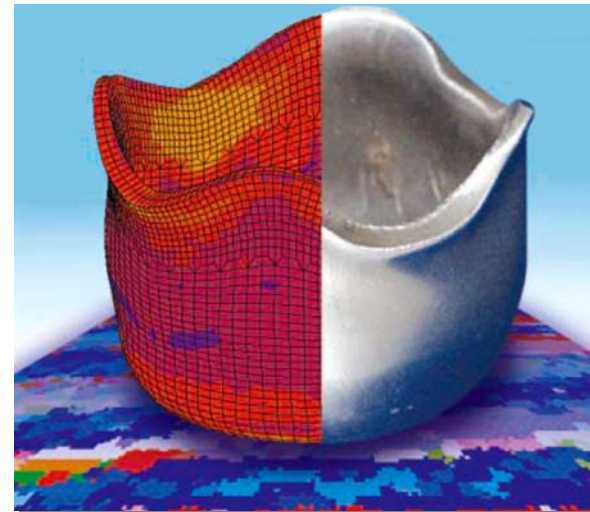
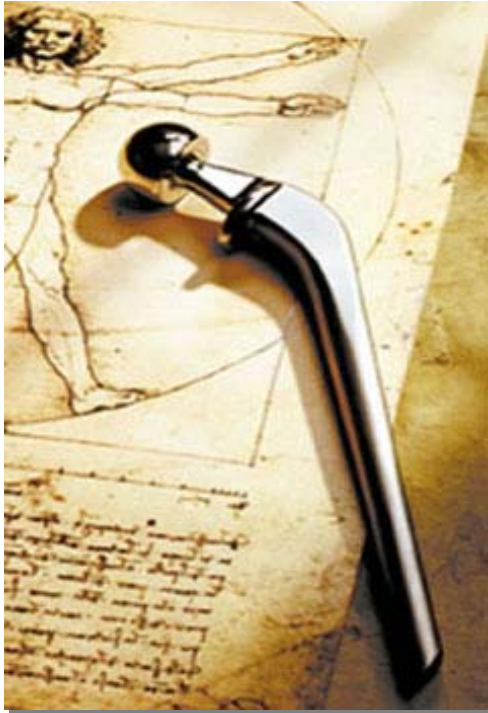


# Class 2007

lecture notes, spring 2007  
Prof. Dr. Dierk Raabe  
*Max-Planck-Institut  
Düsseldorf*



# homework ?

- next Friday:
- class at 9 a.m. at the MPI in Düsseldorf
- see directions on [www.mpie.de](http://www.mpie.de)

# Dislocation Dynamics

## **dislocations**

- **Discrete Dislocation Dynamics**
- **Statistical Dislocation Dynamics**

# •Discrete Dislocation Dynamics

## Basics (2D, Mode 1)

**Force**  $\vec{F}_a = \left( \underline{\underline{\sigma}}^{\text{alle} \rightarrow a} \vec{b}_a \right) \times \vec{t}_a$

**Motion**  $\vec{F} = m \ddot{x} + B\dot{x} \approx B\dot{x}$

$$\sum F = 0$$

$$F_{disloc} + F_{self\ force} + F_{extem} + F_{them} + F_{viscous} + F_{obstacle} + F_{Peierls} + F_{osmotic} + F_{image} + F_{inertia}$$

