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Dynamic Crack Growth at Vanishing Crack Growth Rate

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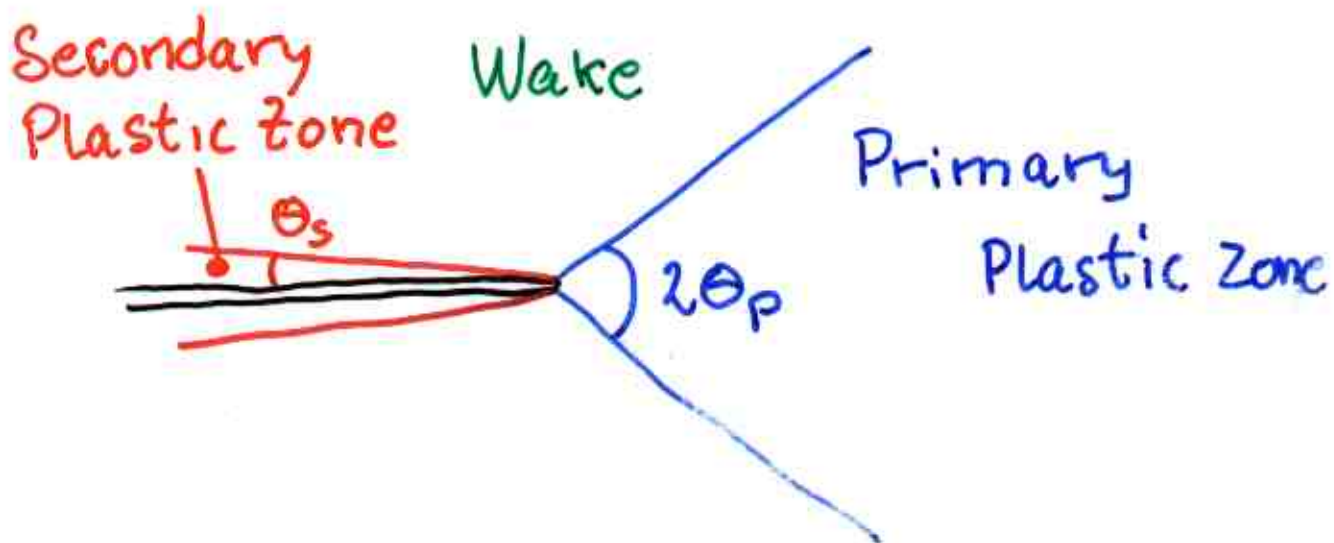
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- Mode III
- Steady State
- Vanishing Hardening Rate
- Vanishing Speed
- Asymptotic Field



