3.40J / 22.71J
Modern Physical Metallurgy

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Lecture 9 NOTES: Dislocation intersections

March 9, 2004

General formulation of Peach-Kohler:

If $|\mathbf{b} \bullet \Sigma \times \mathbf{g}| > f$, a dislocation will move if and only if:

…there exists an available slip system

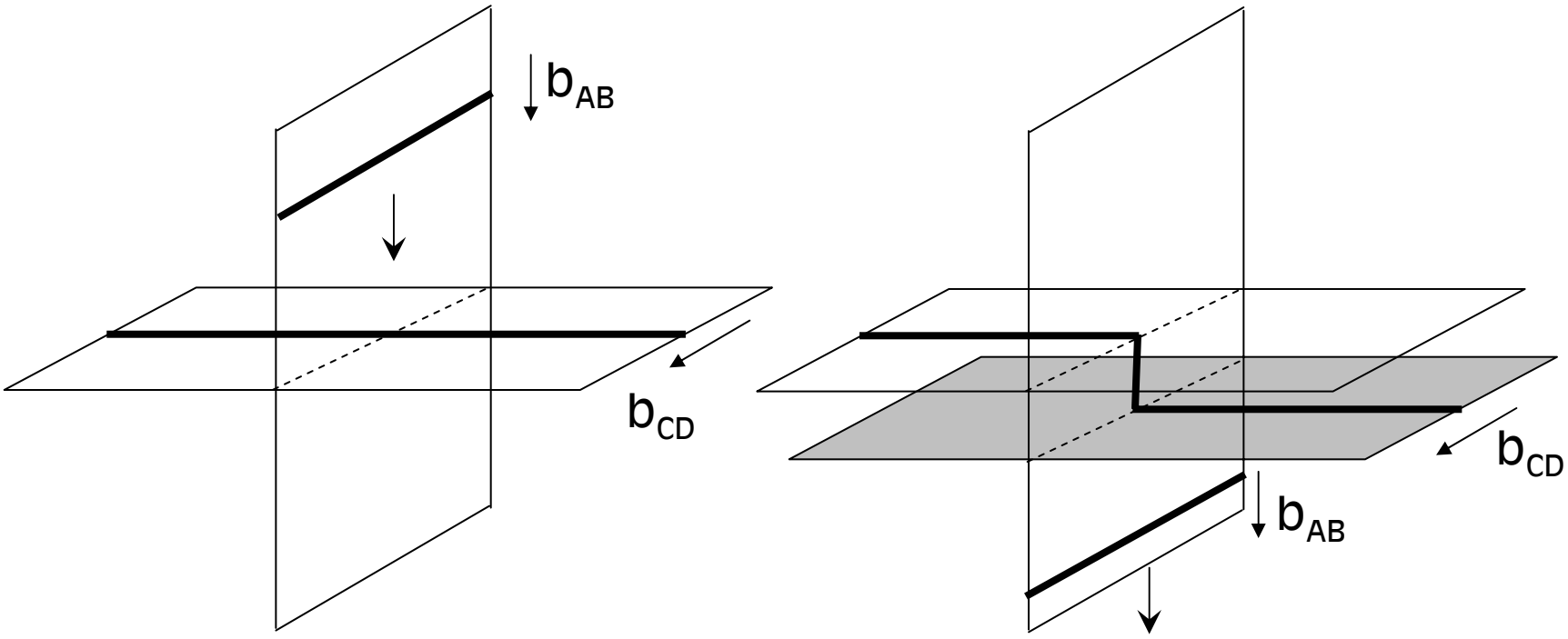
Once a dislocation starts moving…

Q: What happens when 2 moving dislocations intersect?