$F_{disloc}$

**elastic - foreign**

$F_{self\ force}$

**elastic - self**

$F_{extern}$

**external**

$F_{them}$

**Stochastic Langevin**

$F_{viscous}$

**viscous drag**

$F_{obstacle}$

**obstacle**

$F_{Peierls}$

**Peierls**

$F_{osmotic}$

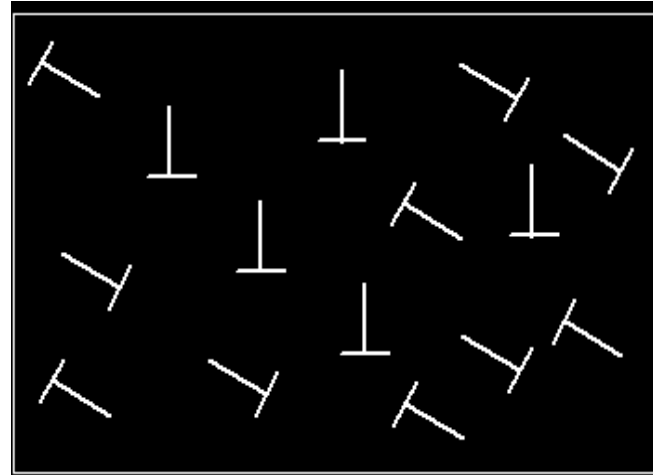
**chemical forces**

$F_{image}$

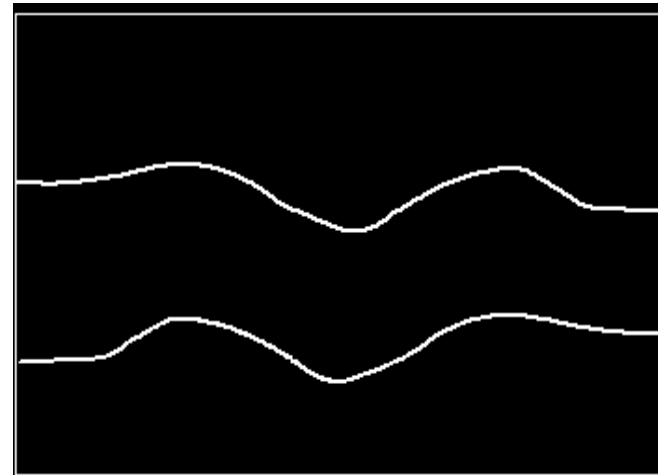
**surface forces**

# Discrete Dislocation Dynamics

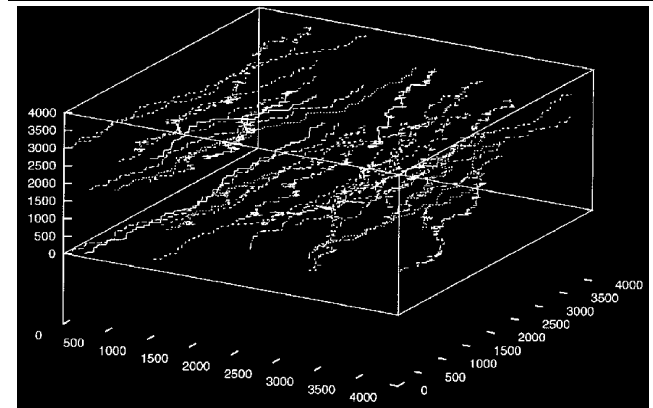
2D - Mode 1



2D - Mode 2



3D





# Mode 2 - Example: edge dislocation

$$\sigma_{xz} = \sigma_{zx} = \sigma_{yz} = \sigma_{zy} = 0$$

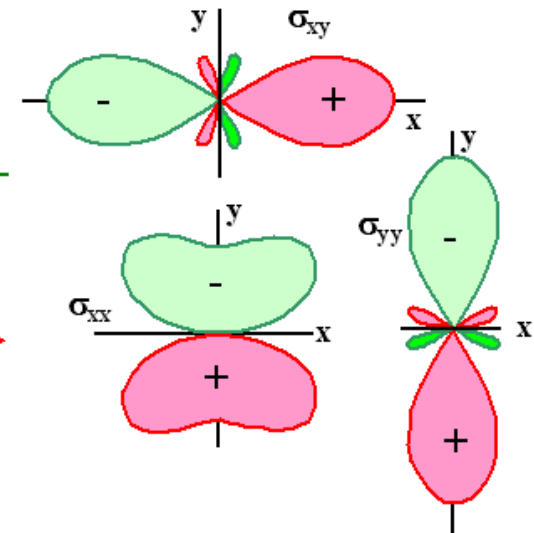
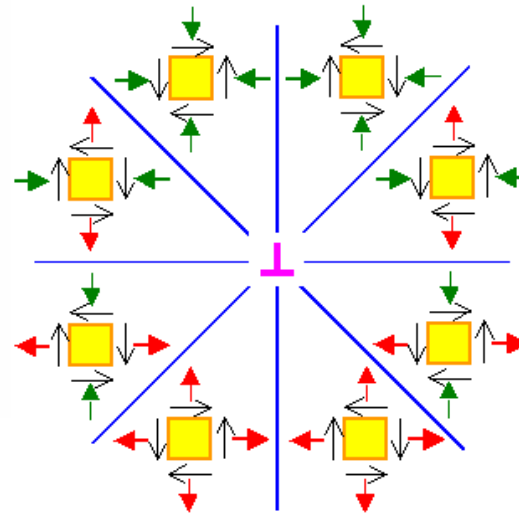
$$\sigma_{xx} = -Dy \frac{3x^2 + y^2}{(x^2 + y^2)^2}, \quad \text{with: } D = \frac{Gb}{2\pi(1-\nu)}$$

$$\sigma_{yy} = Dy \frac{x^2 - y^2}{(x^2 + y^2)^2}$$

$$\sigma_{xy} = \sigma_{yx} = Dx \frac{x^2 - y^2}{(x^2 + y^2)^2}$$

$$\sigma_{zz} = \nu(\sigma_{xx} + \sigma_{yy})$$

1



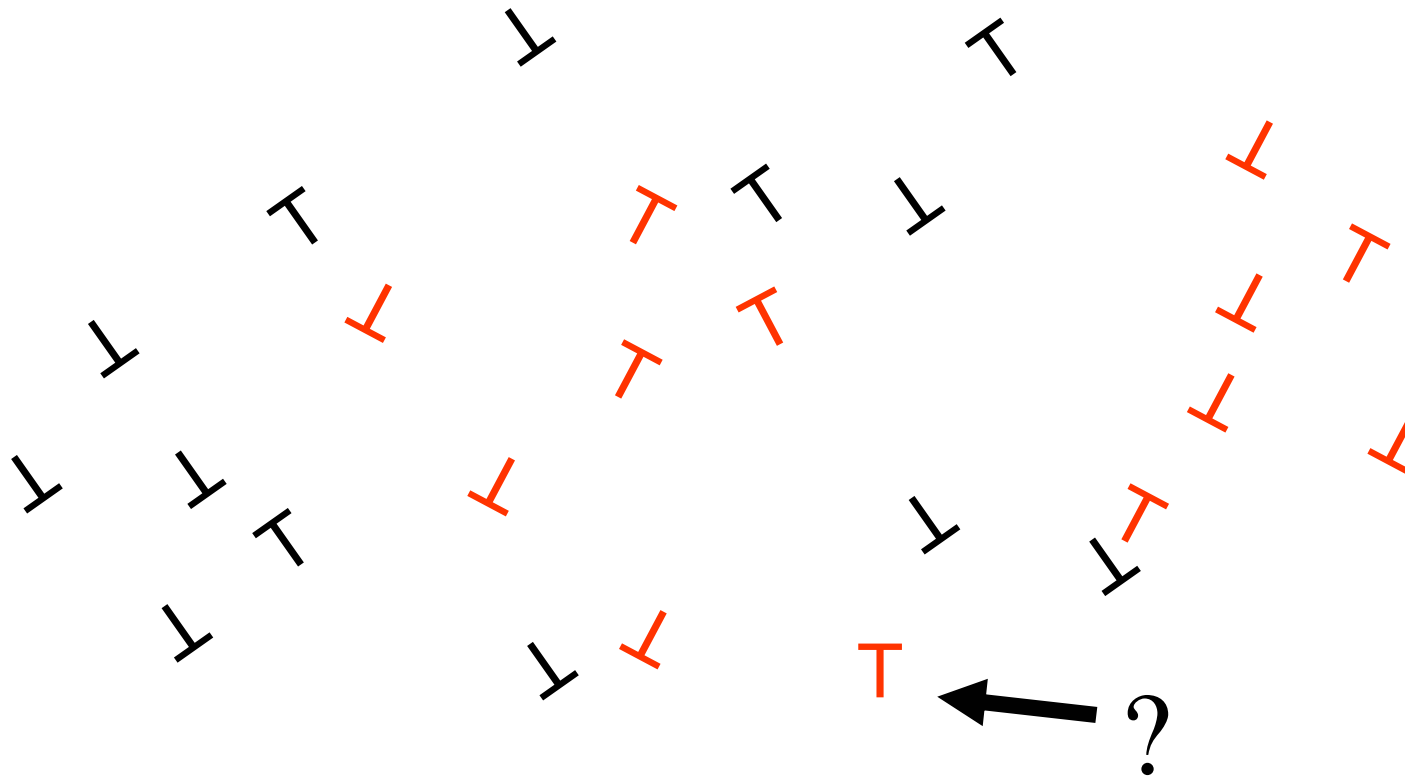
2

$$\vec{F}_a = \left( \underline{\underline{\sigma}}^{\text{all} \rightarrow a} \vec{b}_a \right) \times \vec{t}_a$$

