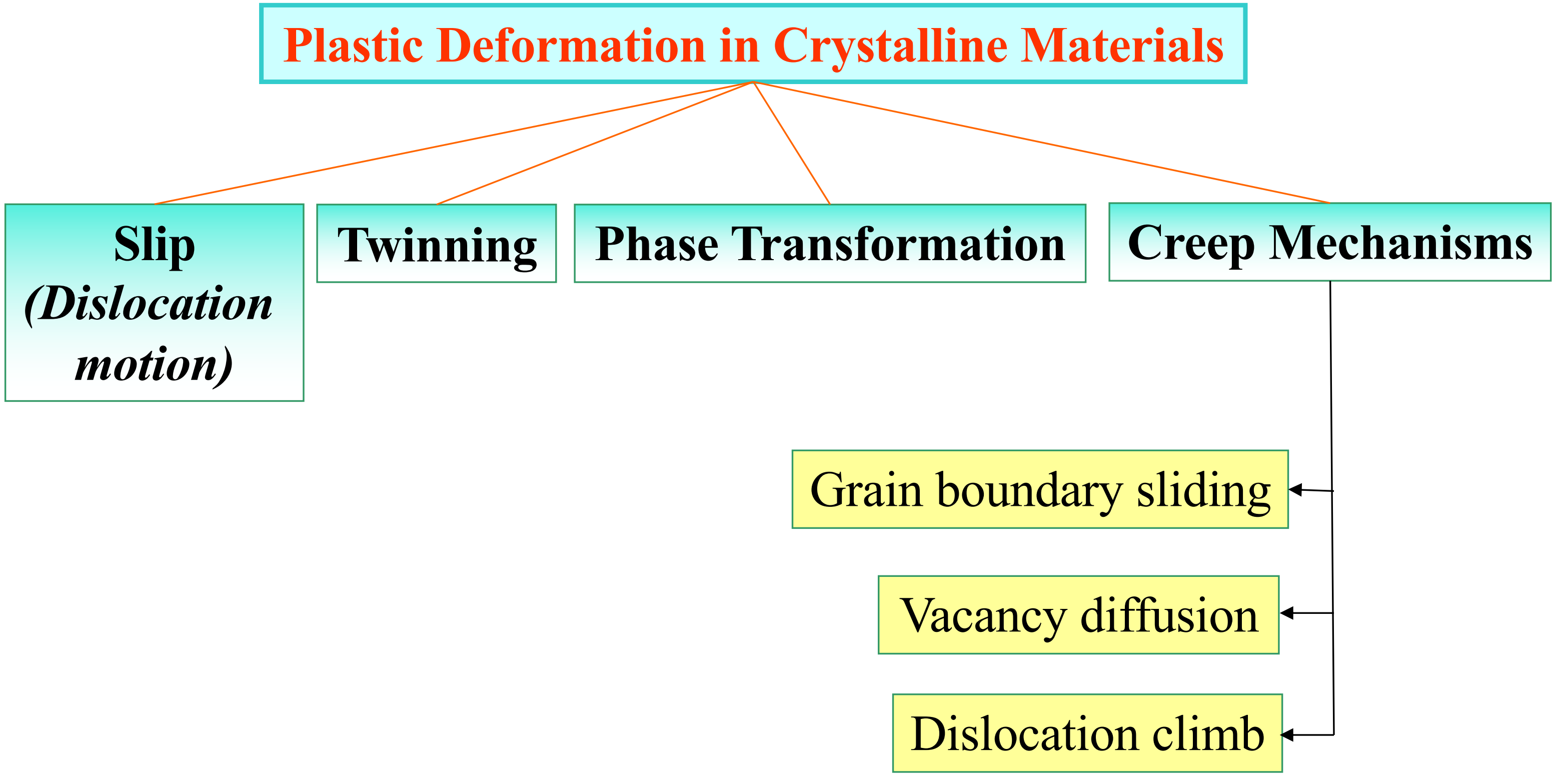
1D defects

DISLOCATIONS

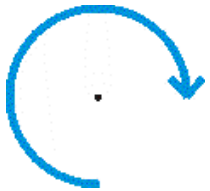
Generic term, but associated to 1D in material science

- Edge dislocation
- Screw dislocation


Plastic Deformation in Crystalline Materials
Slip (Dislocation motion)
Twinning
Phase Transformation
Creep Mechanisms
Grain boundary sliding
Vacancy diffusion
Dislocation climb