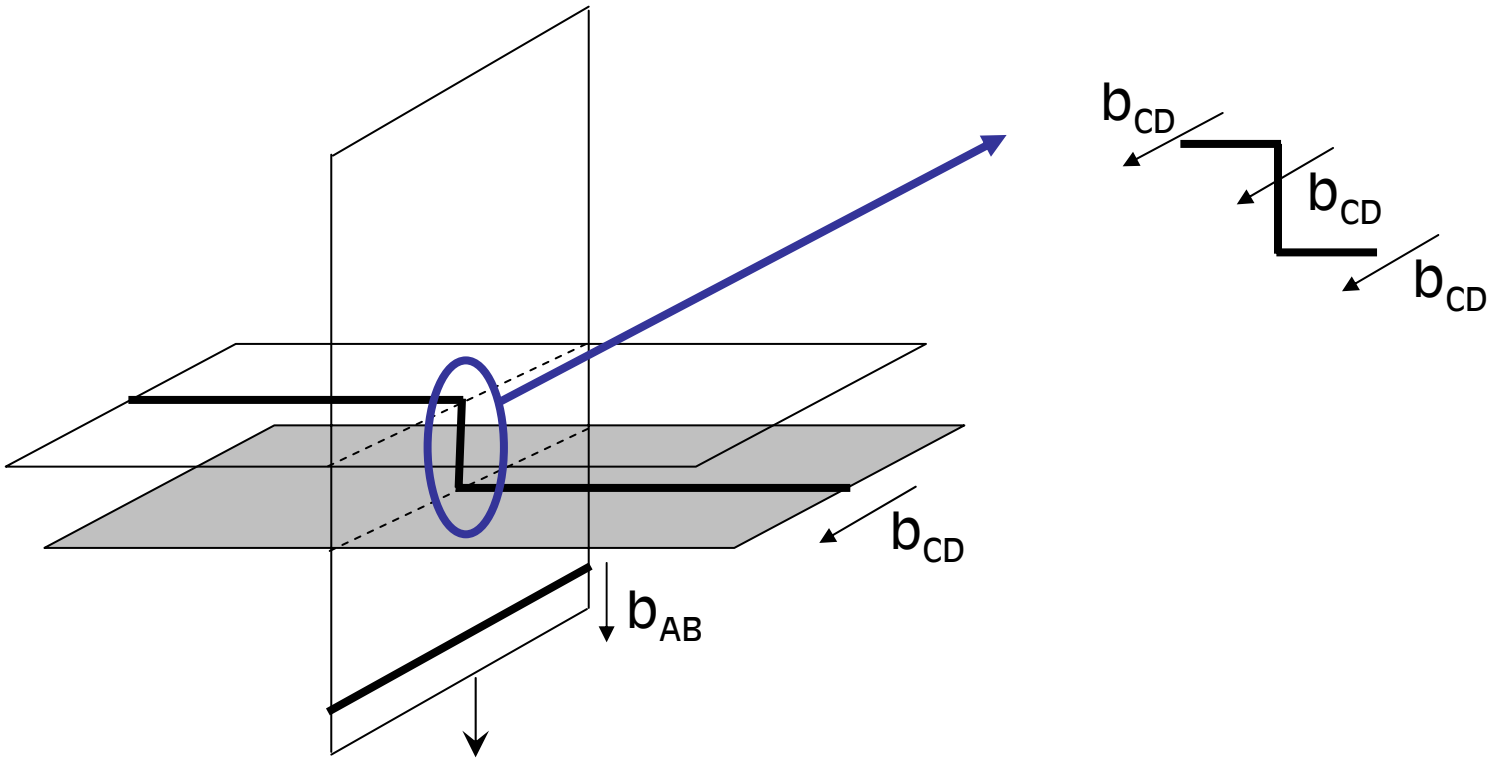
Q: What happens when a lot of dislocations intersect?