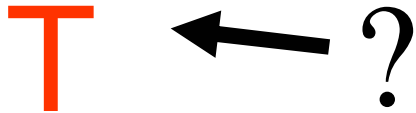
3

$$\vec{F} = B\dot{\vec{x}}$$

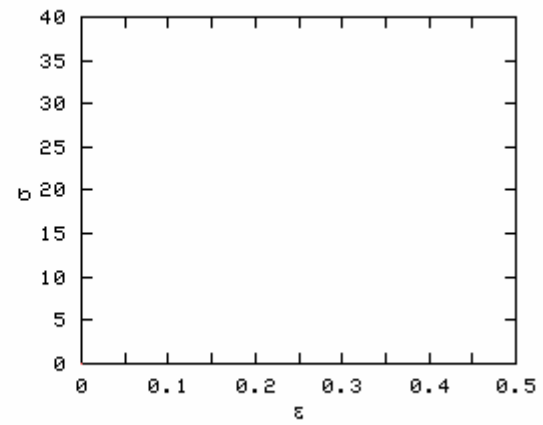
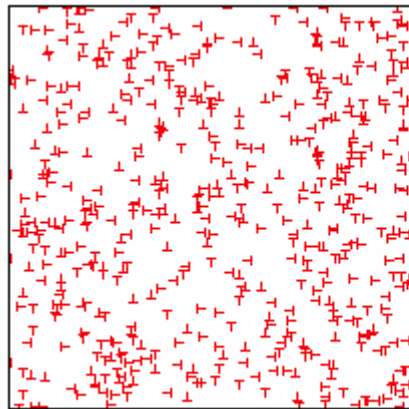
## Mode 2 - Example: edge dislocation



