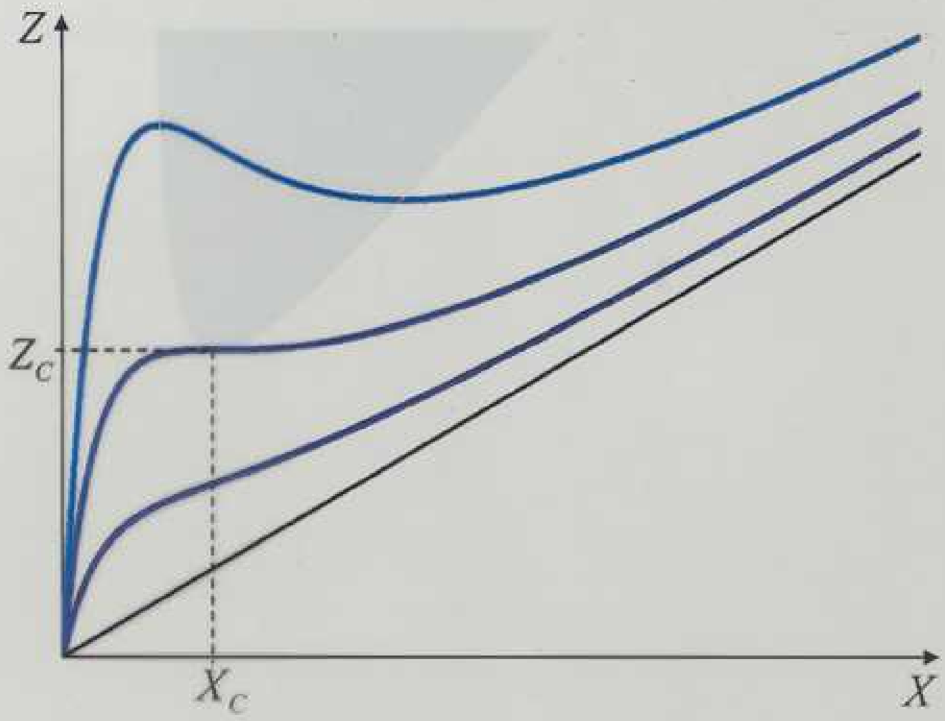
Segregation density

$$C_s(\zeta) - C_0 = \int_{-\infty}^{\zeta} d\eta \, U'(\eta) \exp\left[-\frac{V}{D}(\zeta - \eta)\right]$$

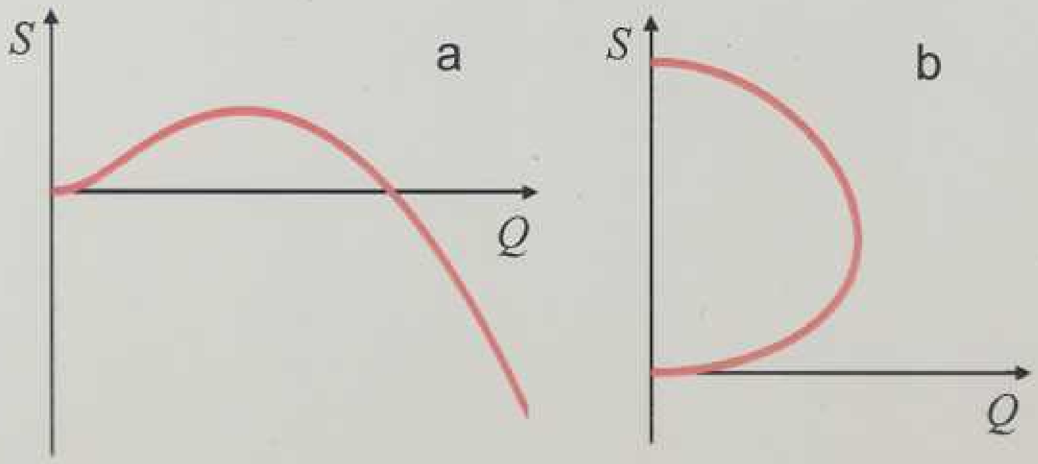


$$C_{eq}(\zeta) = U(\zeta)$$

Force-velocity diagram



Unstable eigen frequencies



D-dimensional defect, coupled to a Ginzburg-Landau field in a d-dimensional crystal

$$H = \int d^d r \left[\frac{1}{2}(\nabla\varphi)^2 + \frac{\varepsilon}{2}\varphi^2 + \frac{u}{4}\varphi^4 + \frac{v}{6}\varphi^6 + \frac{1}{2}U[\mathbf{R}]\,\varphi^2\right] + \int d^D\xi\, \frac{\sigma}{2}(\partial\mathbf{R})^2$$

$$\partial_t \varphi = -\lambda\,(i\nabla)^2 \delta H/\delta\varphi + \theta$$

$$\mathbf{N}\cdot\partial_t\mathbf{R} = -\frac{1}{B}\,\frac{1}{|\partial_\xi \mathbf{R}|}\mathbf{N}\cdot\frac{\delta H}{\delta \mathbf{R}} + \mathbf{N}\cdot\mathbf{k} + \mathbf{N}\cdot\eta$$