DISLOCATION INTERSECTION

- Affects topological character of dislocations
- Common in large-scale plastic flow with multiple slip systems active
- Leads to strain-hardening and dislocation multiplication

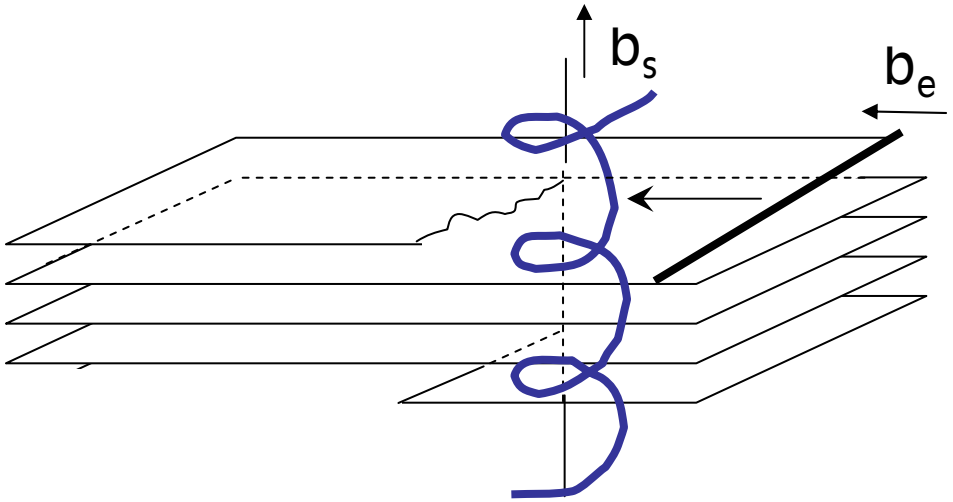


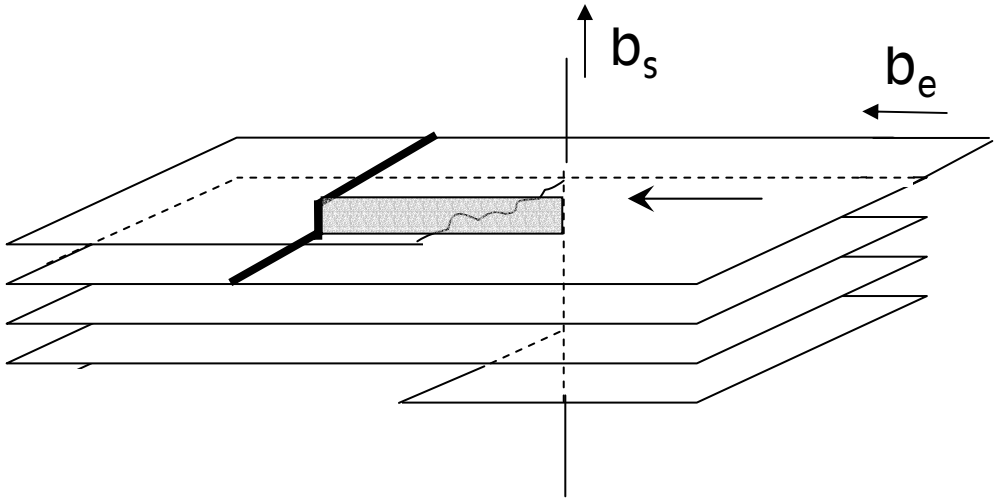
DISLOCATION INTERSECTION



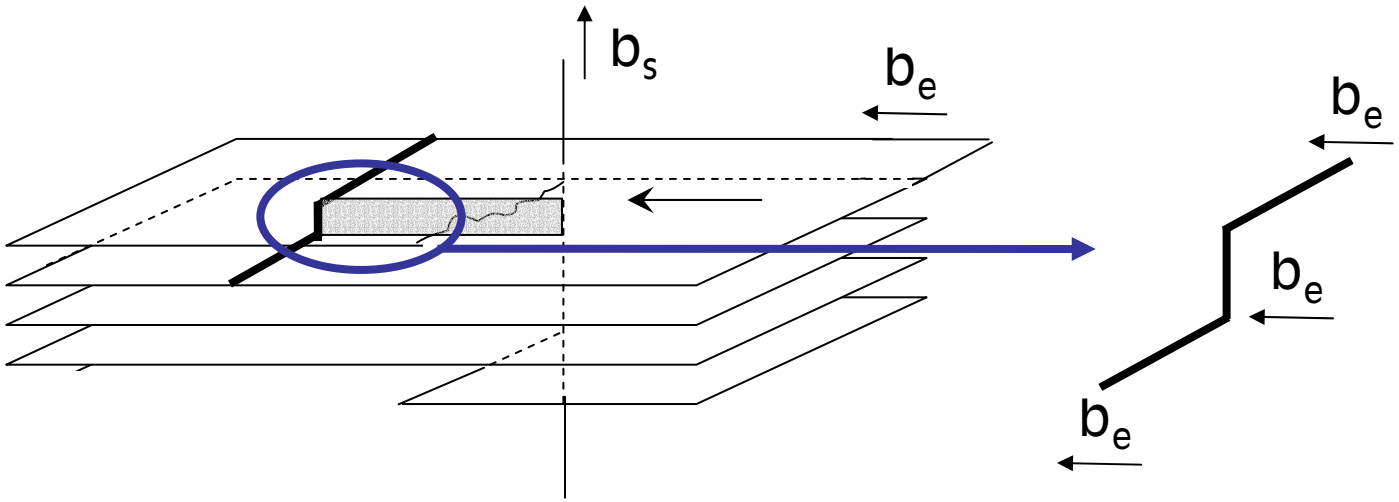
- Dislocation has a constant Burgers vector, but a change in ξ
- Burgers vector of jog is still perpendicular to ξ → edge-type jog
- Slip plane is different, so will slow dislocation motion → drag