DISLOCATIONS

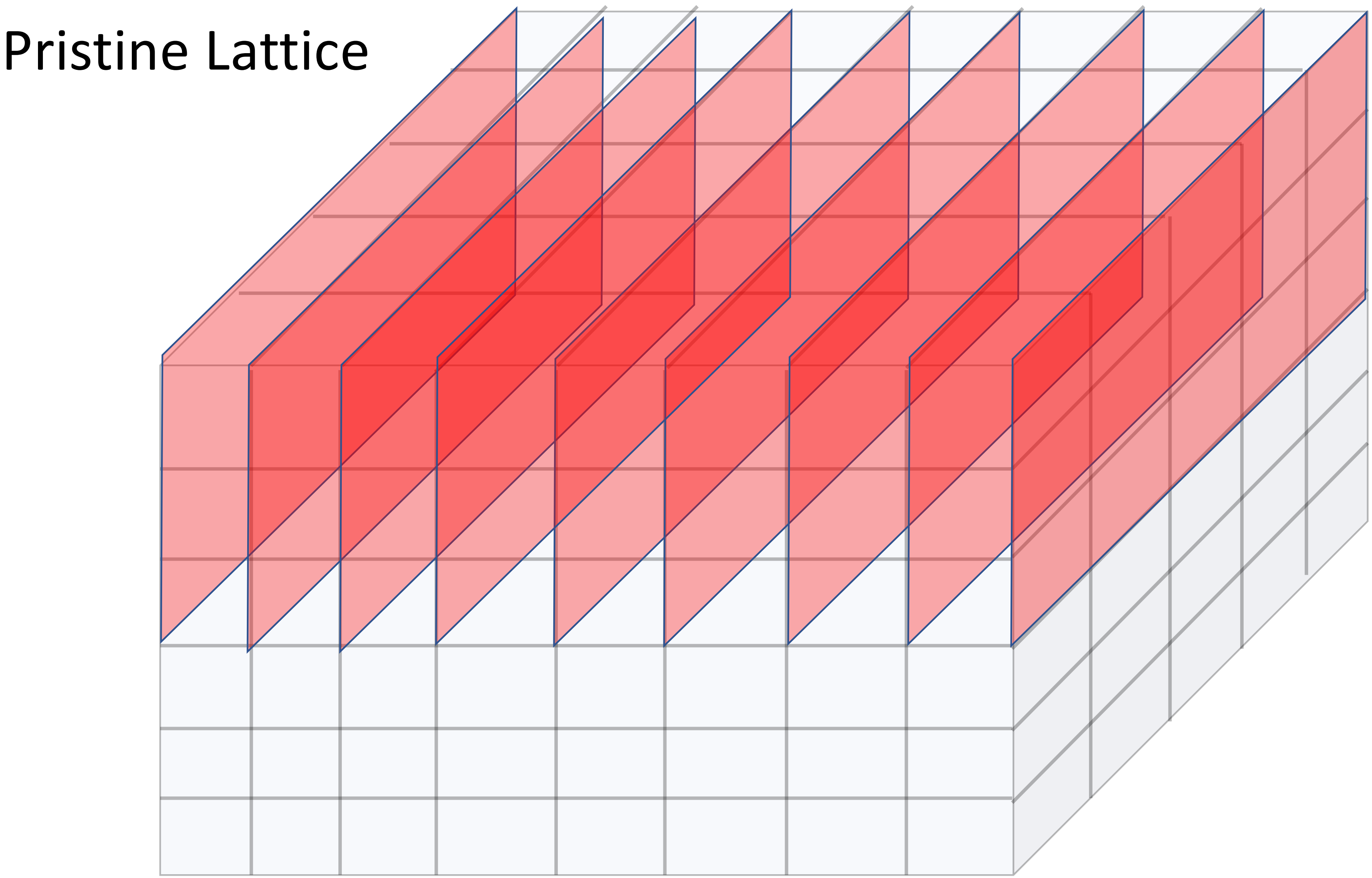
- **EDGE**
- **MIXED**
- **SCREW**



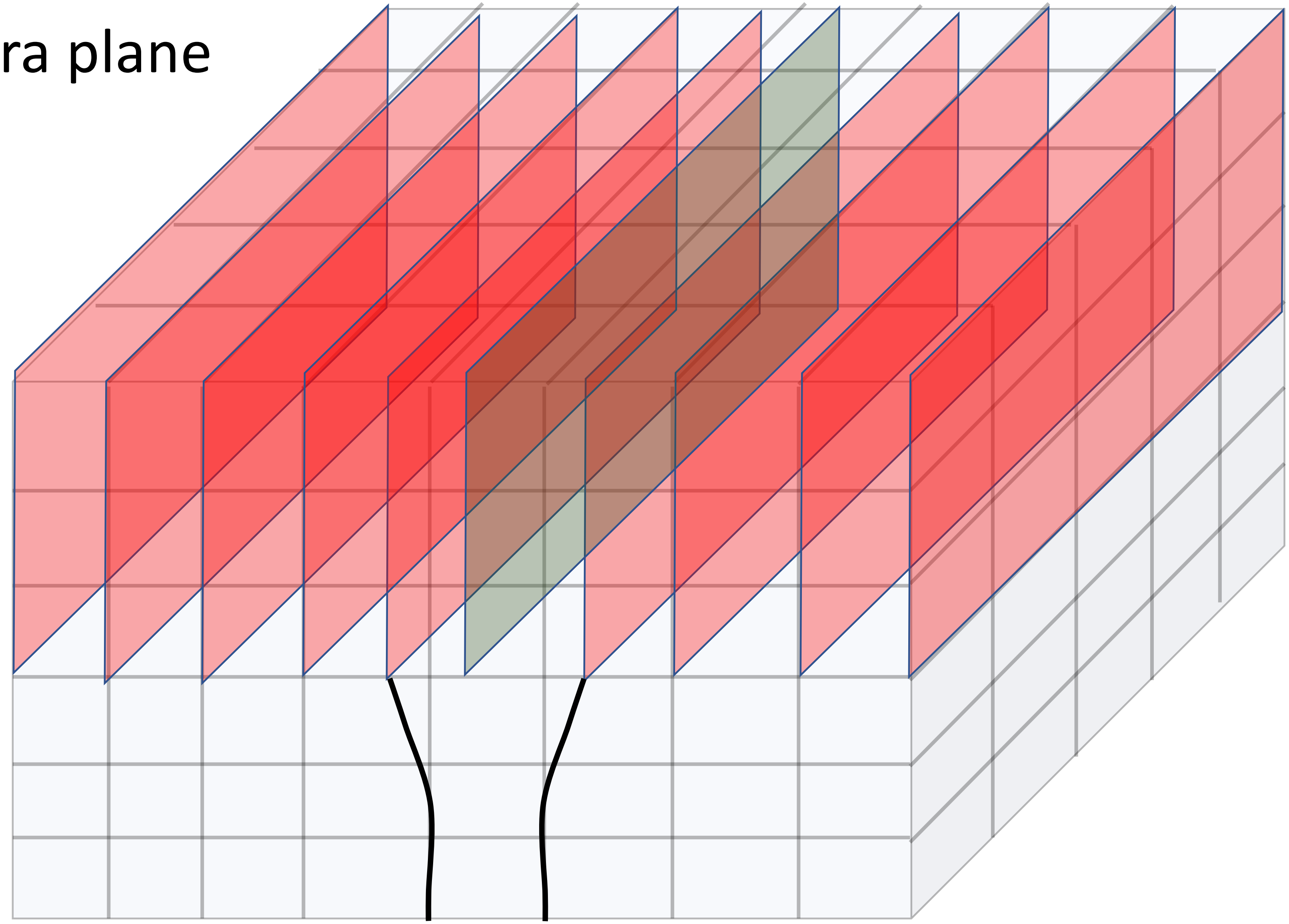
❑ Usually dislocations have a mixed character and *Edge* and *Screw* dislocations are the ideal extremes