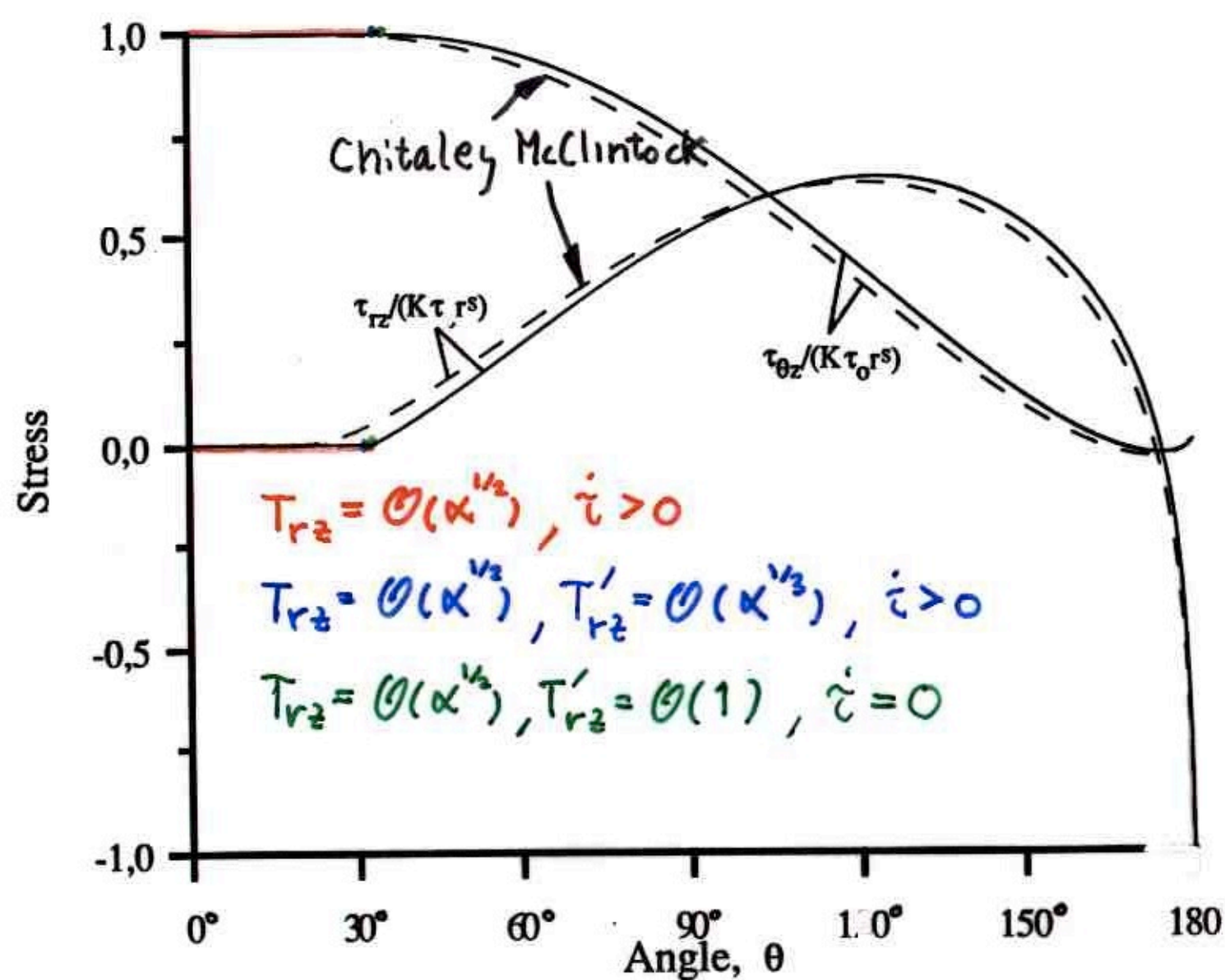
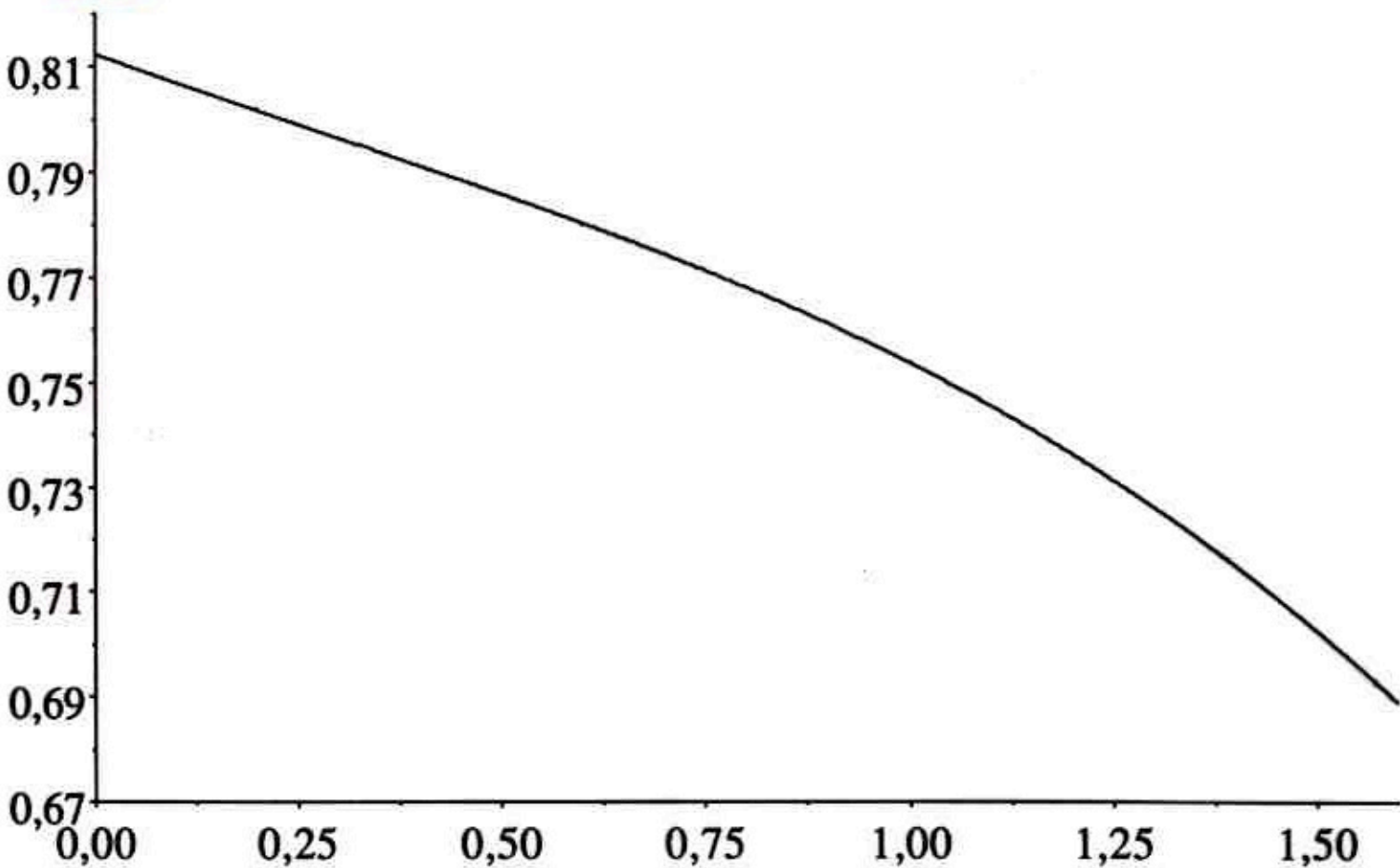


Fig. 4. Angular distribution of the polar stress components τ_{rz} and $\tau_{\theta z}$. The stresses are normalized so that the effective stress equals unity straight ahead of the crack tip. Dashed curves show the result by CHITALEY and MCCLINTOCK [4].