DISLOCATION INTERSECTION



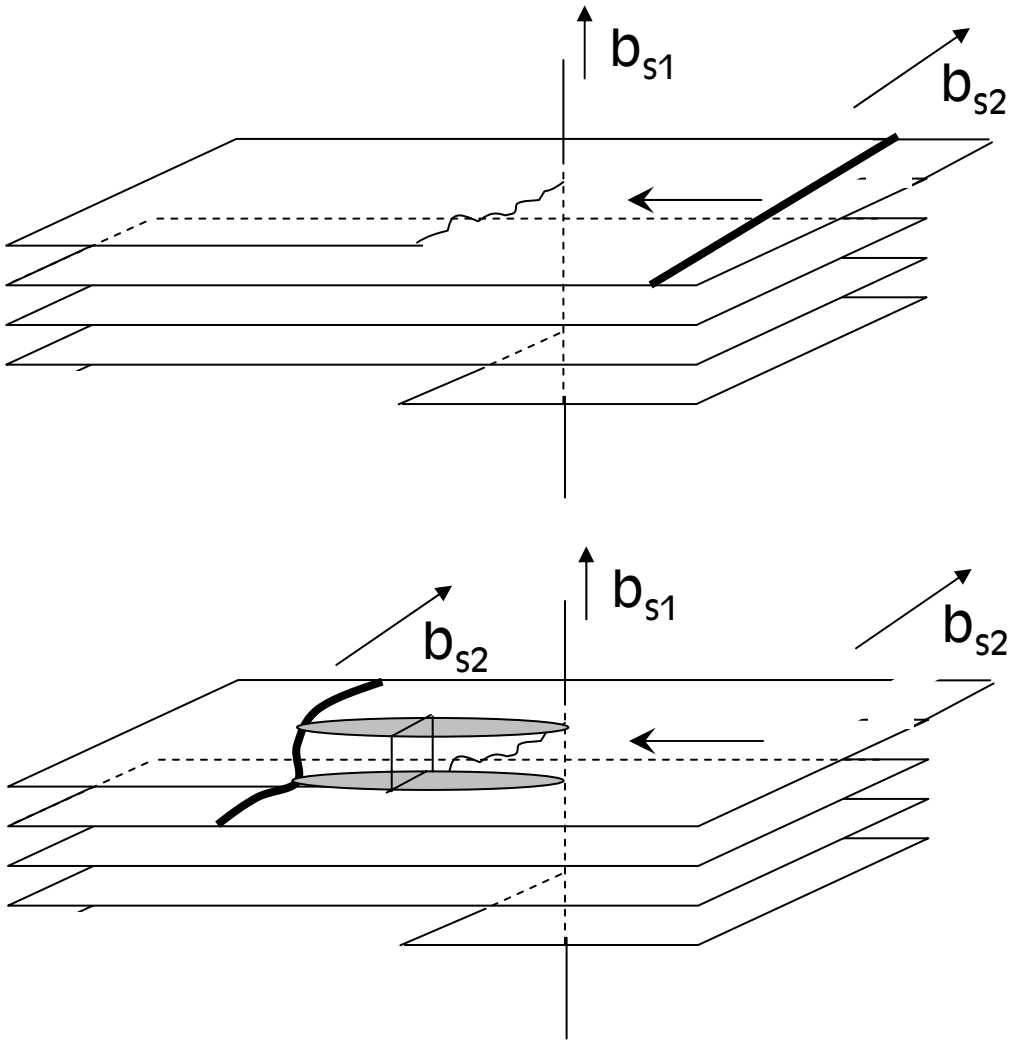


DISLOCATION INTERSECTION



- Edge dislocation slips down one step of the screw by amount b
- Dislocation has a constant Burgers vector, but a change in ξ
- Burgers vector of jog is still perpendicular to ξ → edge-type jog
- Slip plane is different, so will slow dislocation motion → drag