DISLOCATIONS

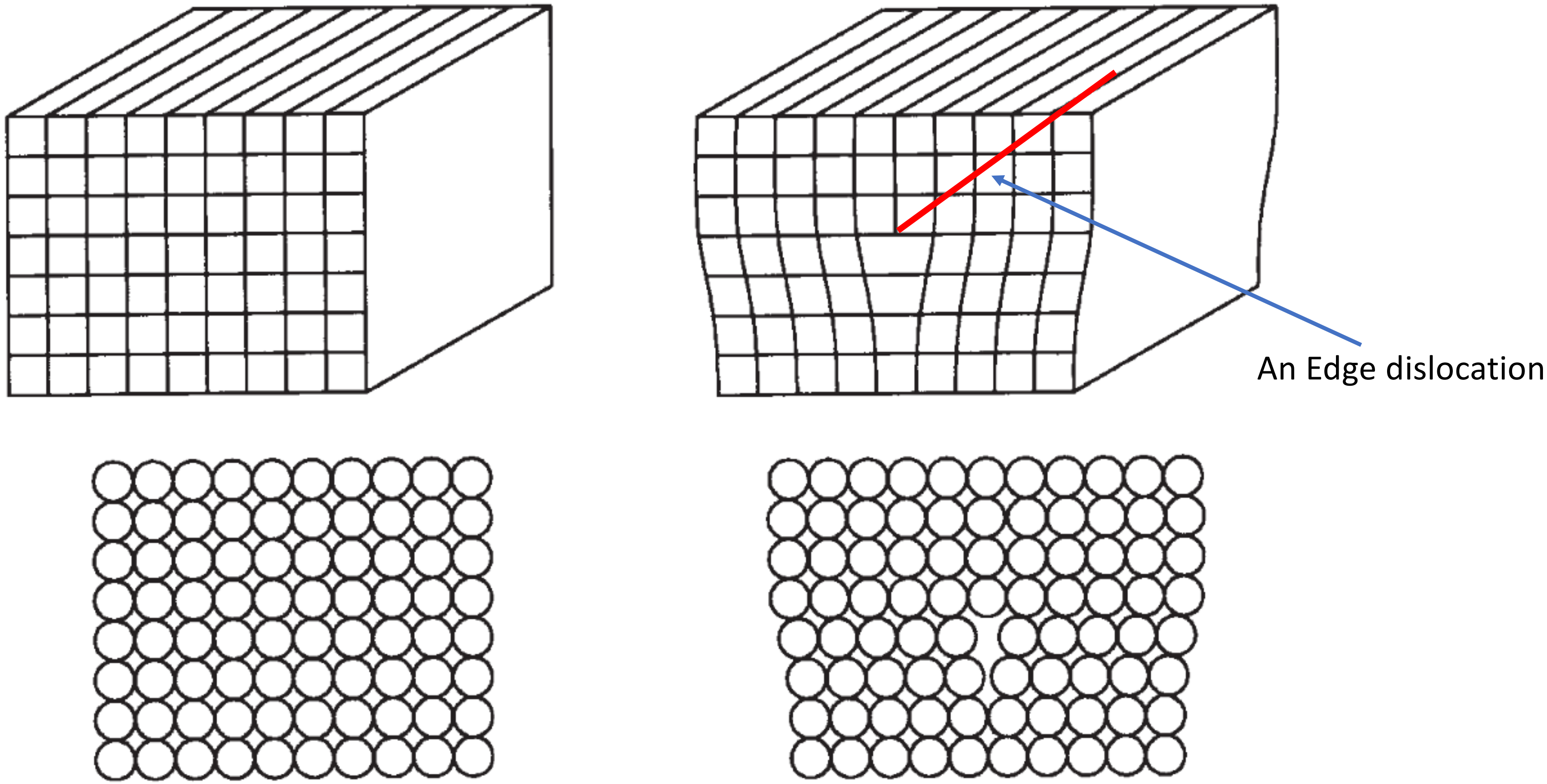
- Random
- Structural
  - Geometrically necessary dislocations