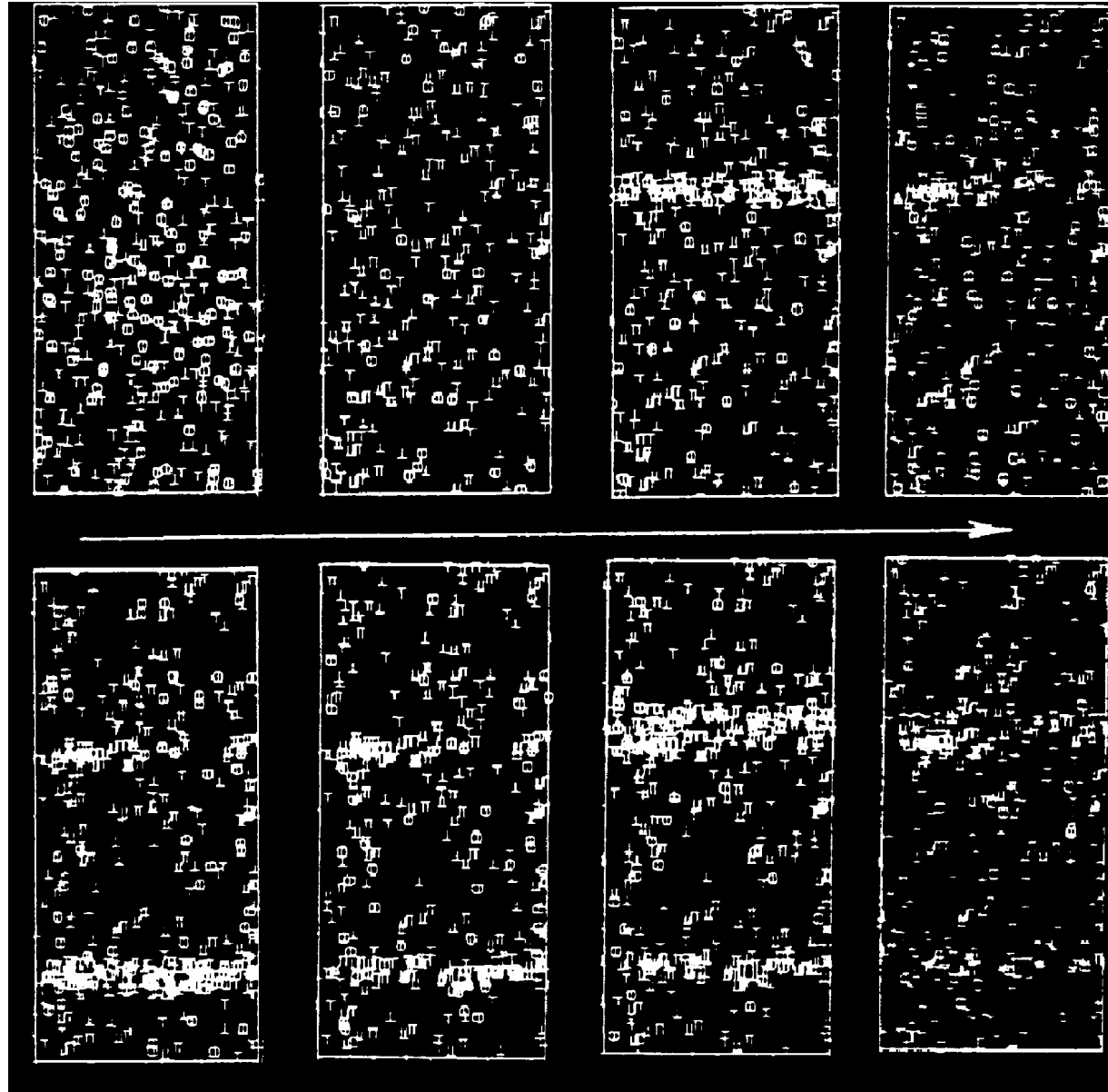
## Mode 2 - Example: edge dislocation

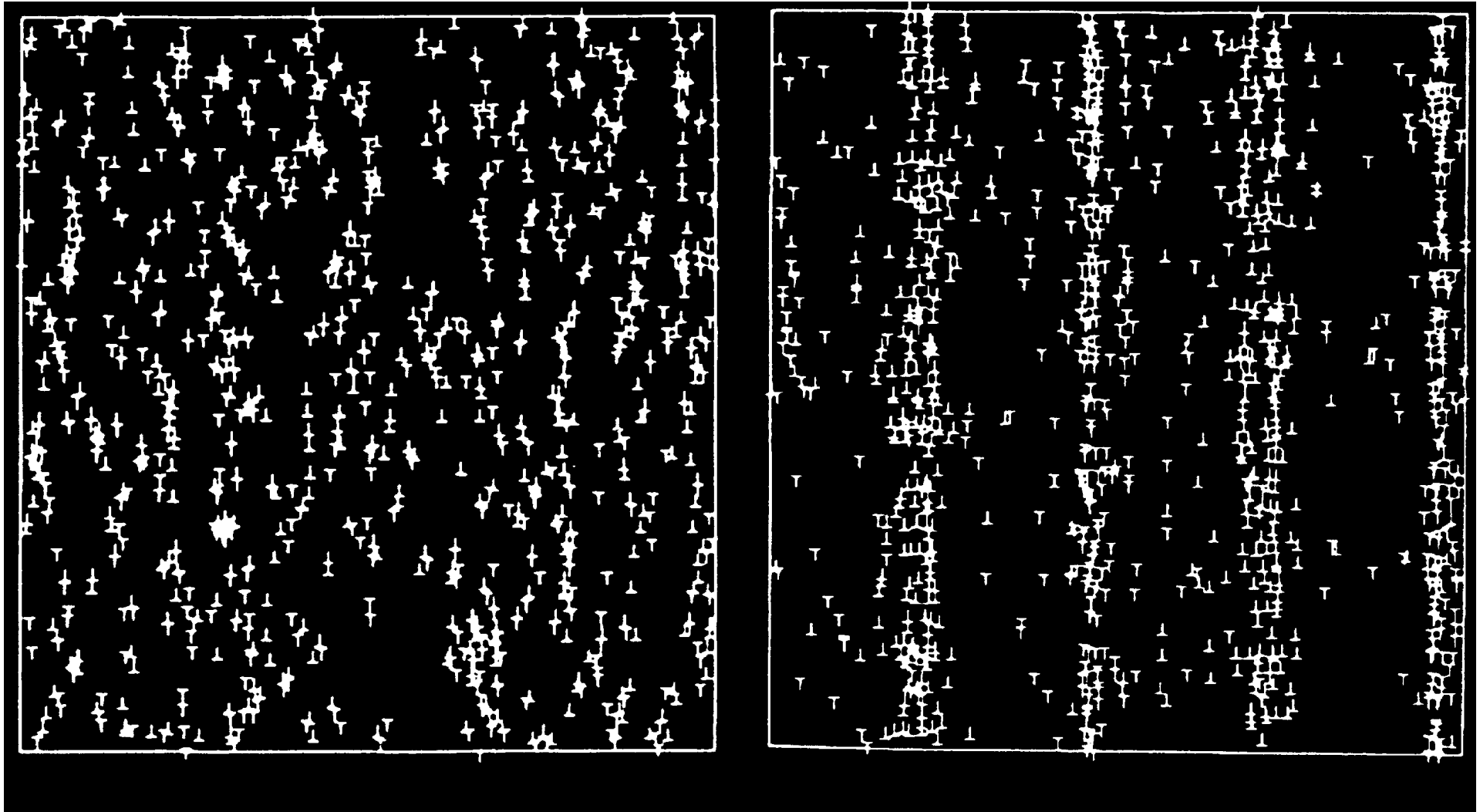


- 1) calculate stress field of machine and of all other dislocations at position of **T**
- 2) Use Peach-Koehler equation to get force on dislocation
- 3) integrate with very small time step (explicit) viscous eq. of motion

