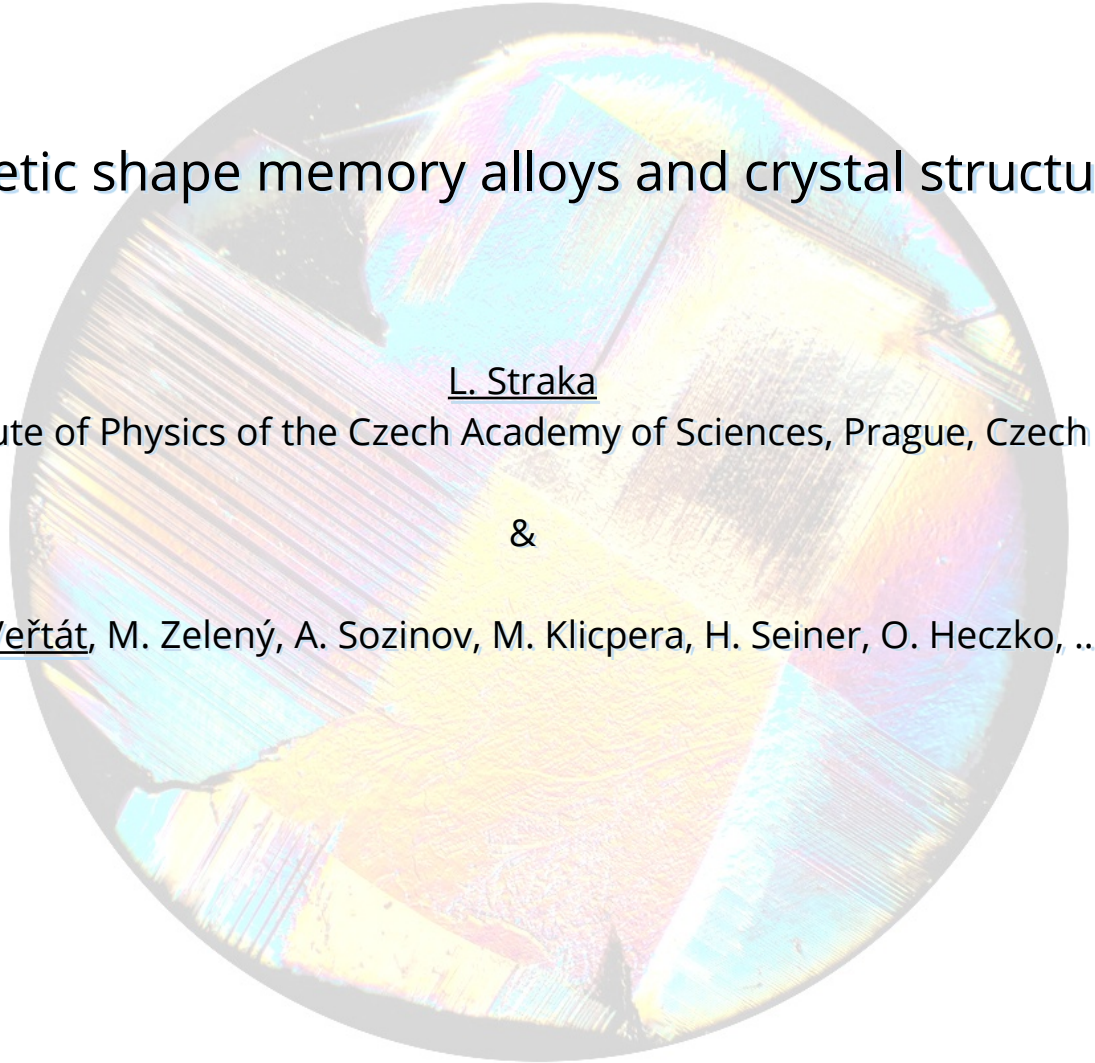
The magic of magnetic shape memory alloys and crystal structure perspective