Pristine Lattice

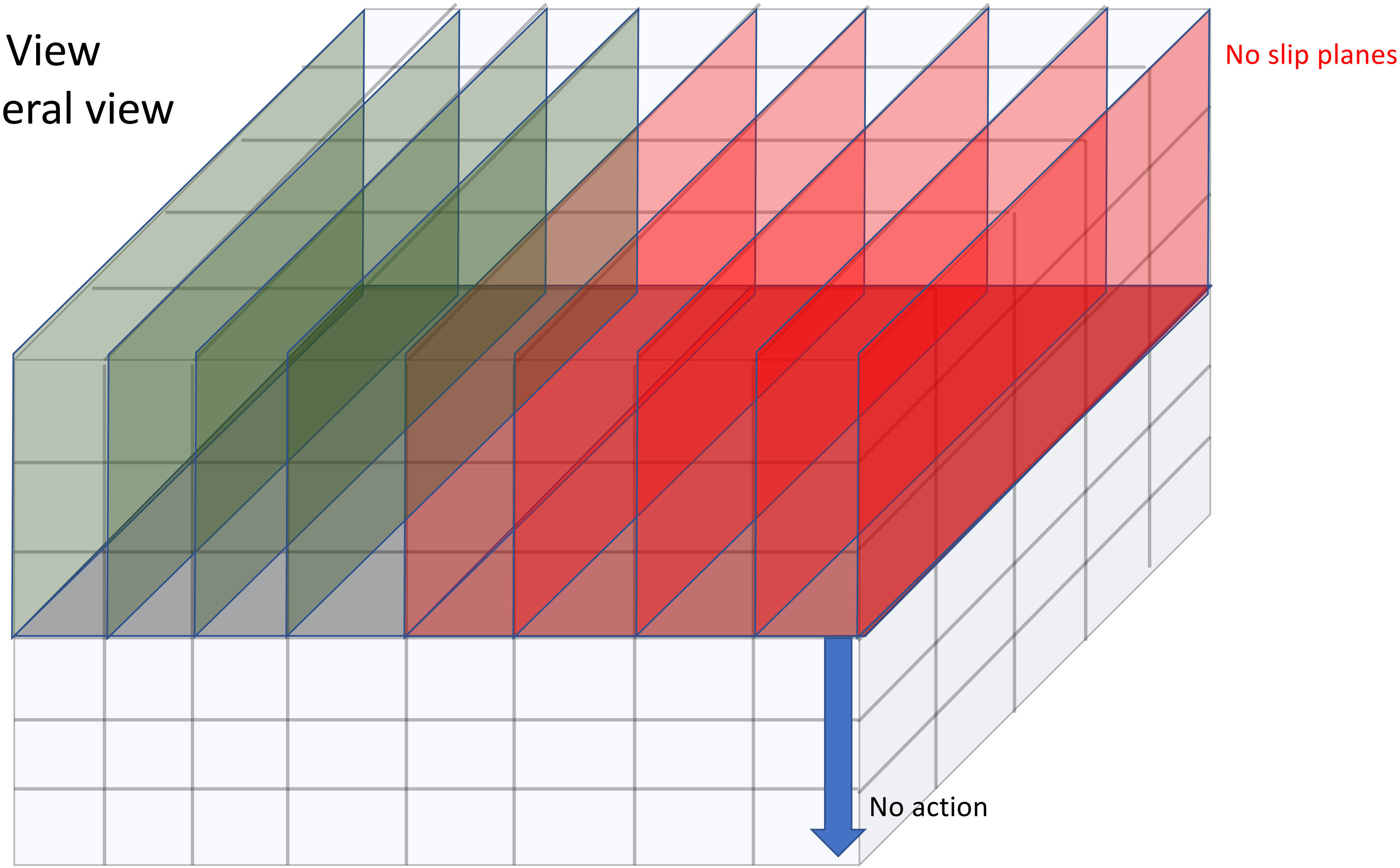
One extra plane

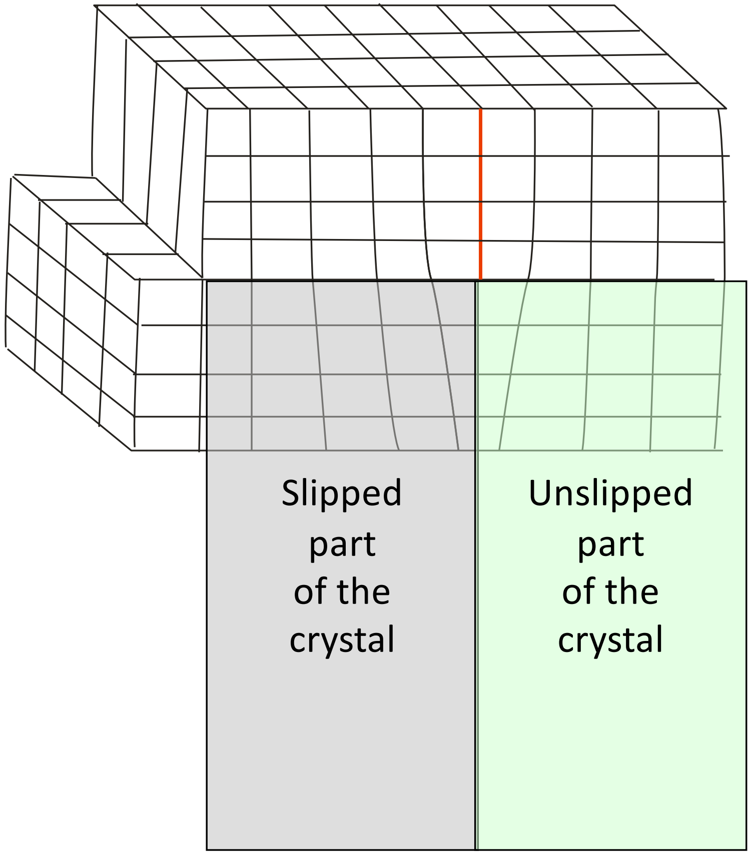


An incomplete plane



Alternate View
More general view





Dislocation is a boundary between the slipped and the unslipped parts of the crystal lying over a slip plane

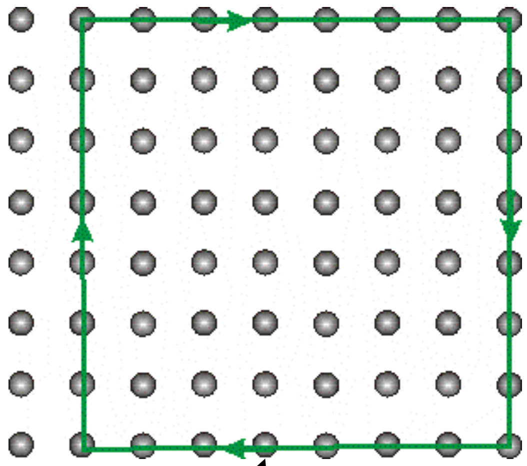
A dislocation has associated with it two vectors:

$\vec{t} \rightarrow$ A unit tangent vector along the dislocation line

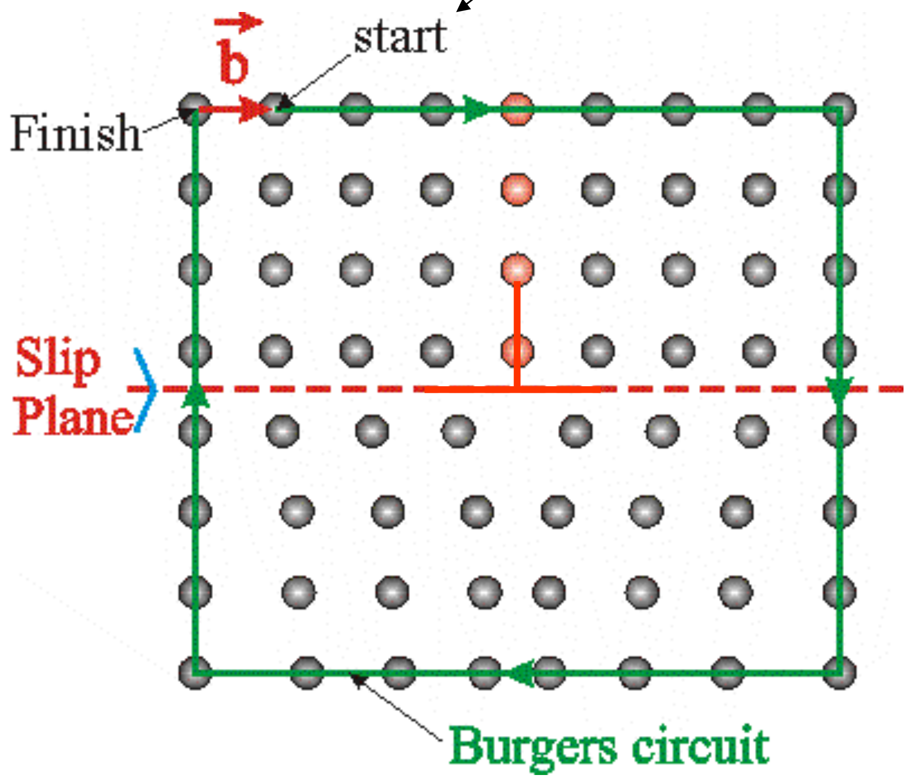
$\vec{b} \rightarrow$ The Burgers vector