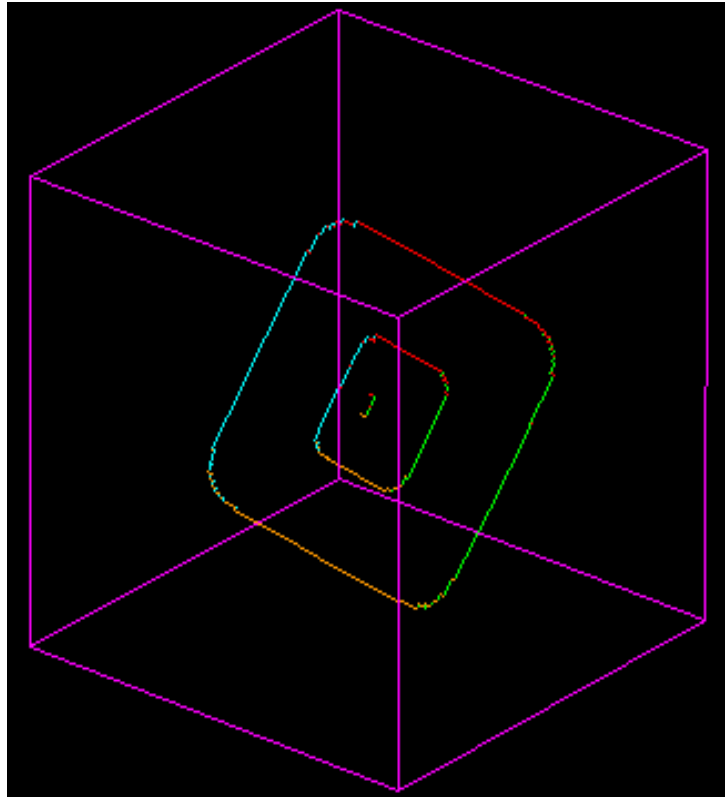


# 2D - Mode 1



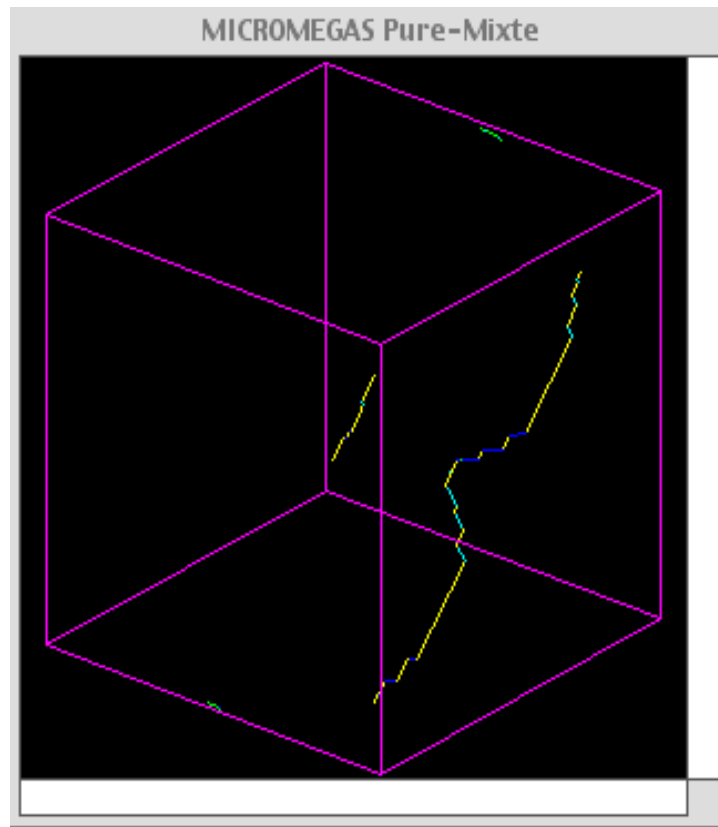


## dislocations



## dislocations

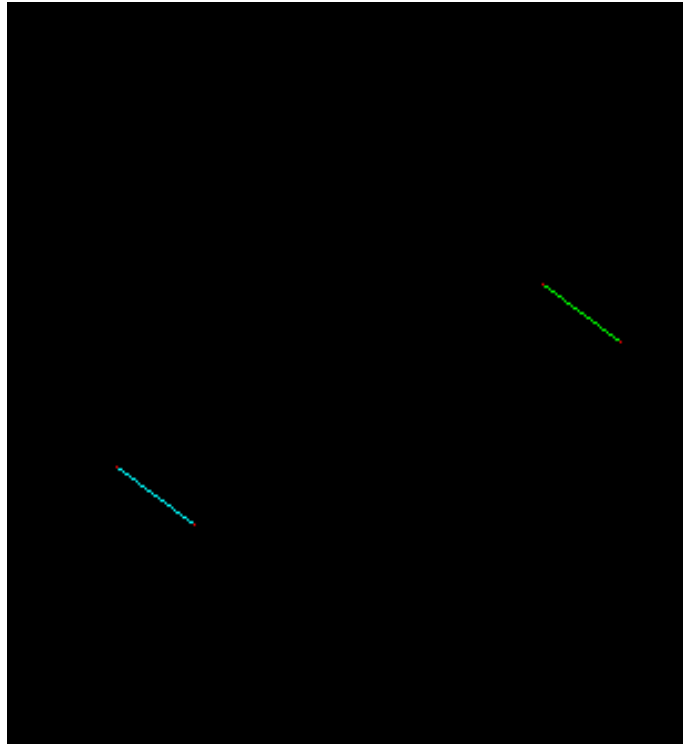
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## dislocations

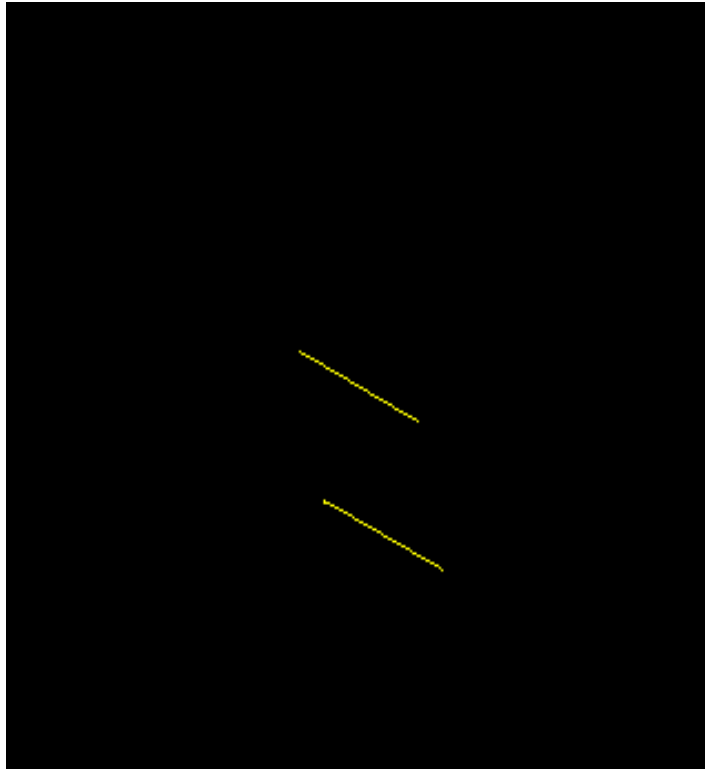
micromechanics class notes, Prof. D. Raabe, Max-Planck-Institut für Eisenforschung