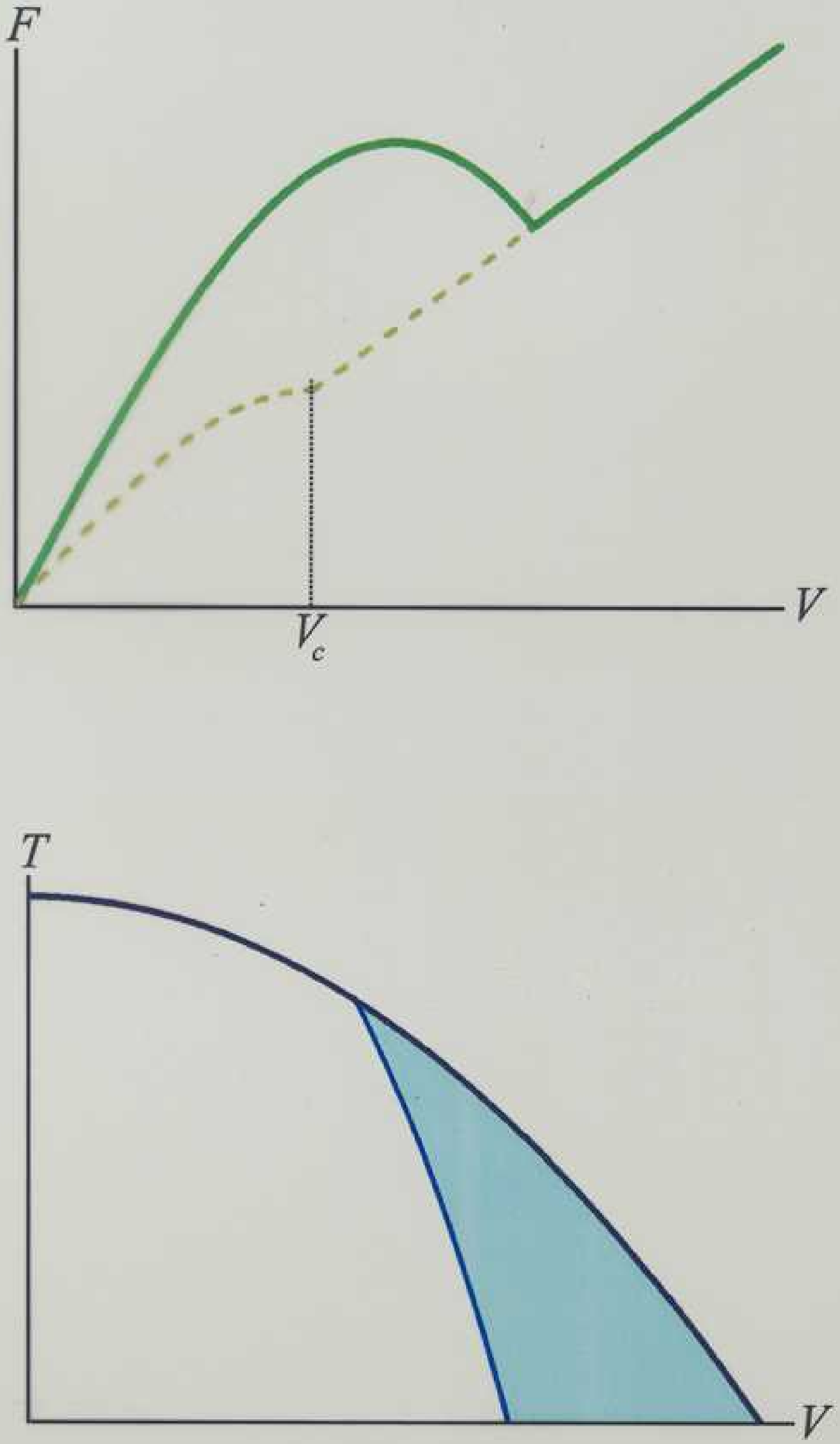
Edge dislocation (D=1,d=3)

$$U \equiv Tr\,\varepsilon(\mathbf{r},[\mathbf{R}]) = \kappa\,\frac{b_z}{2\pi}\,\frac{1-2\nu}{1-\nu}\,\frac{y}{[z-Z(x,t)]^2+y^2}$$