Burgers Vector

Edge dislocation



Perfect crystal

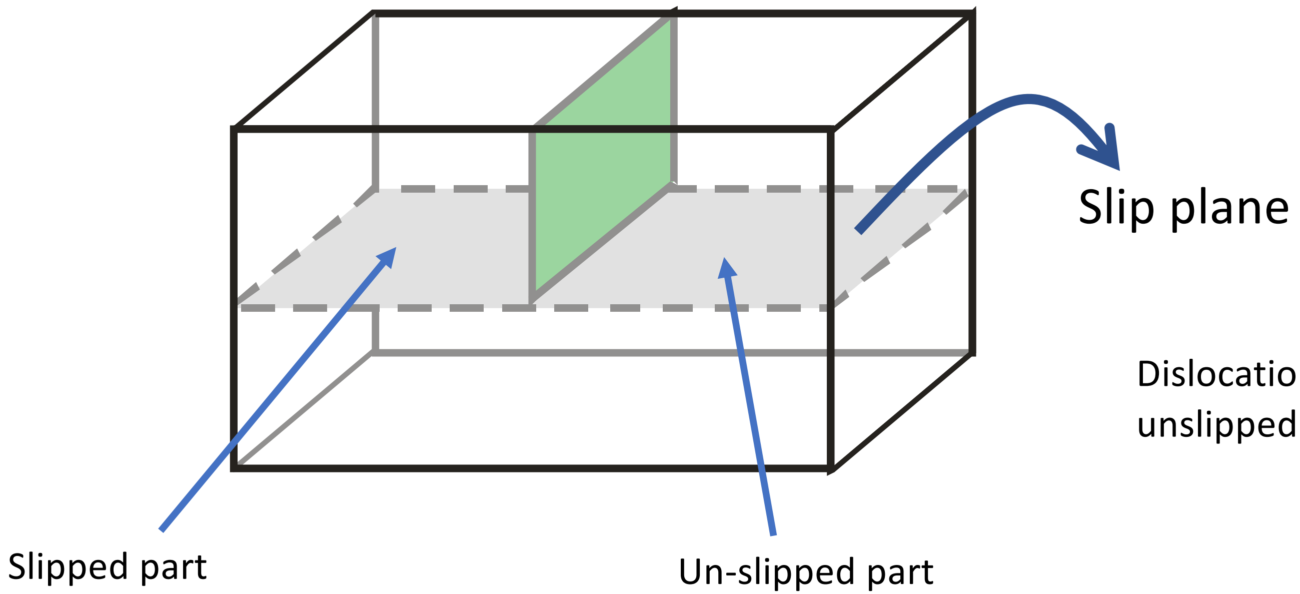


Crystal with edge dislocation

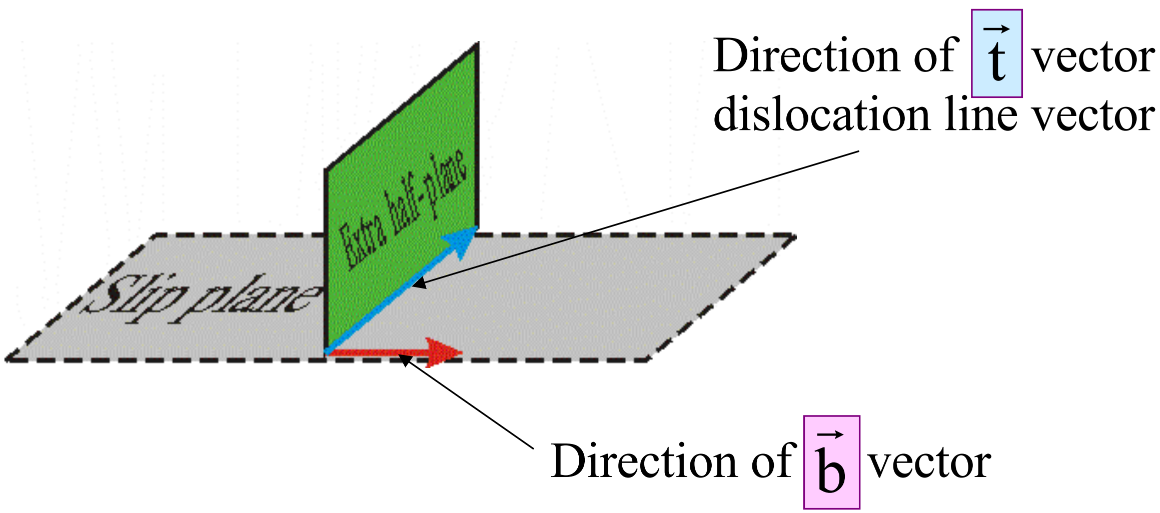
RHFS:
Right Hand Finish to Start convention