DISLOCATION INTERSECTION



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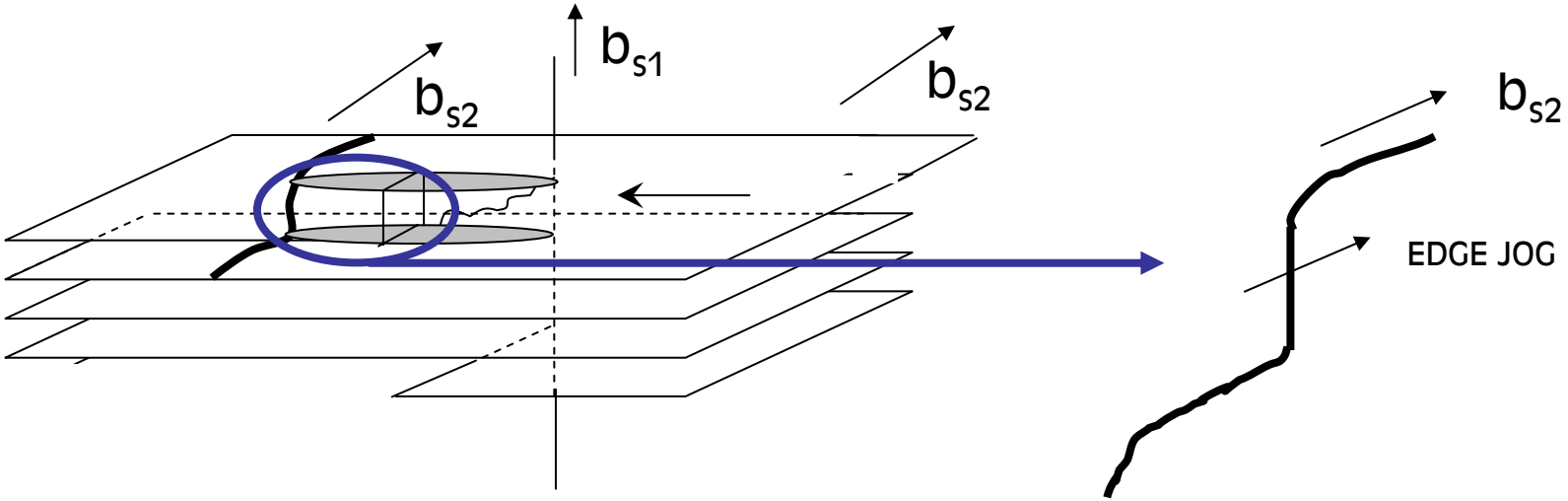
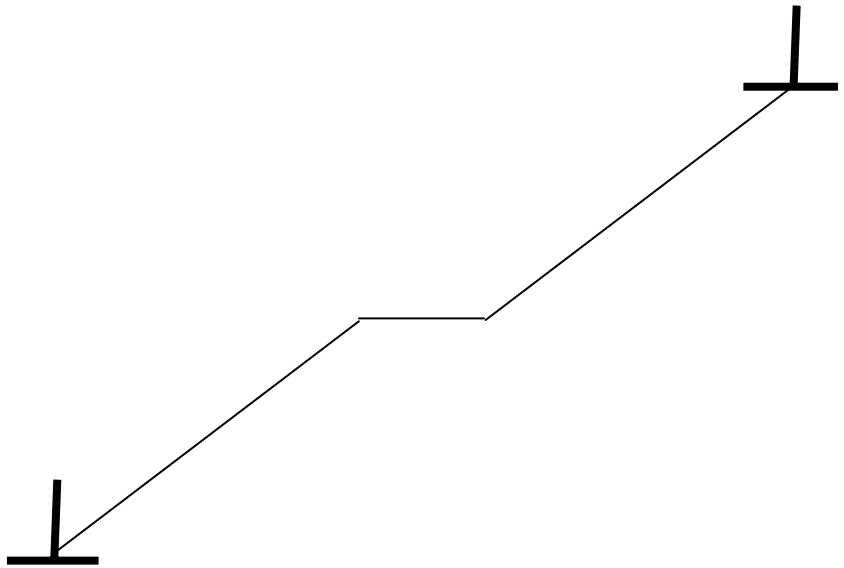


- Edge jog forms in moving screw dislocation
- Continued motion requires dislocation climb → row of vacancies/self-interstitials