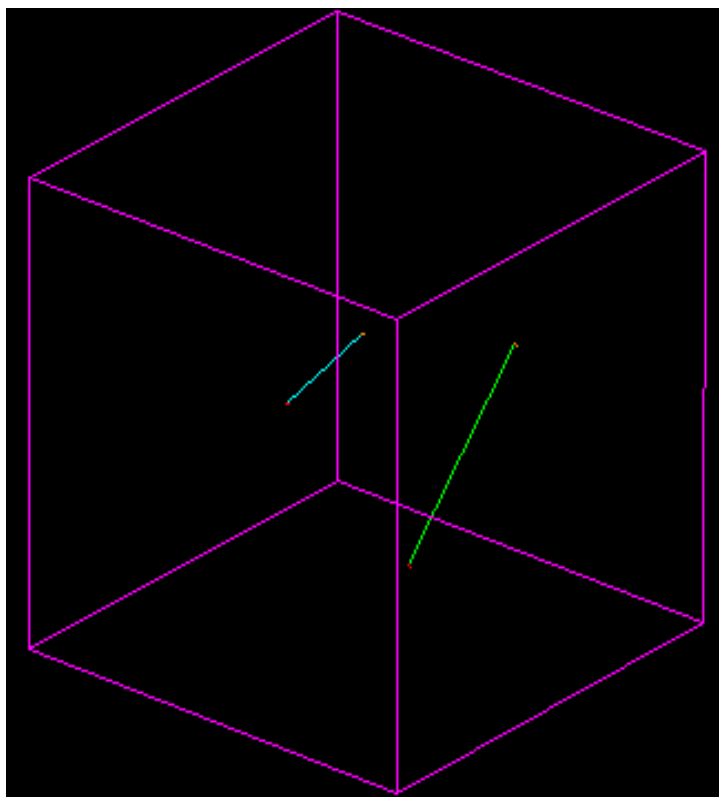
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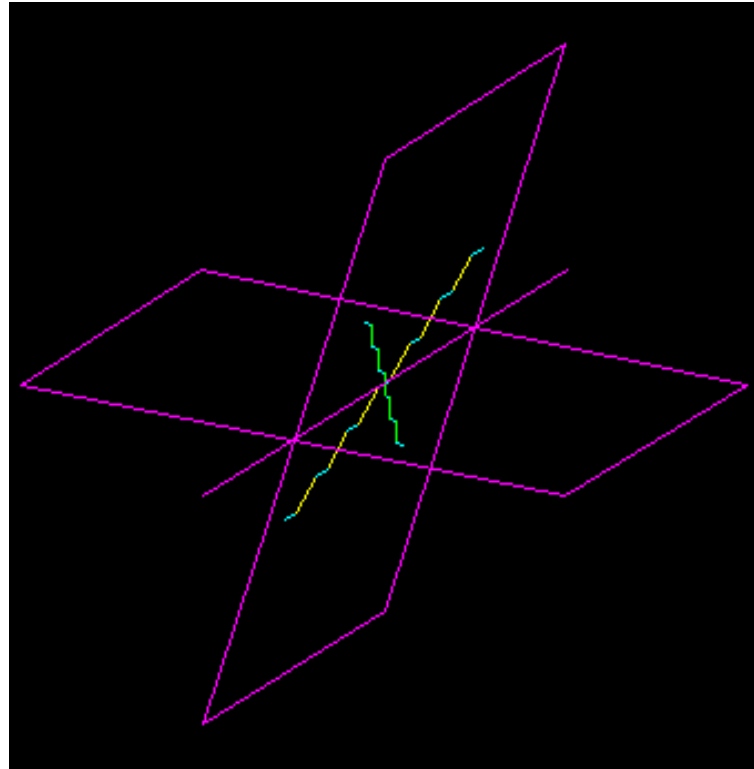
## dislocations

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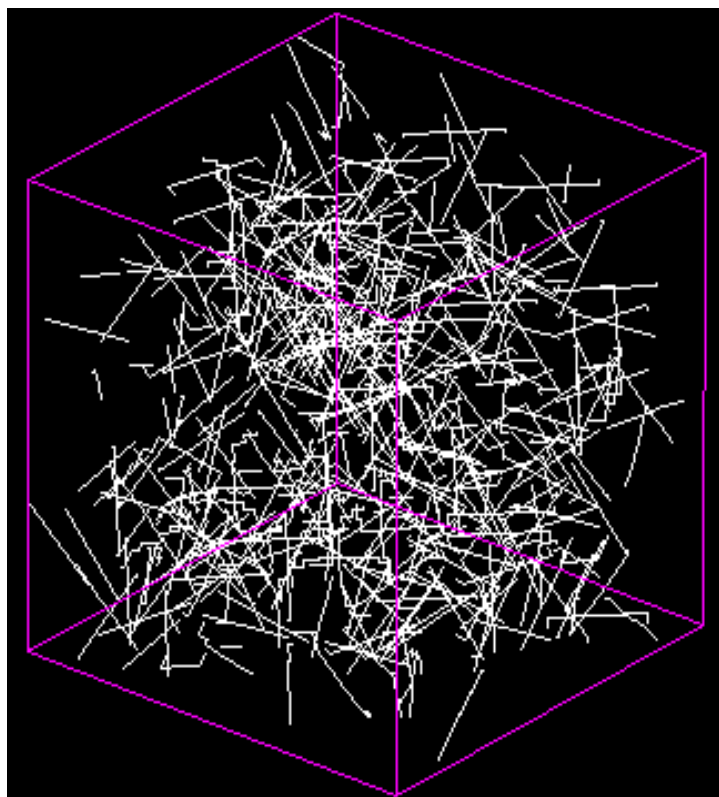
## dislocations

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## dislocations

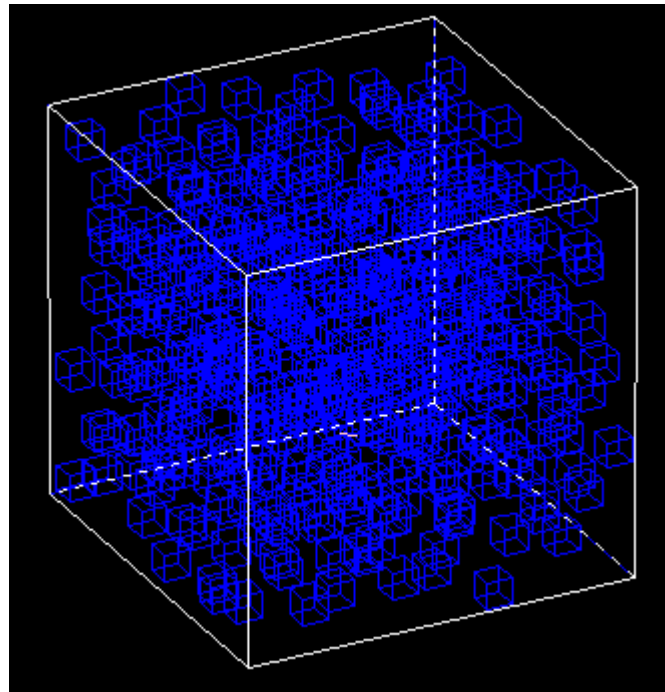
micromechanics class notes, Prof. D. Raabe, Max-Planck-Institut für Eisenforschung

