Lecture Recap: 9/21/09

Dislocation Energy

$$W = E = \int_0^{\gamma} \tau d\gamma = \frac{1}{2}\tau\gamma_{rz} = \frac{1}{2}\mu\gamma_{rz}^2$$

$$W/V = \frac{\mu b^2}{8\pi^2 r^2}$$

$$W_{screw} = \int_z \int_r \frac{\mu b^2}{8\pi^2 r^2}$$

$$W = l\frac{\mu b^2}{4\pi}\ln\left(\frac{r_{outer}}{r_{inner}}\right)$$

Screw

$$\frac{W}{l} \sim \mu b^2$$

Edge

$$\frac{W}{l} \sim \frac{\mu b^2}{1-\nu}$$

- Energy of dislocation proportional to length
  - Same dimensions as F, "line tension"
- Edge dislocation always higher energy
  - $(1-\nu)<1$
- Crystals try to form long screw dislocations
  - Dislocations often zigzag to accommodate screw

http://www.tf.uni-kiel.de/matwis/amat/def_en/kap_5/backbone/r5_2_3.html

Mixed Dislocations

Stress	Edge	Screw
σ_{xx}	$-\frac{\mu b_y}{2\pi(1-\nu)}\frac{3x^2+y^2}{(x^2+y^2)^2}$	0
σ_{yy}	$\frac{\mu b_y}{2\pi(1-\nu)}\frac{x^2-y^2}{(x^2+y^2)^2}$	0
σ_{zz}	$\nu(\sigma_{xx}+\sigma_{yy})$	0
τ_{xy}	$\frac{\mu b_x}{2\pi(1-\nu)}\frac{x^2-y^2}{(x^2+y^2)^2}$	0
τ_{xz}	0	$\frac{\mu b}{2\pi r}\cos\Theta$
τ_{yz}	0	$\frac{\mu b}{2\pi r}\sin\Theta$

Stress Fields

- Dislocations can interact
- Imagine them like charges: similar dislocations repel, opposites attract

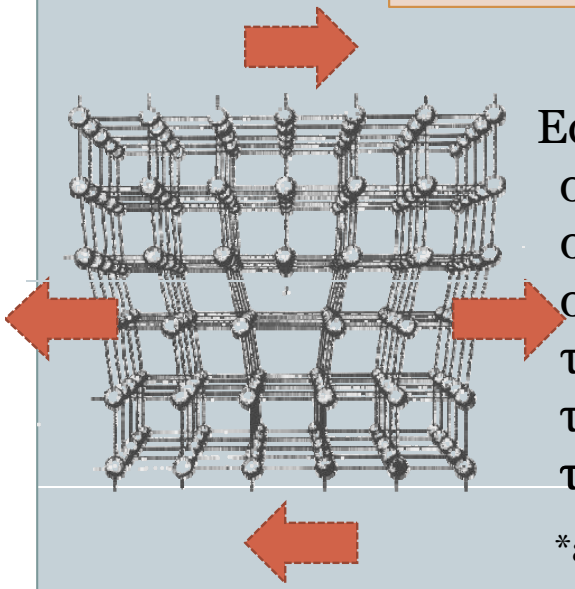
Image of stress fields around two dislocations removed due to copyright restrictions.

http://www.matter.org.uk/matscicdrom/manual/images/image109.gif

Dislocation Motion

- Peach-Koehler Equation

$$F_x = b_x\sigma_{xy} + b_y\sigma_{yy} + b_z\sigma_{zy}$$
$$F_y = -\left(b_x\sigma_{xx} + b_y\sigma_{xy} + b_z\sigma_{xz}\right)$$



Edge Dislocation

$\sigma_{xx} \longrightarrow F\downarrow$
$\sigma_{yy} \longrightarrow F=0$
$\sigma_{zz} \longrightarrow F=0$
$\tau_{xy} \longrightarrow F\rightarrow$
$\tau_{xz} \longrightarrow F=0$
$\tau_{yz} \longrightarrow F=0$

Screw Dislocation

$\sigma_{xx} \longrightarrow F=0$
$\sigma_{yy} \longrightarrow F=0$
$\sigma_{zz} \longrightarrow F=0$
$\tau_{xy} \longrightarrow F=0$
$\tau_{xz} \longrightarrow F\downarrow$
$\tau_{yz} \longrightarrow F\rightarrow$