- Creates large drag on the screw → relatively immobile/sessile
- In general, jogs on screws reduce motion more than jogs on edges

DISLOCATION INTERSECTION

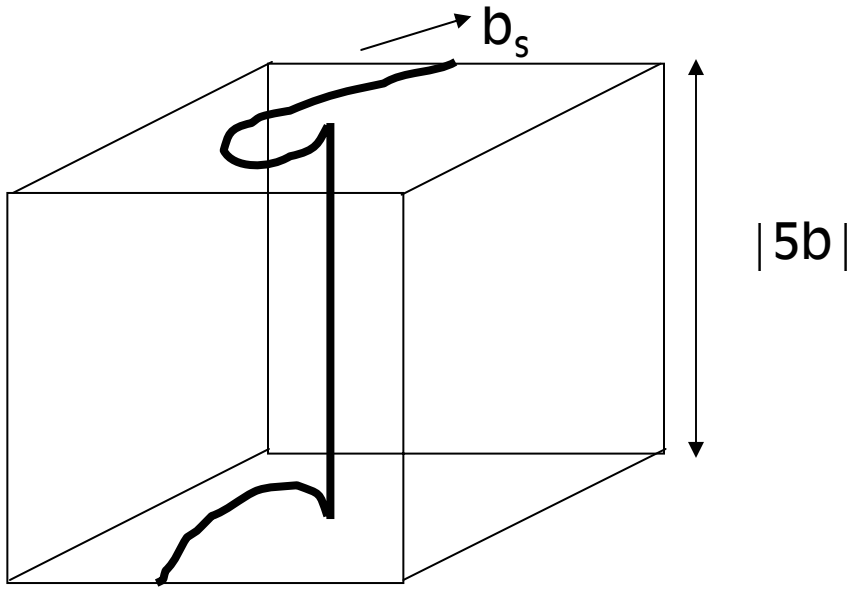
Kinks: Extra dislocation line length in the glide plane