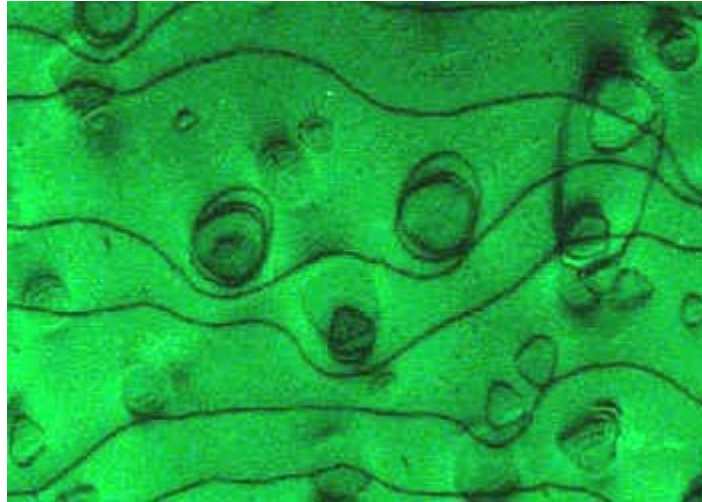


## dislocations

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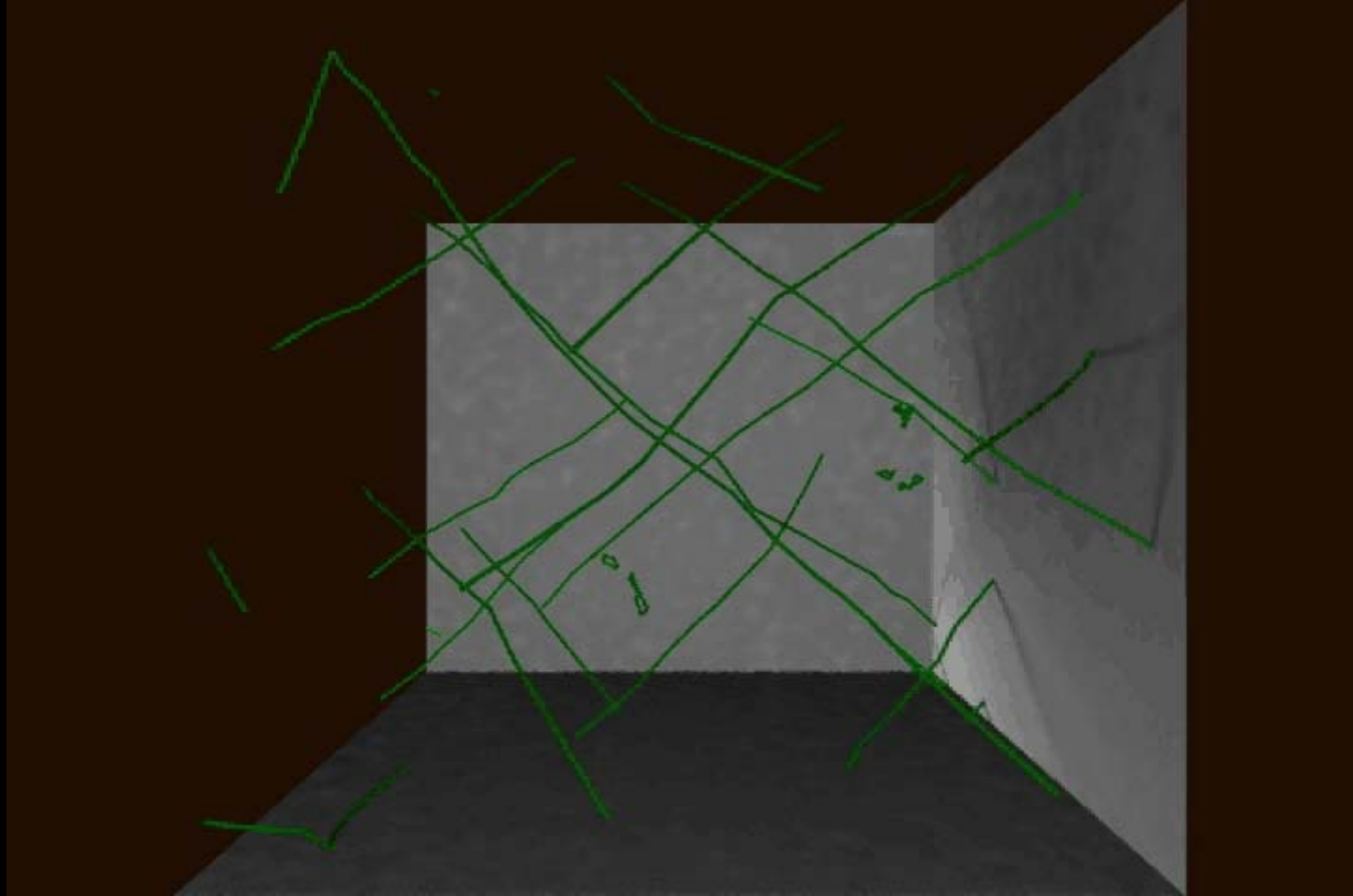