Twin boundary (D=2,d=3)

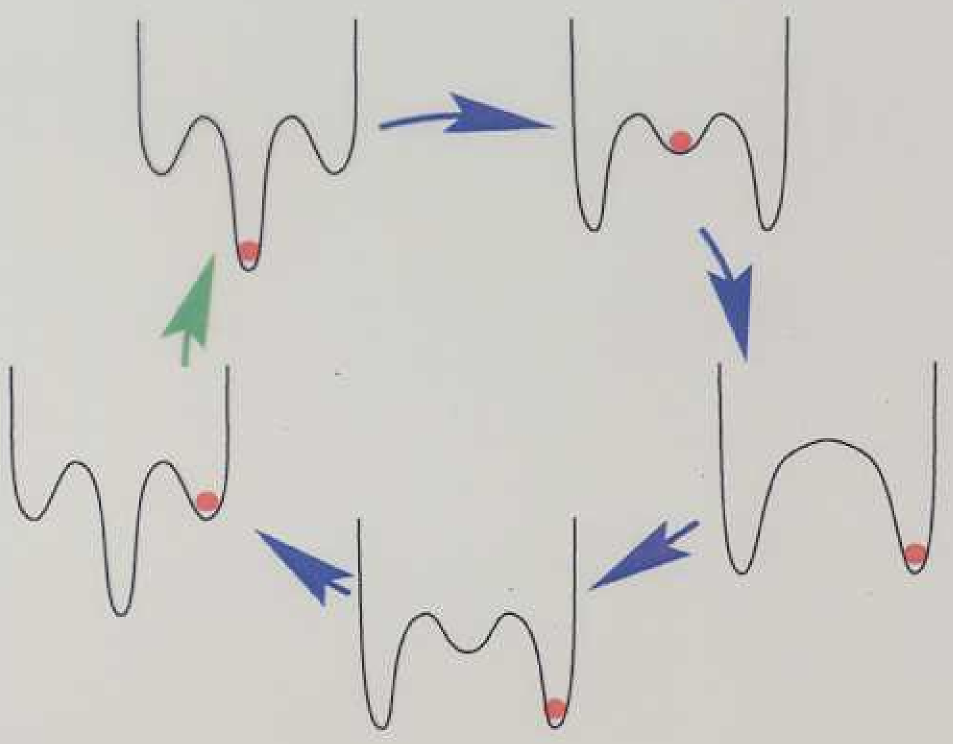
$$U = -\kappa\,\delta[z - Z(x,y,t)]$$

Twin-boundary instability near a second-order transition

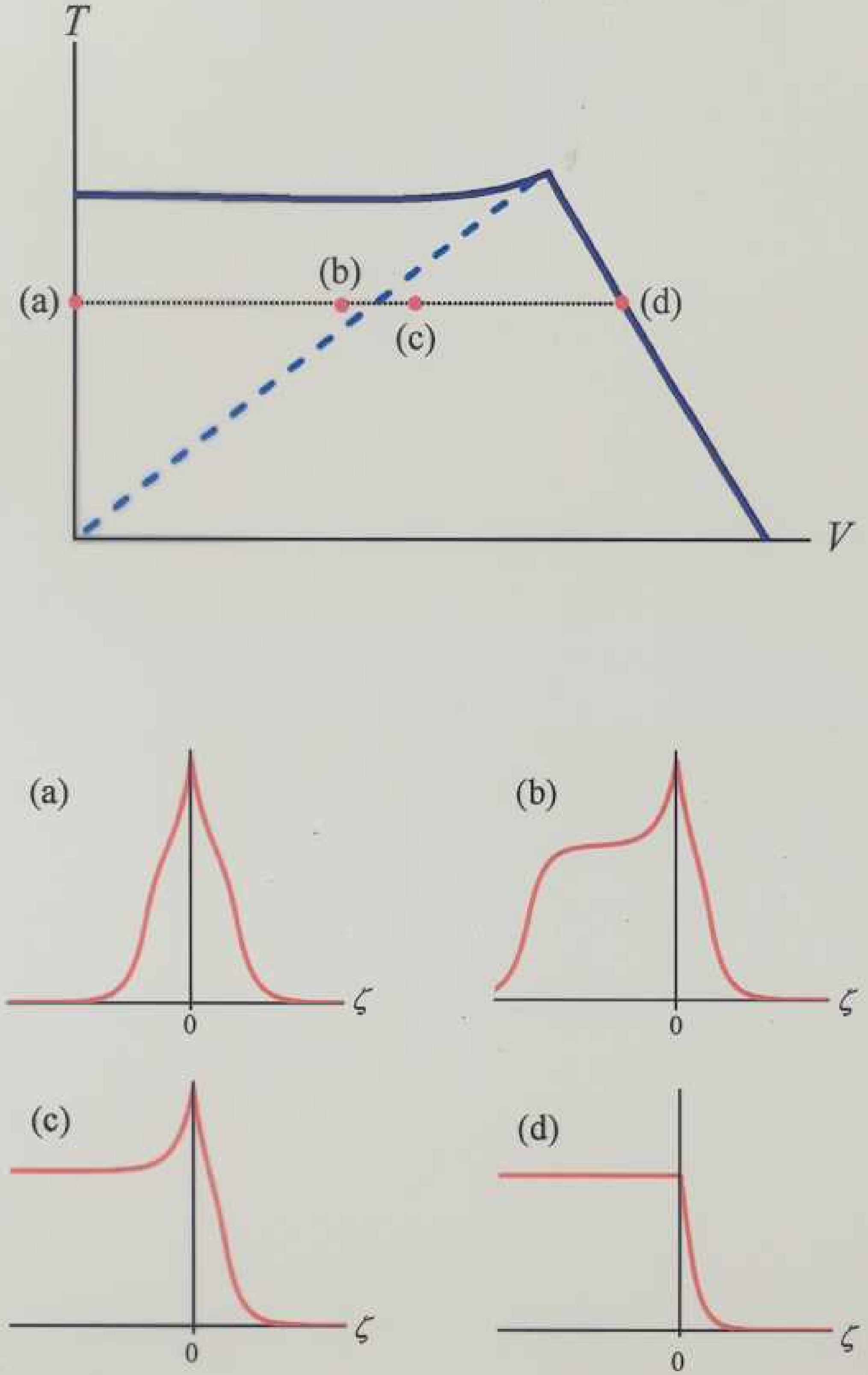


Generation of a metastable layer
on a moving domain boundary

Free energy at a fixed position