$-SK^{-1/2}$



$V^2 S / G_z$

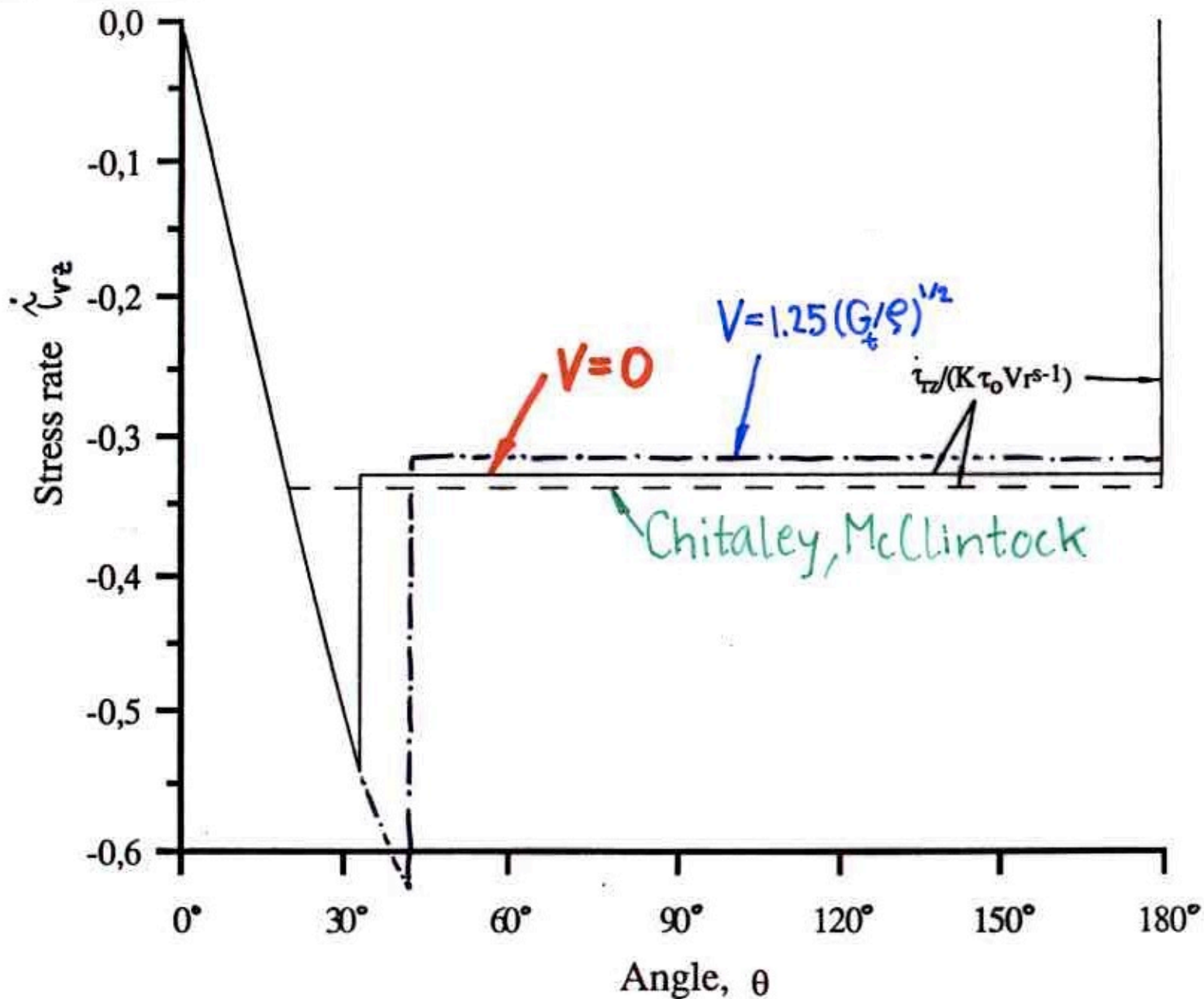
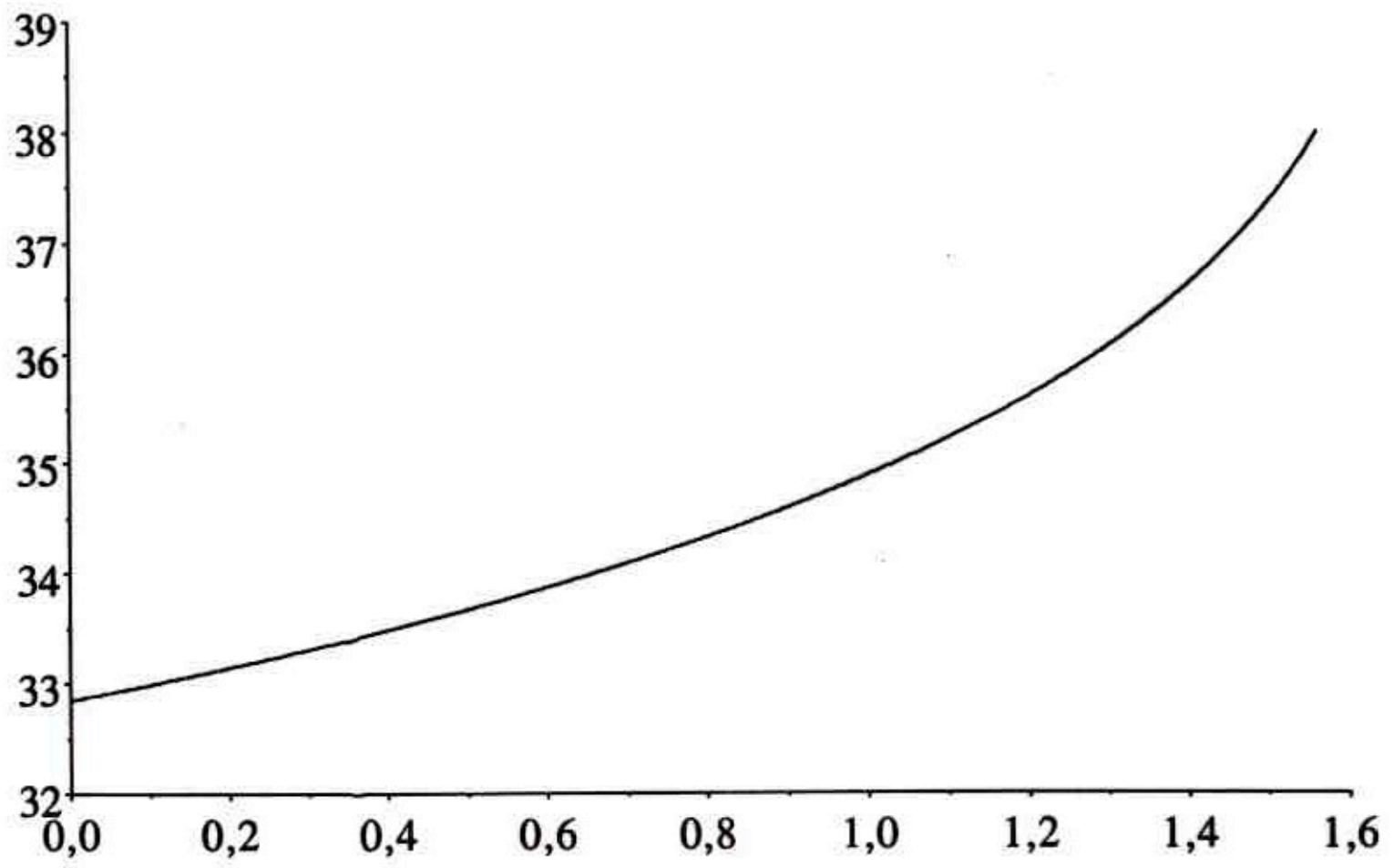