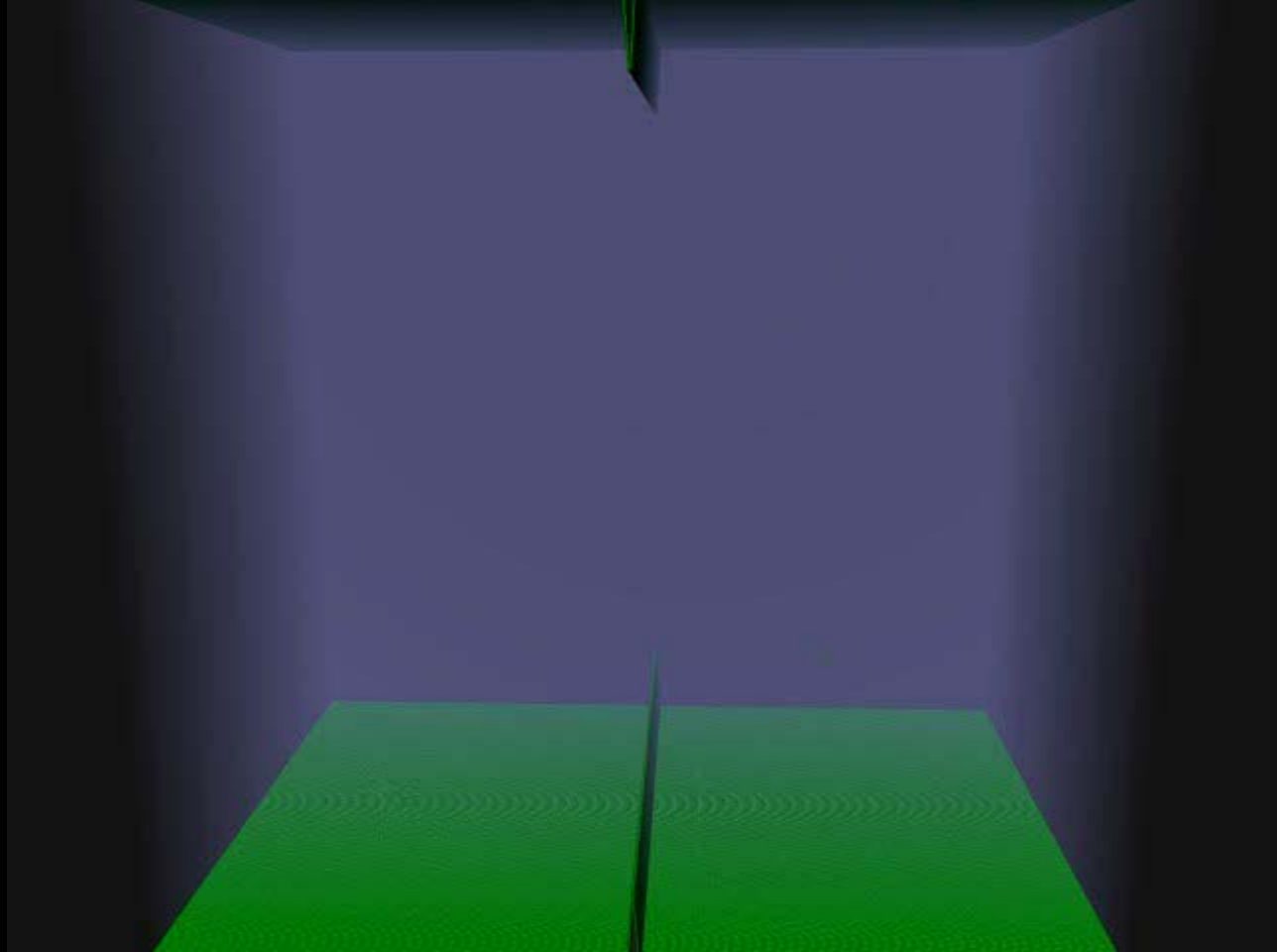


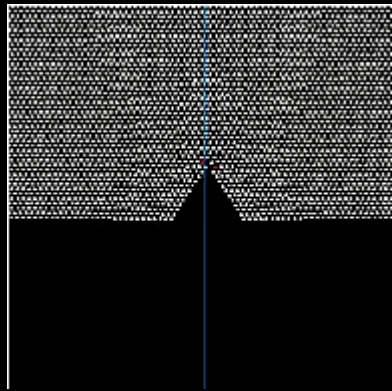
# Simulation alternative:

- direct atomistic dynamics (molecular dynamics)

$$F = -\frac{dU}{dx}$$

$$F = m \frac{d\dot{x}}{dt}$$





0.2

[REDACTED]

[REDACTED]

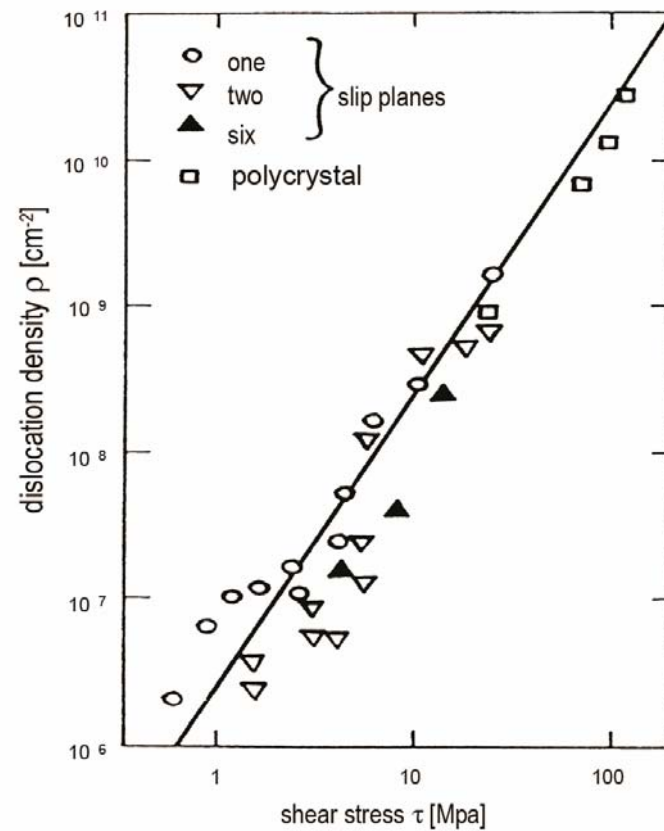
# •Statistical Dislocation Dynamics

# **WHY Statistical Dislocation Dynamics ?**



- kinetic equation of state
- structure evolution
- coupling to continuum kinematics

- kinetic equation of state



$$\tau = \alpha G b \sqrt{\rho}$$

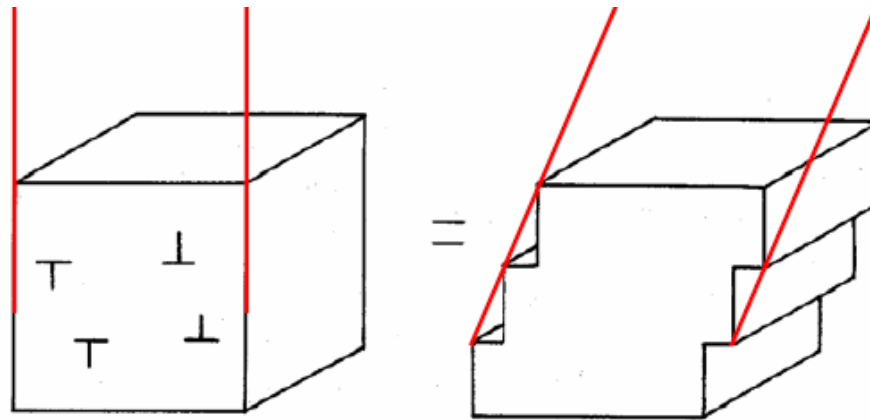
T	L	T	L
L	T	L	T
T	L	T	L
L	T	L	T

The table above contains blue 'T' and 'L' characters in a 4x4 grid. The top-left cell (row 1, column 1) is circled in red. In the second row, third column, there are two lowercase 'a' characters: one to the right of the 'L' and one below it.

- structure evolution

$$\frac{d\rho}{d\gamma} = A\rho^+ + B\rho^-$$

- coupling to continuum kinematics



$$\dot{\gamma} = \frac{d\gamma}{dt} = n \frac{dx}{X} \frac{b}{Z} \frac{1}{dt} = \rho_m b v$$