relative to the moving defect

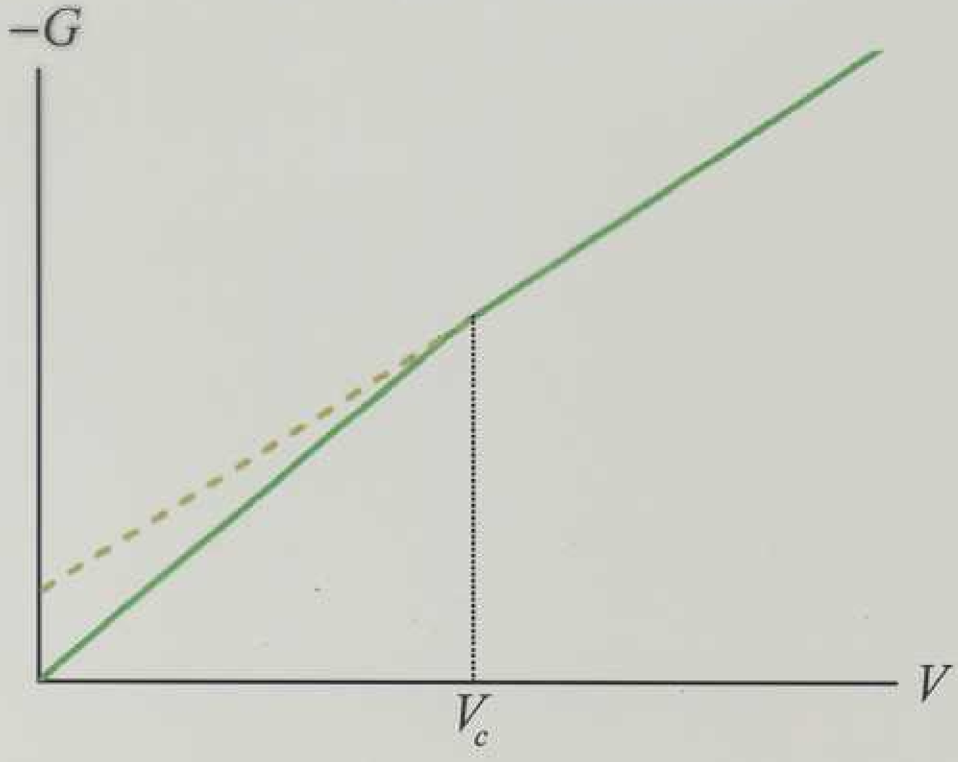


First-order kinetic wetting of a twin boundary



Nucleus-induced friction force

$$G \equiv -\left\langle \frac{\delta H}{\delta Z} \right\rangle = \frac{1}{2} \int d^2x \, (\partial_z U) \langle \varphi^2 \rangle$$



$$T = const$$