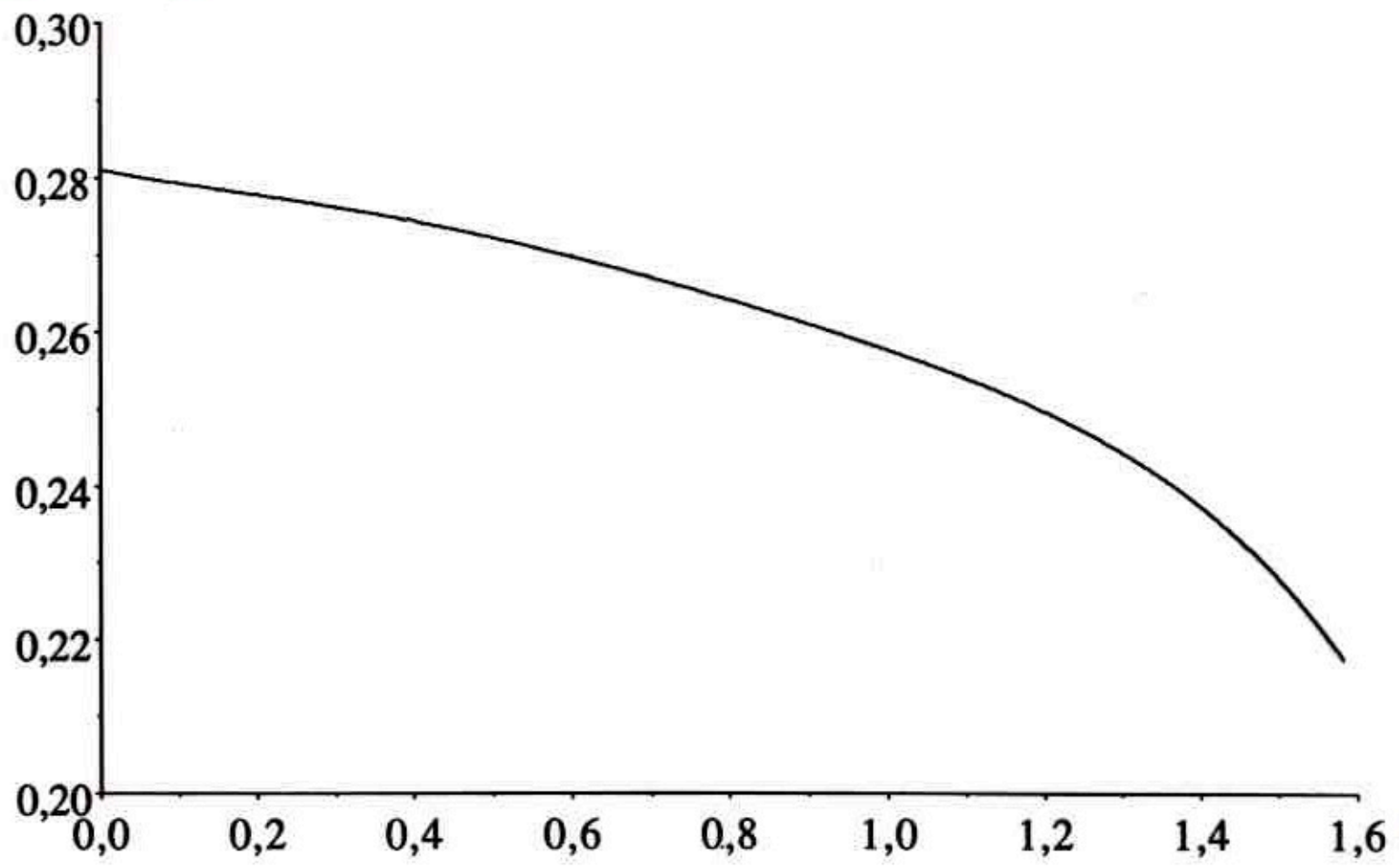
Fig. 7. Angular distribution of the polar stress rate components $\dot{\tau}_{rz}$ and $\dot{\tau}_{\theta z}$. The stress rates are normalized so that the effective stress equals unity straight ahead of the crack tip. Dashed curves show the result by CHITALEY and MCCINTOCK [4]