Edge dislocation

Terminology



Dislocation is the boundary between slipped and unslipped part

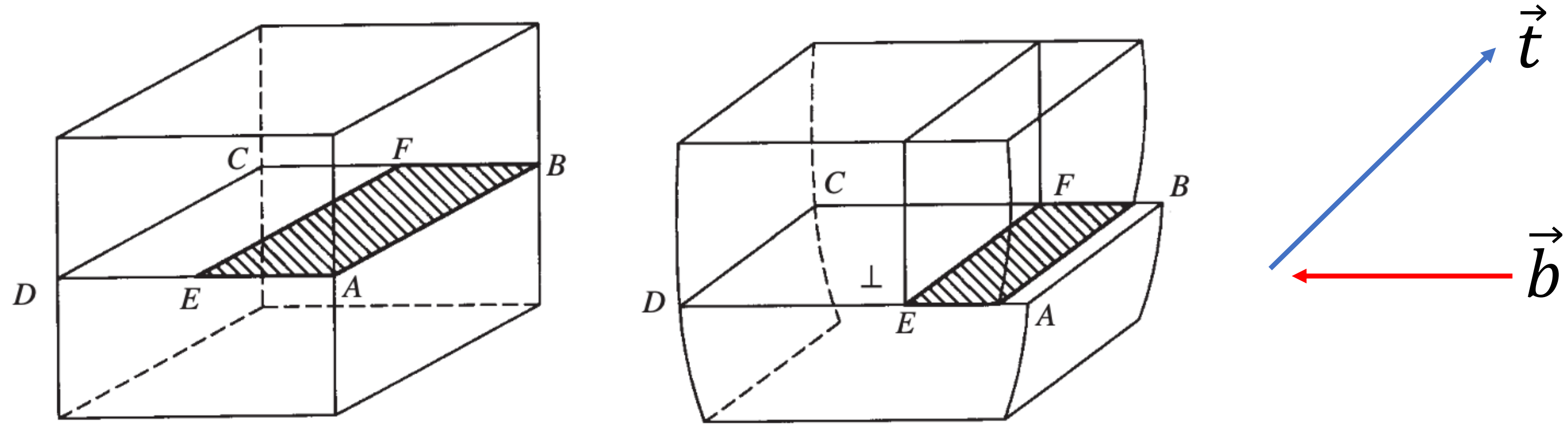


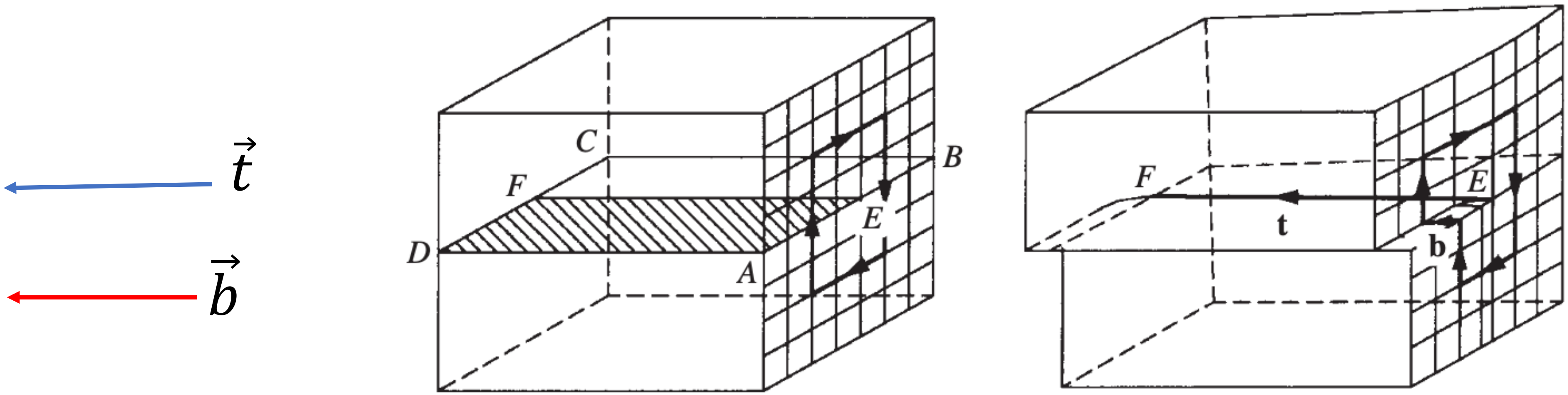
Dislocation Properties

- Dislocation is a boundary between the slipped and the unslipped parts of the crystal lying over a slip plane
- The intersection of the extra half-plane of atoms with the slip plane defines the dislocation line *(for an edge dislocation)*
- Direction and magnitude of slip is characterized by the Burgers vector of the dislocation
  The Burgers vector is determined by the Burgers Circuit
- Right hand screw (finish to start) convention is used for determining the direction of the Burgers vector
- As the periodic force field of a crystal requires that atoms must move from one equilibrium position to another $\Rightarrow$ **b** must connect one lattice position to another *(for a full dislocation)*
- Dislocations tend to have as small a Burgers vector as possible

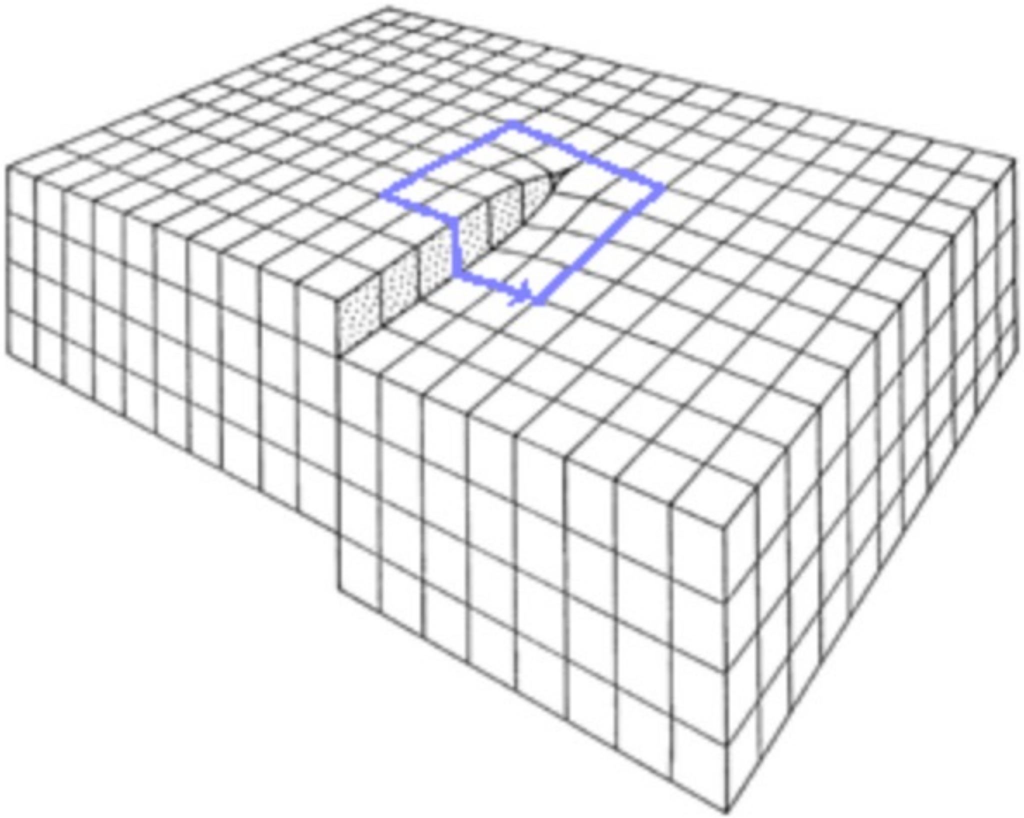
- The edge dislocation has compressive stress field above and tensile stress field below the slip plane
- Dislocations are non-equilibrium defects and would leave the crystal if given an opportunity