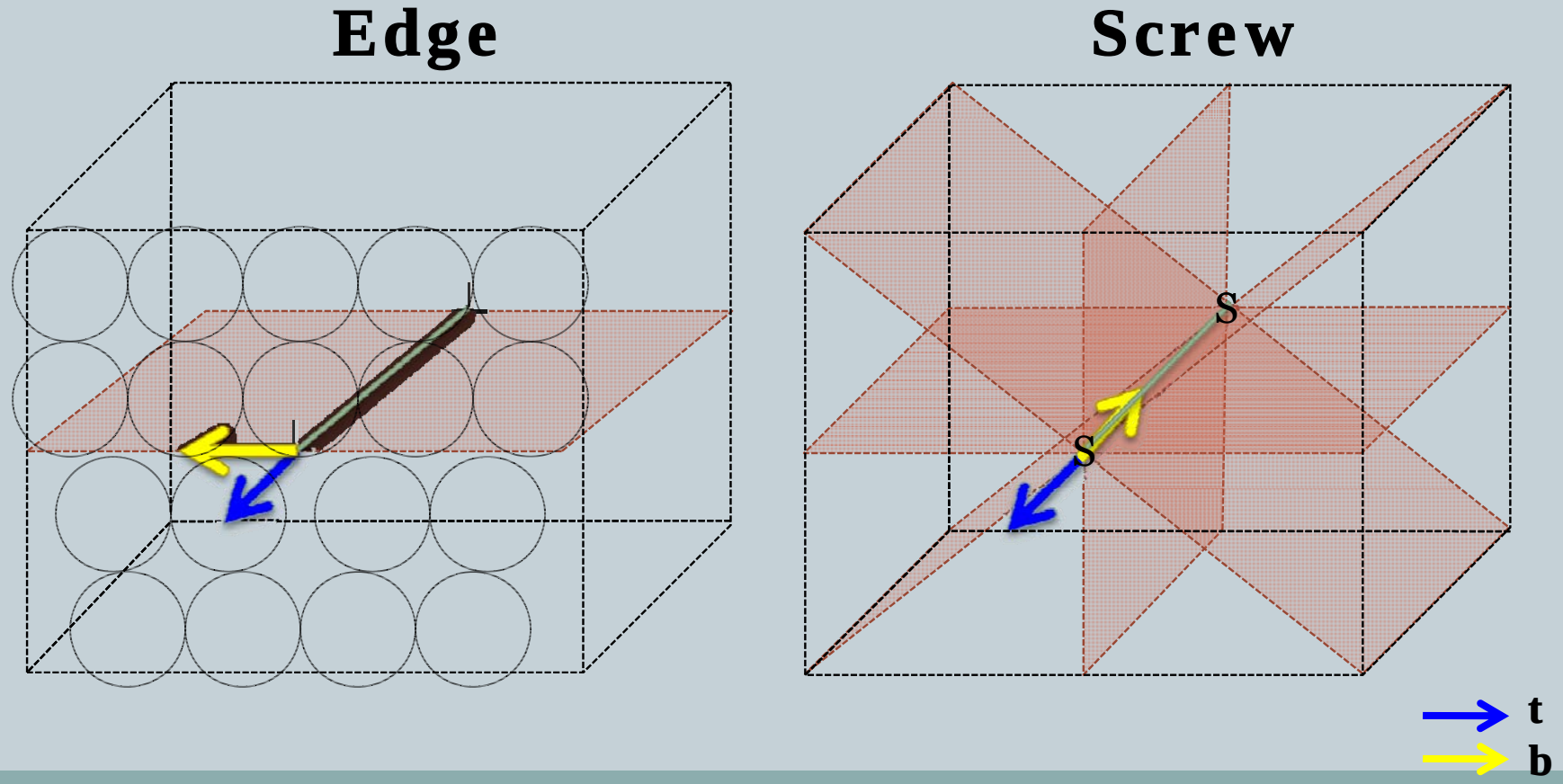
*assumes pos Edge, RH Screw

Image removed due to copyright restrictions. Please see the cover of *Nature Physics* 5 (April 2009).

http://www.tf.uni-kiel.de/matwis/amat/def_en/kap_5/illustr/dislocation_3dim.jpg

Dislocation Motion

- Dislocation moves along plane containing **b, t**



3.40J / 22.71J / 3.14 Physical Metallurgy

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