θ_p



$V^2 S / G_*$

$180^\circ - \theta_s$



$V^2 S / G_x$

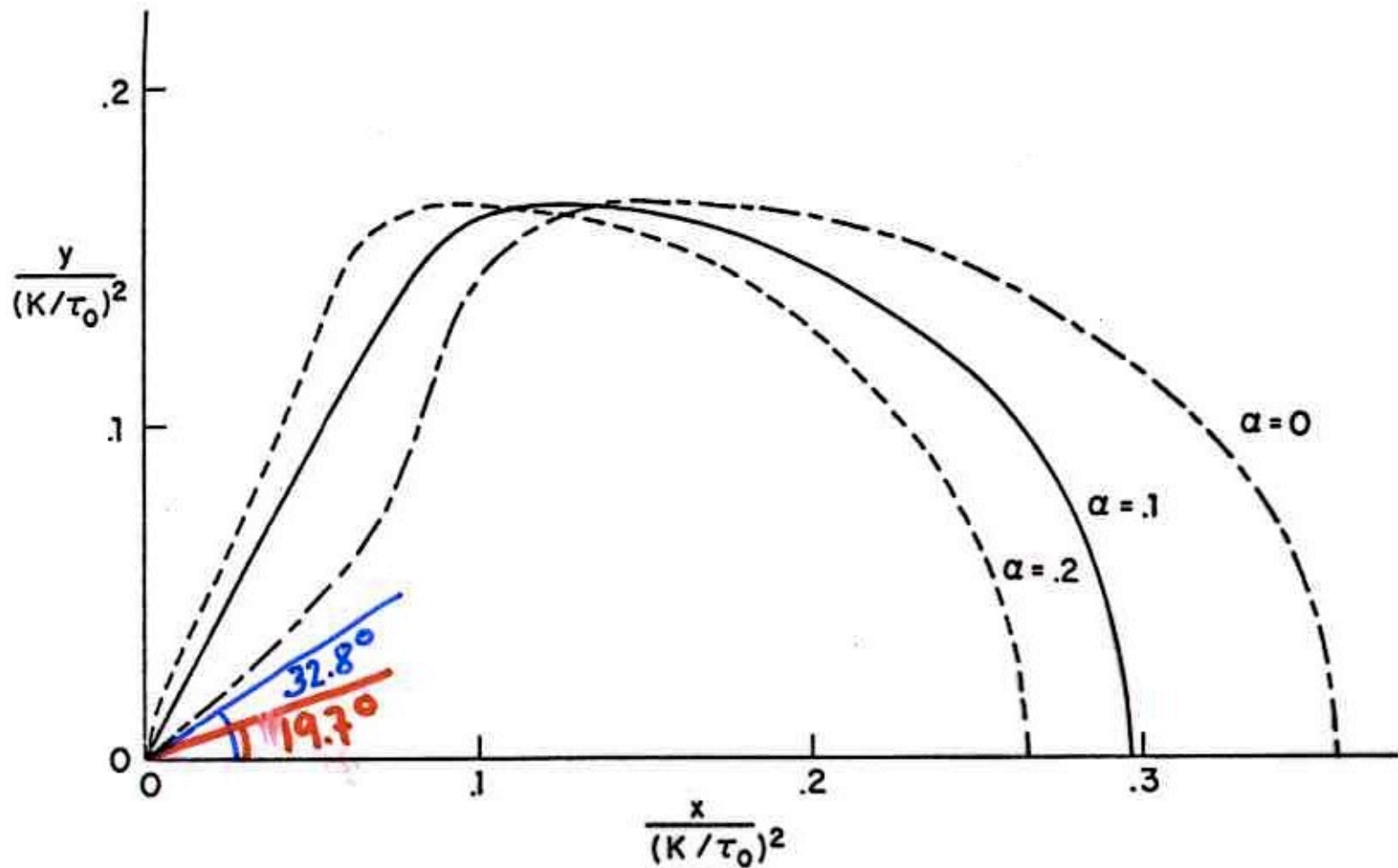


Fig. 6 Effect of linear hardening parameter α on active plastic zone shape in Mode III.

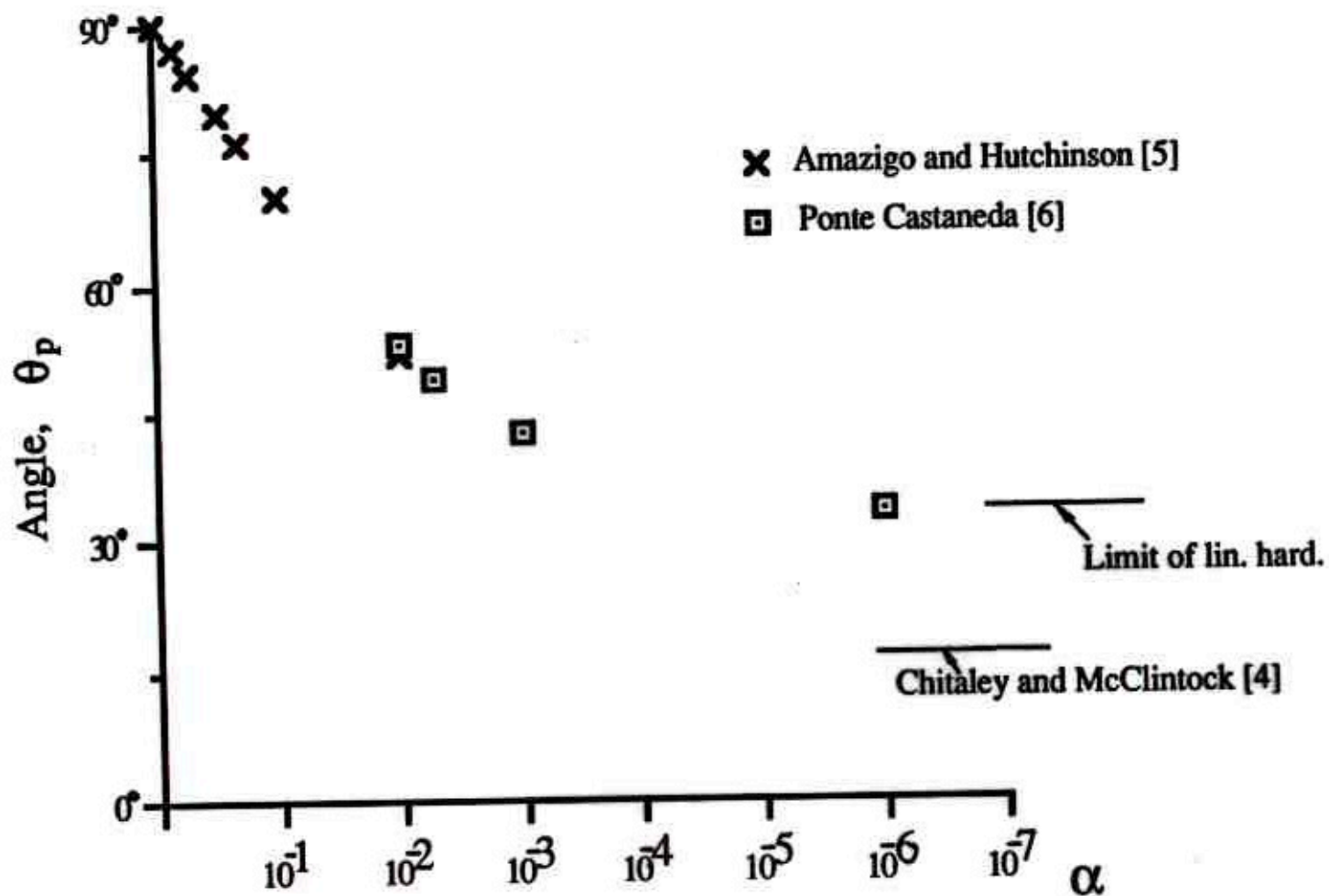


Fig. 9. Unloading angle θ_p for materials with different hardening rates $\alpha=G_I/G$. Results obtained by AMAZIGO and HUTCHINSON [5] and PONTE CASTANEDA [6] compared with the present result for the limit as $\alpha \rightarrow 0$ and the result obtained by CHITALEY and MCCLINTOCK [4]