Edge and Screw Dislocation



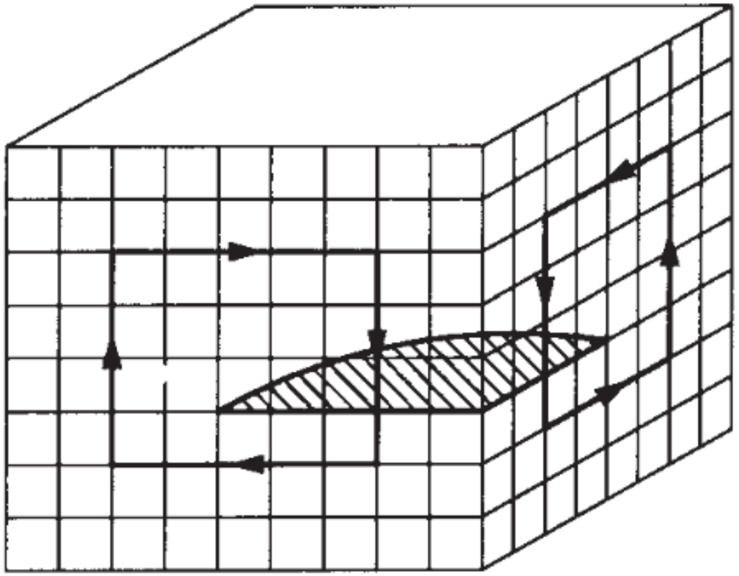


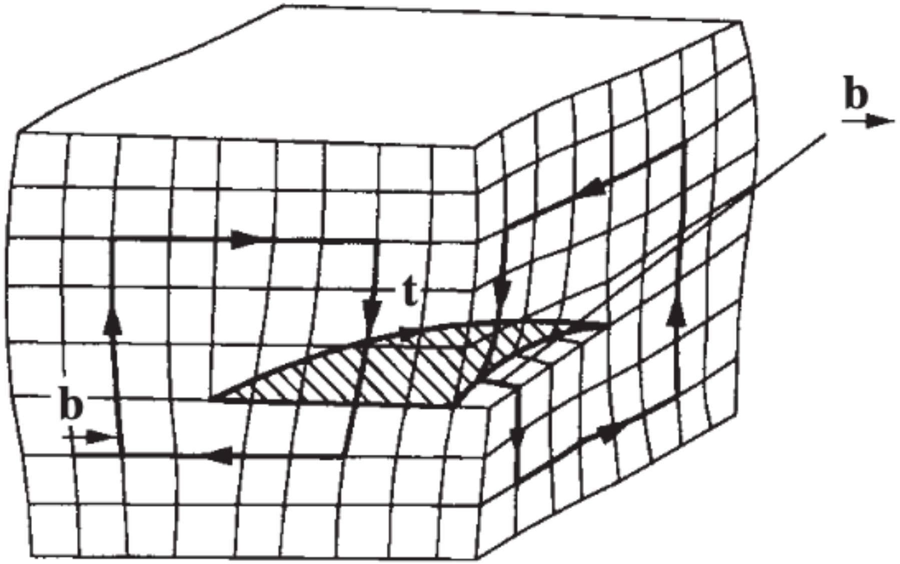
Drawing the Burger's circuit for a screw



Burgers vector is invariant along the dislocation line

Mixed Dislocations

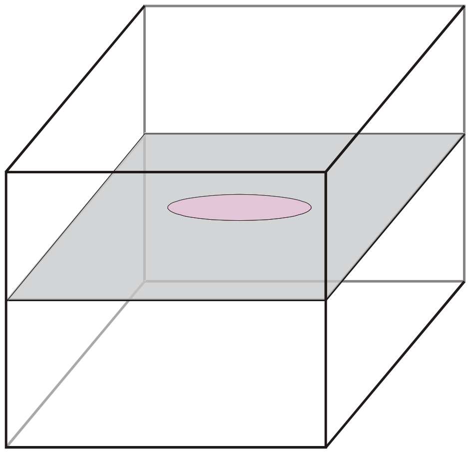


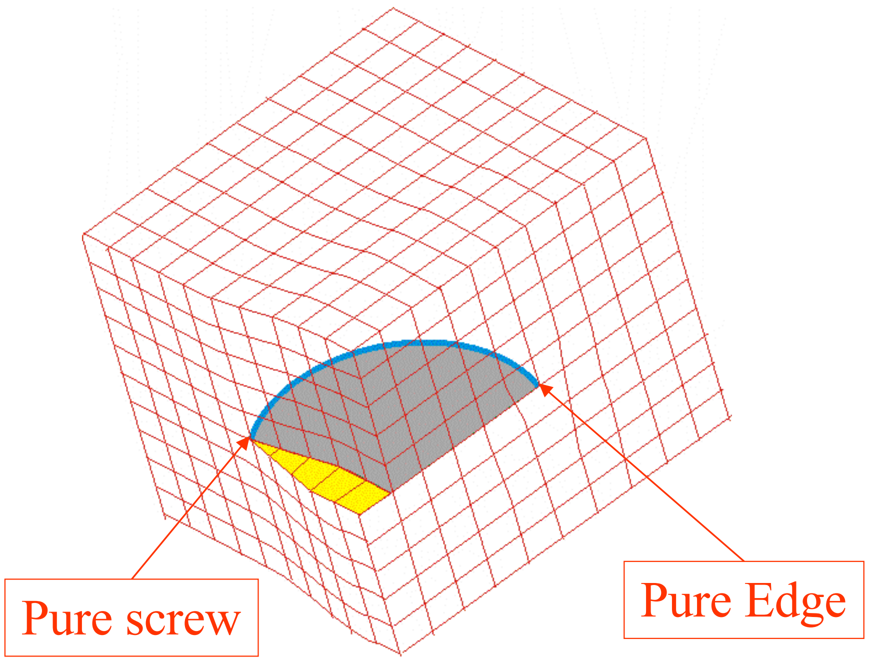


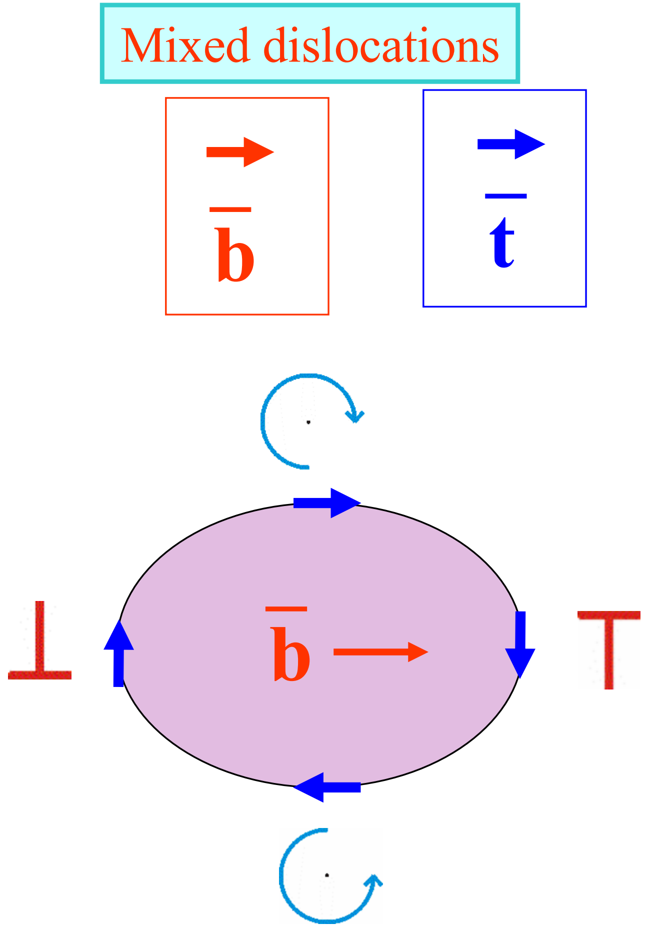
Relationship between $\vec{t}$ and $\vec{b}$ are neither neither parallel or perpendicular.