DISLOCATION INTERSECTION: Energetic penalty

- Jog of magnitude |b| increases lattice energy as:
  $W/L = Gb^2$
  $L = b$
  $W = Gb^3$ → as b increases, penalty increases

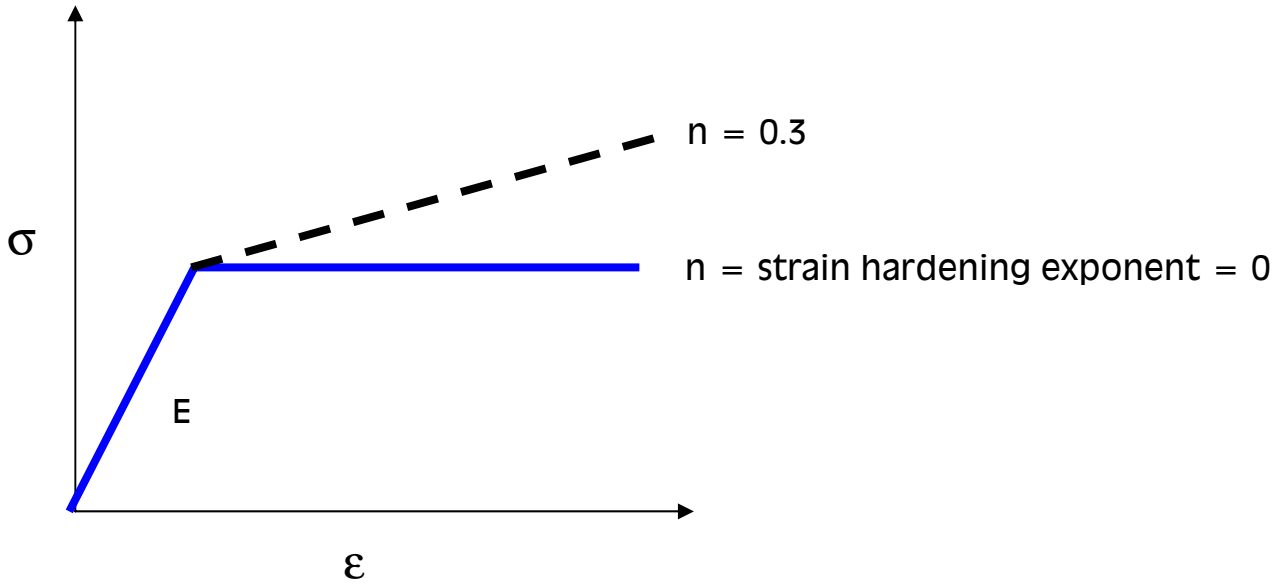
- Mobility reduction also depends on b
  If jog is of magnitude |b|, causes significant drag on edge/screw
  If jog is of several |b|, composite jog allows independent motion of dislocations at the ends of the jog:



This continued motion is because the screw portions at the end of the superjogs are far enough away that they don't interact significantly (P-K), and move independently.

DISLOCATION STRAIN HARDENING

Intersection of dislocations → immobile dislocation regions
Requires greater strain to move these dislocation lines
Greater strain of deformation → STRAIN HARDENING



Each strain increment requires increased applied stress

DISLOCATION STRAIN HARDENING

Nanoindentation modeling:

Molecular dynamics → Atomic response governed by F = ma

Visible atoms have imperfect coordination number

FCC → $N_{perfect}$ =

Indentation with sphere imposes stress in single crystal.

Defects form and interact beneath the indenter.