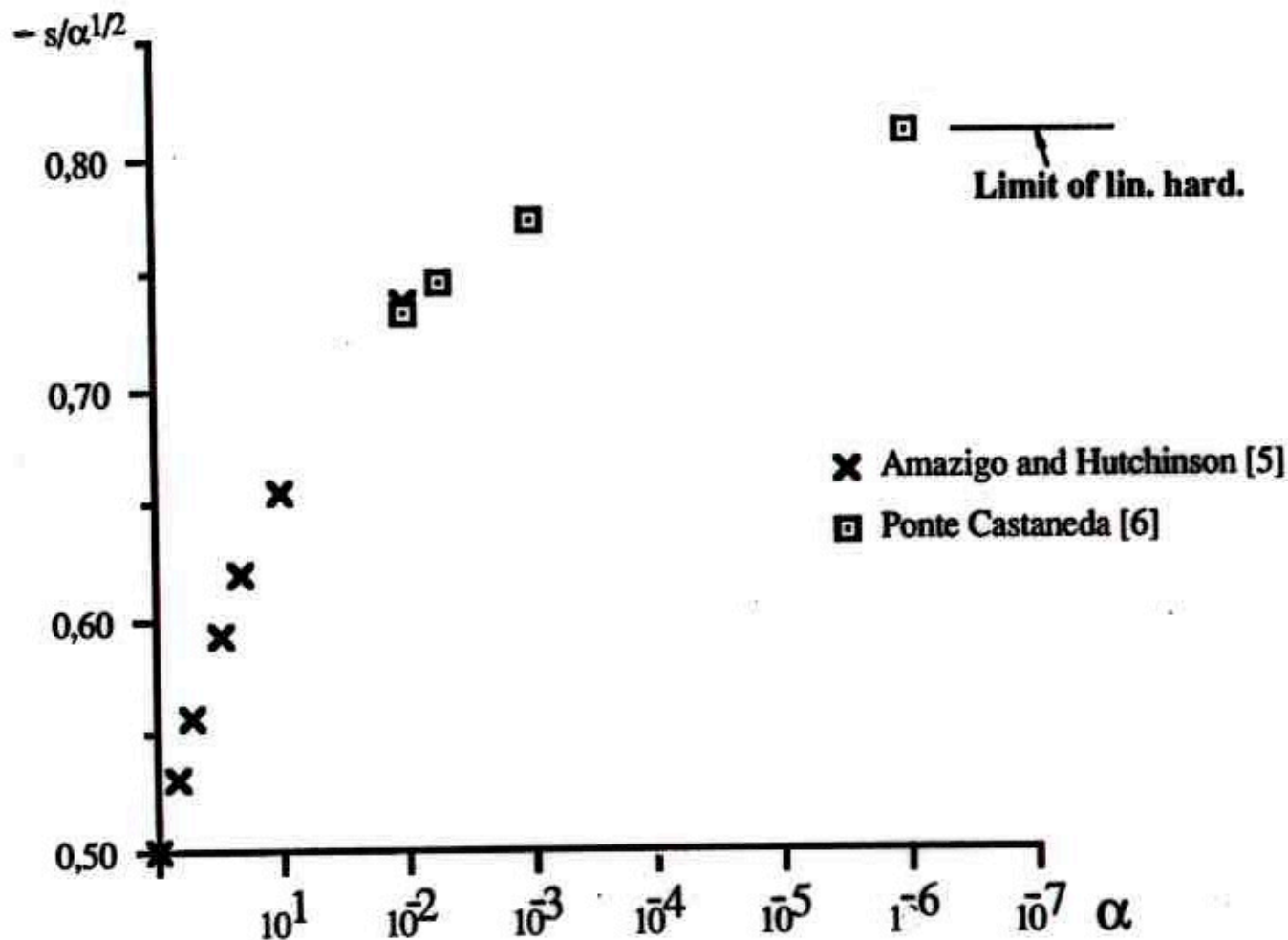
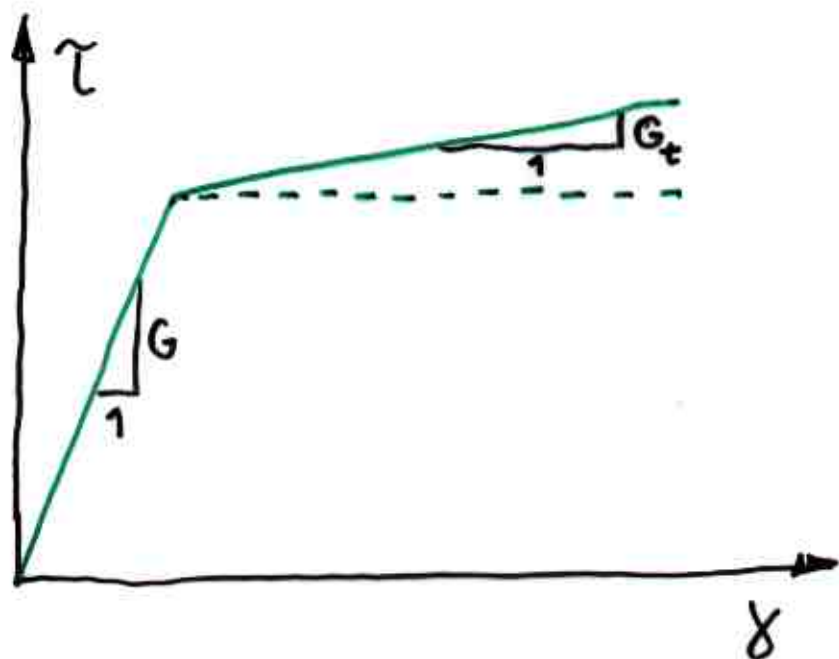


Fig. 10. Ratio $s/\alpha^{1/2}$ for materials with different hardening rates $\alpha=G_I/G$. Results obtained by AMAZIGO and HUTCHINSON [5] and PONTE CASTANEDA [6] compared with the present result for the limit as $\alpha \rightarrow 0$.

Linear Hardening



$$\alpha = \frac{G_h}{G}$$

Assumed: $\alpha \rightarrow 0$

$$v \sqrt{\frac{\rho'}{G_h}} - \text{finite}$$

Equations

Steady state $\dot{(\)} = -V(\)_{,x}$

Equation of motion $\tau_{\alpha\beta, \alpha} = \rho \ddot{w}$

Compatibility $\gamma_{\alpha\beta} = w_{, \alpha}$

Material $\dot{\gamma}_{\alpha\beta} = G^{-1} \dot{\tau}_{\alpha\beta} + (G_t^{-1} - G^{-1}) \tau_{\alpha\beta} \dot{t} t^{-1}$