Pure screw on the right
Pure edge on the front

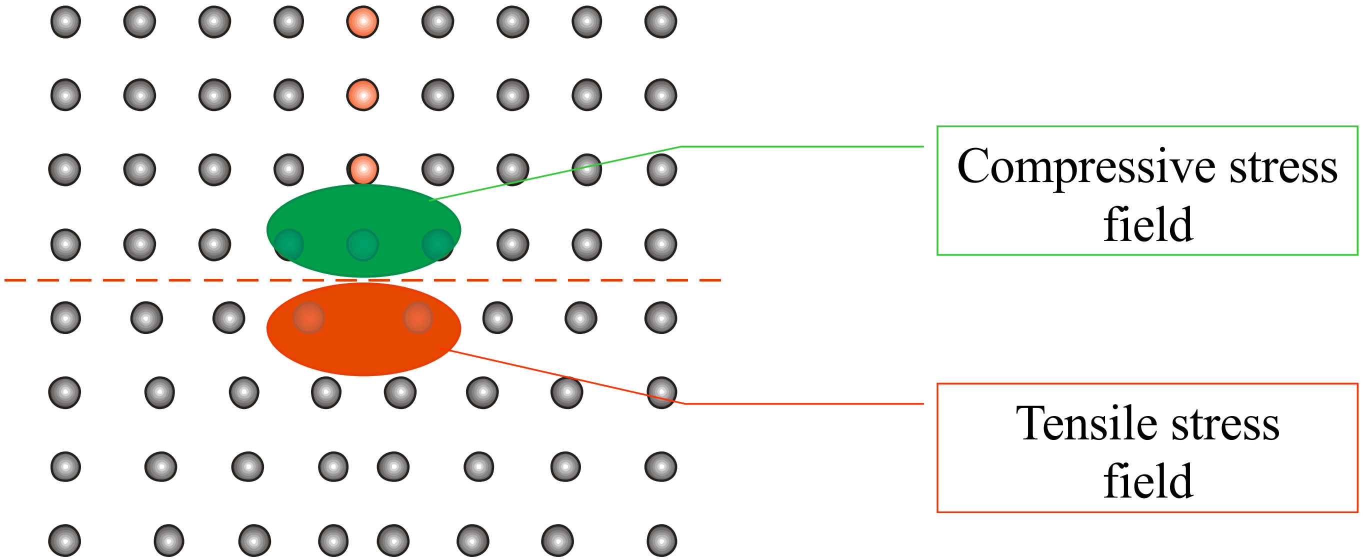
Everything in-between also observed.




Pure screw
Pure Edge

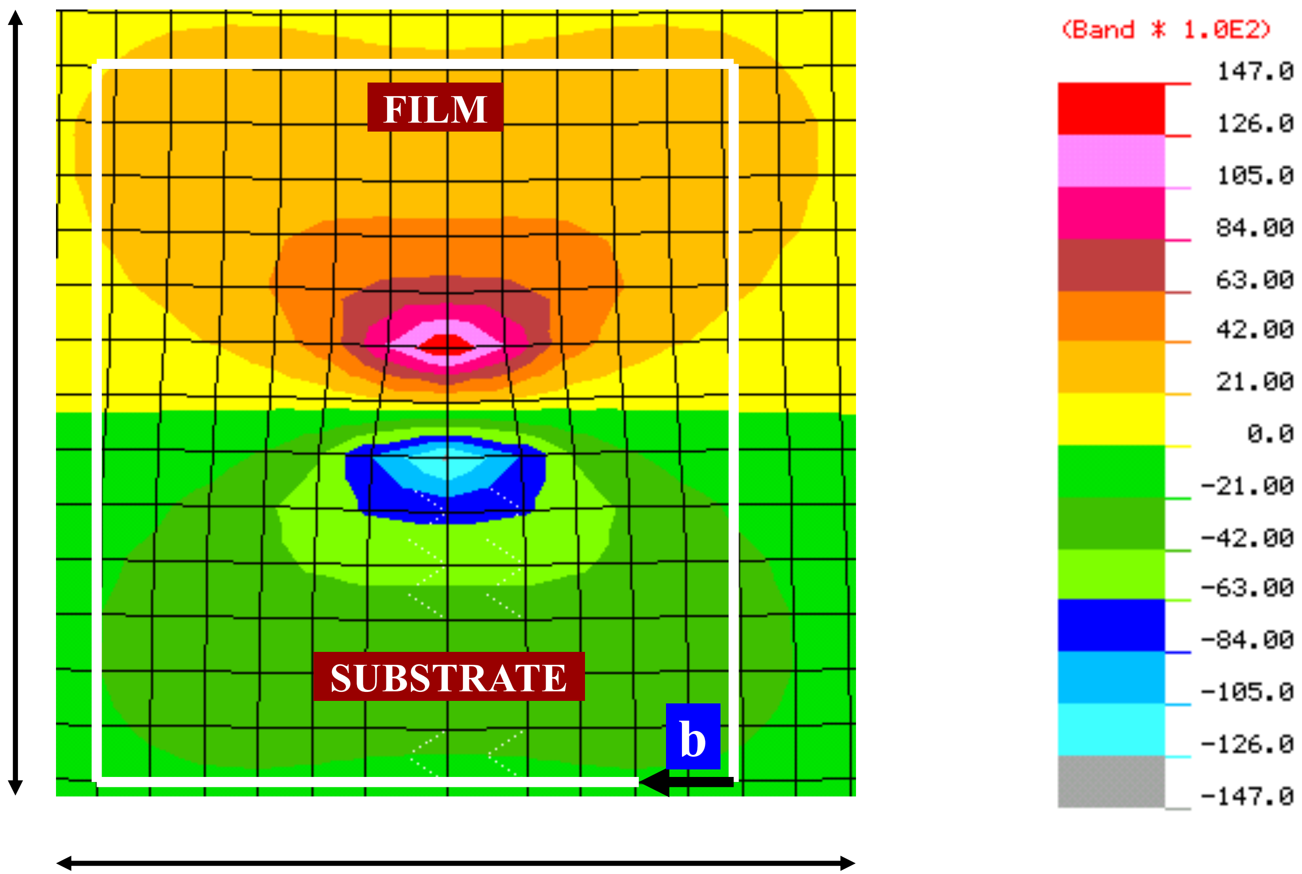

Mixed dislocations
b
t
b
⊥
T

Strain fields around a dislocation



STRESS FIELD OF A EDGE DISLOCATION

σ_X – FEM SIMULATED CONTOURS



Some final take aways :

1. Burgers vector is invariant along the dislocation line

1. Burgers vector is the smallest lattice translation
   Fractional lattice translations leads to stacking faults – a 2D layer of defects.

2. Dislocations cannot abruptly end in a crystal - Needs a surface or another defect to annihilate

- The dislocation line ends on:
  - The free surface of the crystal
  - Internal surface or interface
  - Closes on itself to form a loop
  - Ends in a *node*

- A *node* is the intersection point of more than two dislocations

- The vectoral sum of the Burgers vectors of dislocations meeting at a node = 0

Geometric properties of dislocations

Dislocation Property	Type of dislocation	
	Edge	Screw
Relation between dislocation line (**t**) and **b**	$\perp$	$\parallel$
Slip direction	$\parallel$ to **b**	$\parallel$ to **b**
Direction of dislocation line movement relative to **b**	$\parallel$	$\perp$
Process by which dislocation may leave slip plane	climb	Cross-slip