Continuity Conditions

Full stress continuity

$$[\tau_{xz}] = 0$$

Drugan,
Rice 1982

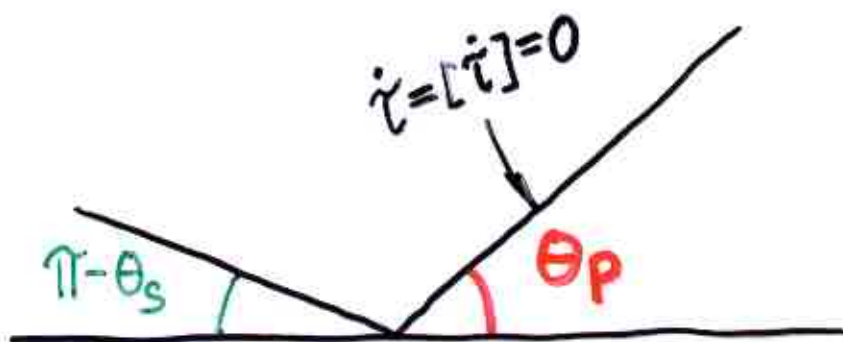
Hardening material

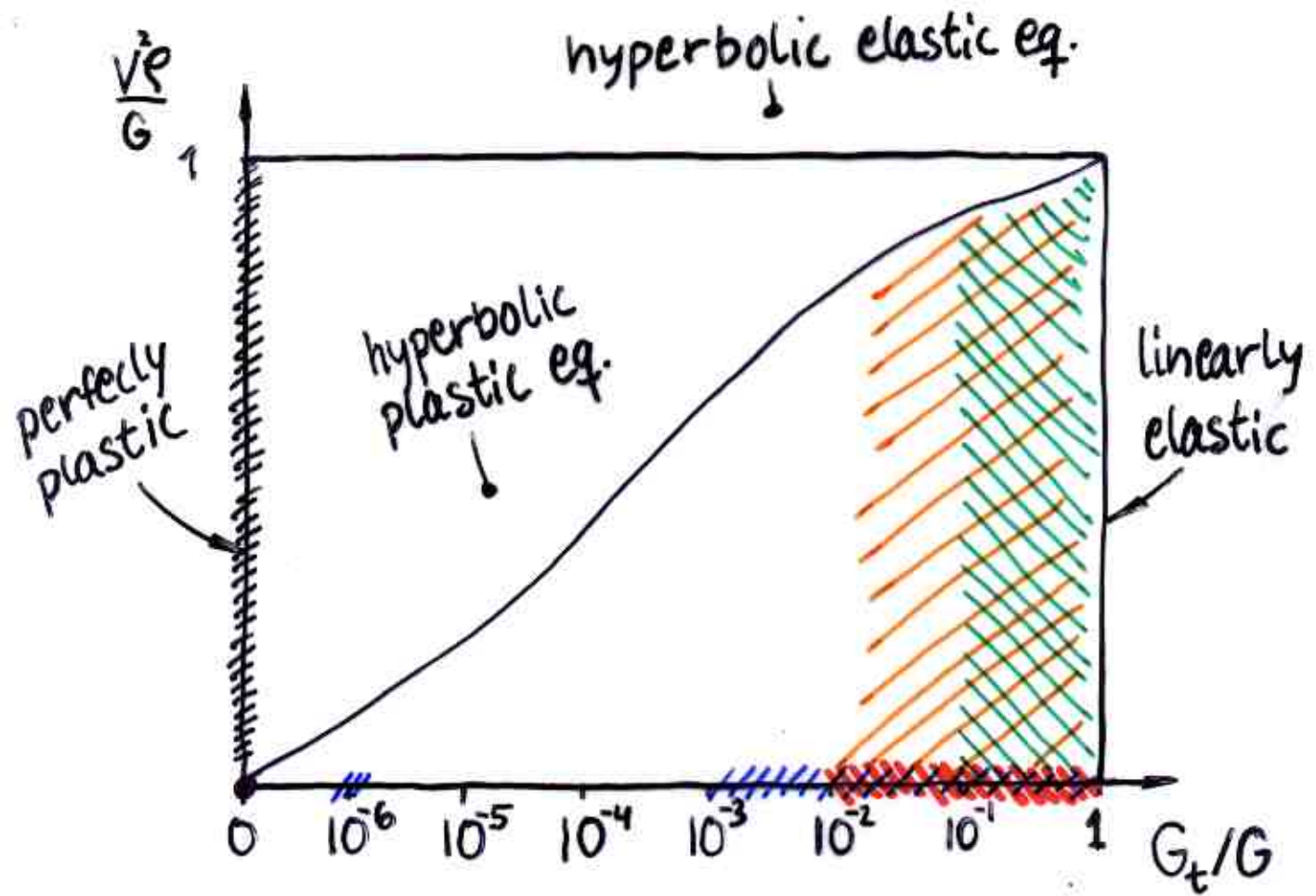
$$[\dot{\gamma}_{xz}] = 0$$

Amazigo,
Hutchinson 1977

Unloading

$$\dot{\gamma} = 0$$





- Chitaley, McLintock 1971
- /// Amazigo, Hutchinson 1977
- /// Achenbach, Karminen 1978
- /// Ponte Castañeda 1987
- /// Freund, Douglas 1982
- /// Östlund, Gudmundson 1987

Method

Assumed:

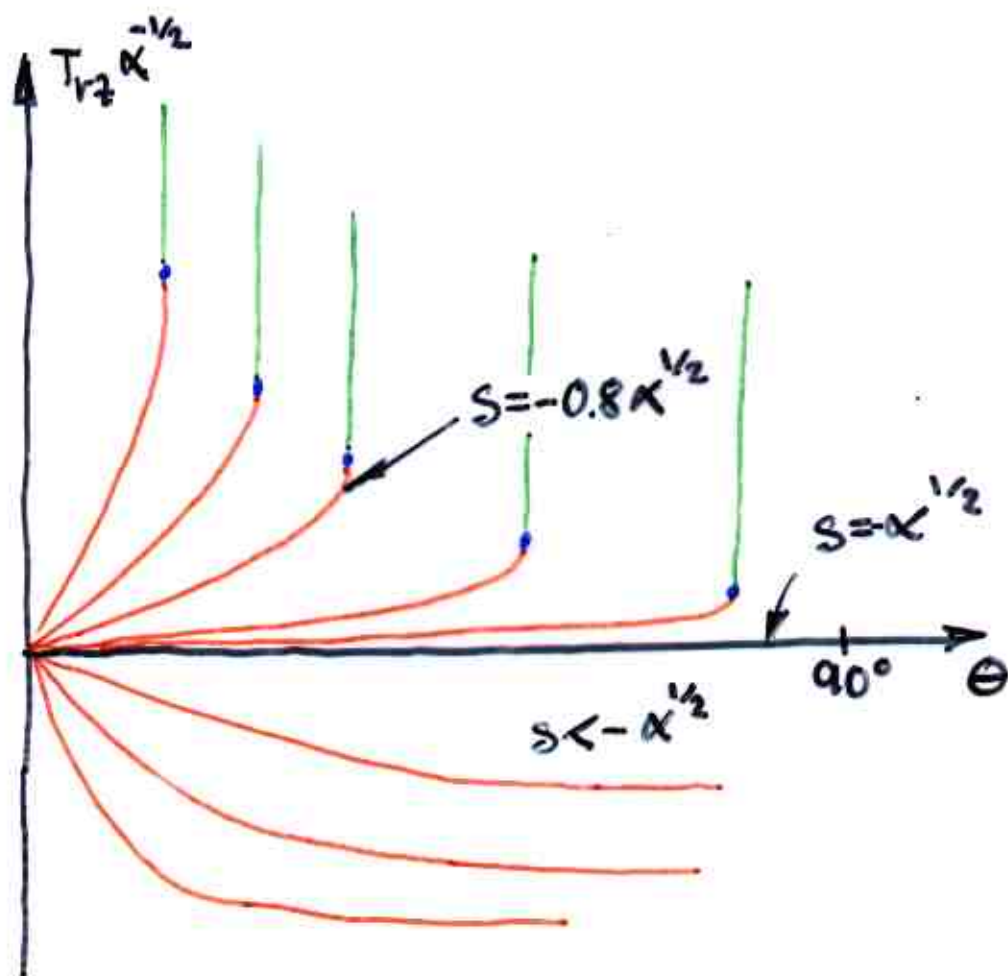
$$\tilde{l}_{r_z} = T_{r_z}(\theta) r^s$$

Small deviation from
centered fan:

$$T_{r_z} \rightarrow 0 \text{ as } \kappa \rightarrow 0 \text{ in } \theta < \theta_c$$

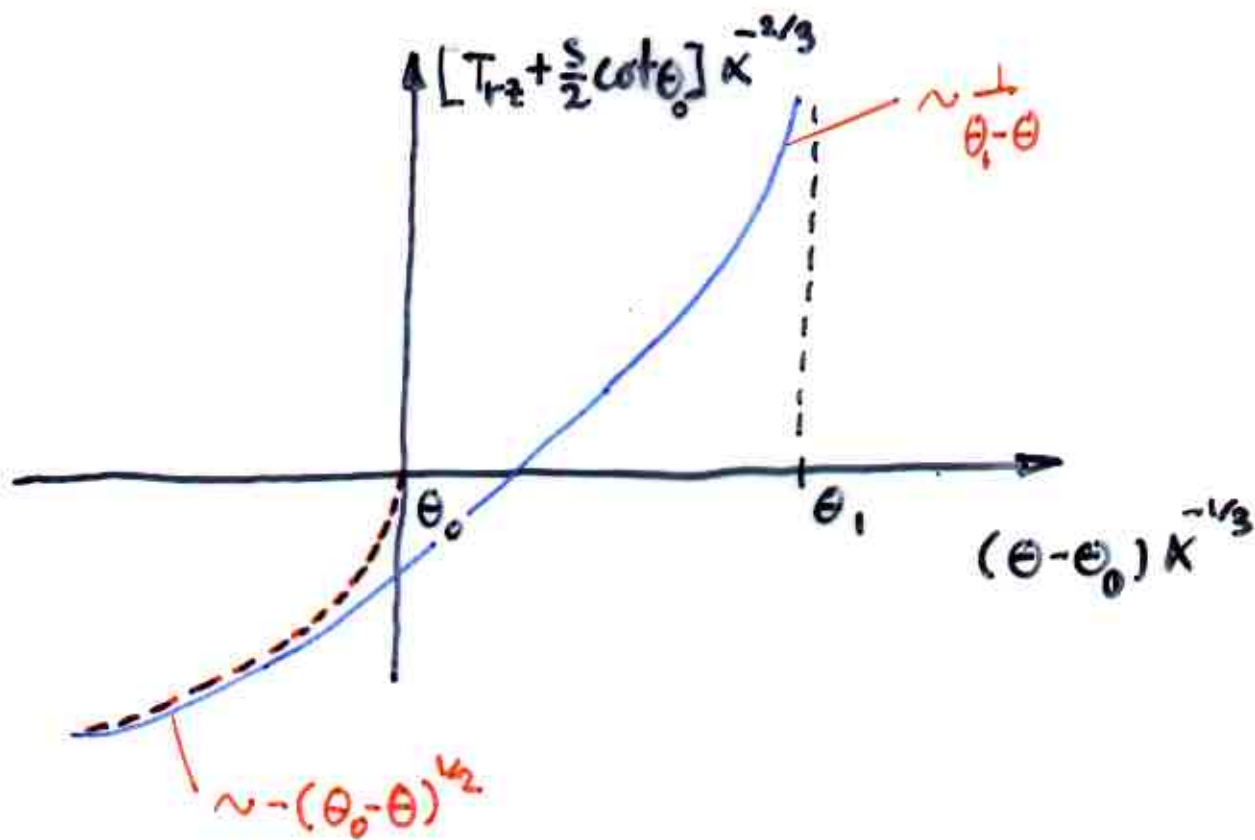
$$T_{r2}'(s + 2T_{r2} \tan \theta) - 2sT_{r2} \tan \theta + T_{r2}^2 \kappa - s^2 = 0$$

$$s = \mathcal{O}(\kappa^{1/2}) \quad T_{r2}', T_{r2} = \mathcal{O}(\kappa^{1/2})$$



$$T_{r2}'' = \mathcal{O}(1) \quad T_{r2}' = \mathcal{O}(x^{1/3}) \quad T_{r2} = -\frac{5}{2} \cot \theta_0 + \mathcal{O}(x^{2/3})$$

$$(T_{r2}'' + \cot \theta_0)(T_{r2}^2 + x) - 2T_{r2}'(T_{r2} + \frac{5}{2} \cot \theta_0) = 0$$



$$T_{r_2}'' = \mathcal{O}(\alpha^{-1/2}) \quad T_{r_2}' = \mathcal{O}(1) \quad T_{r_2} = -\frac{S}{2} \omega t \theta_0 - \mathcal{O}(\alpha^{1/2})$$

$$T_{r_2}''(T_{r_2}^2 + \alpha) + 2T_{r_2}'T_{r_2}(T_{r_2}' - 1) - ST_{r_2}' \omega t \theta_0 = 0$$