L. Straka
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&

P. Veřtát, M. Zelený, A. Sozinov, M. Klicpera, H. Seiner, O. Heczko, ...

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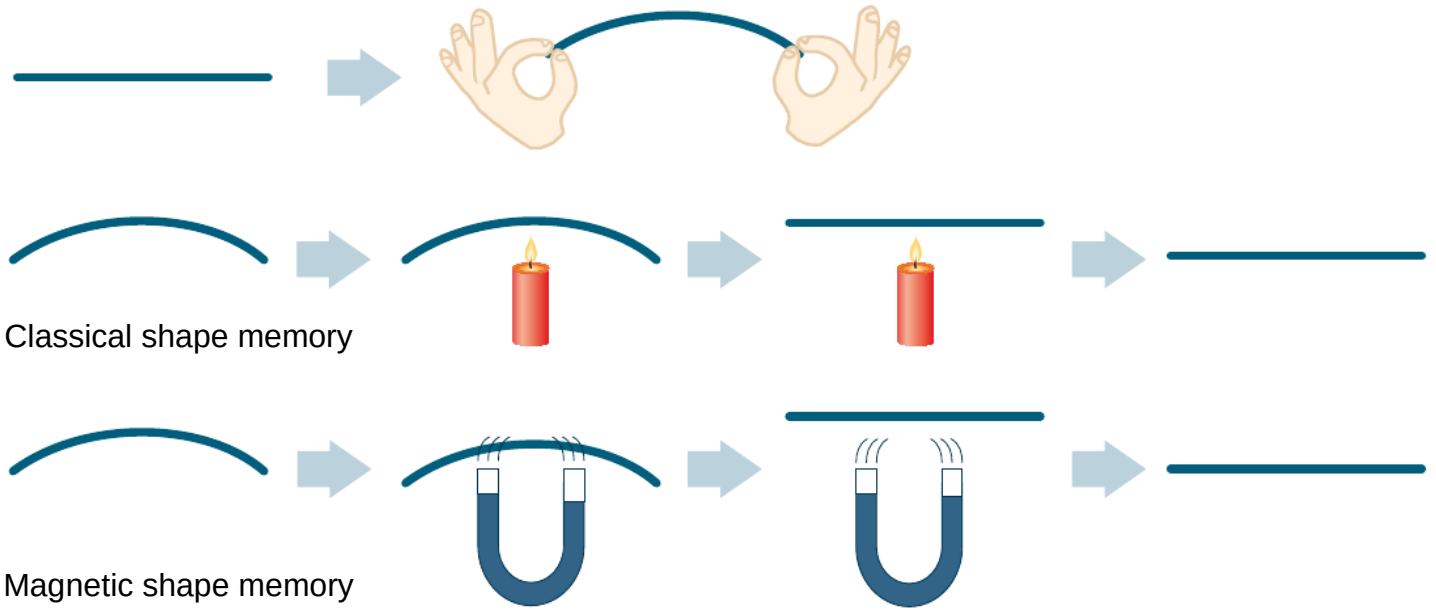
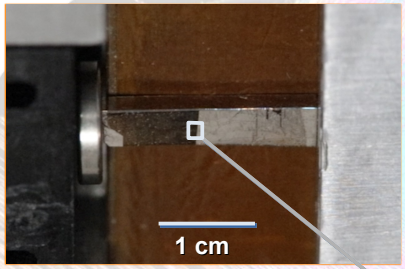
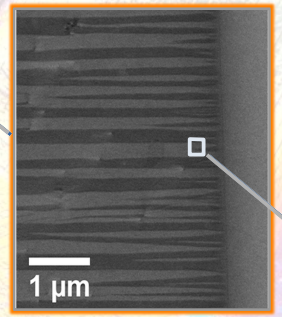
The magic of magnetic shape memory...

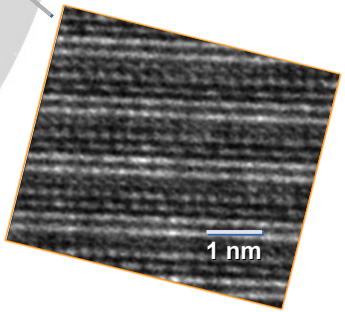


The magic of magnetic shape memory...

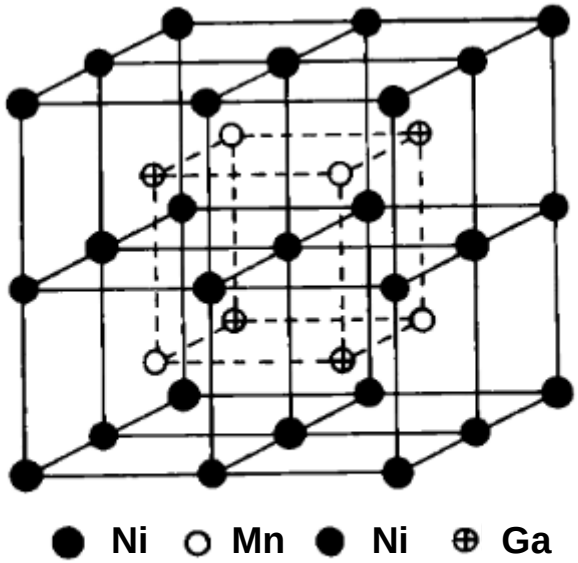
- Intro & Macrotwins
- *Movie with examples*
- Microtwins
- Nanotwins
- Summary







Ni_2MnGa ($Ni_{50}Mn_{25}Ga_{25}$) with the Heusler $L2_1$ structure as the prototype MSM alloy



(alternatives: Fe-Pt, Fe-Pd, Nd, $La_{2-x}Sr_xCuO_4$)

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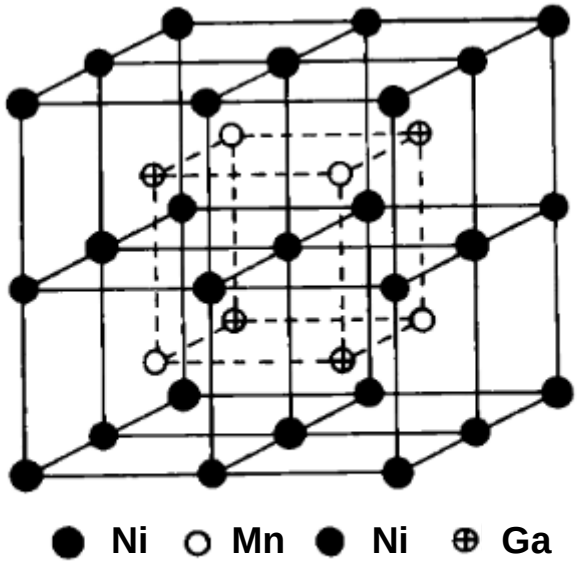

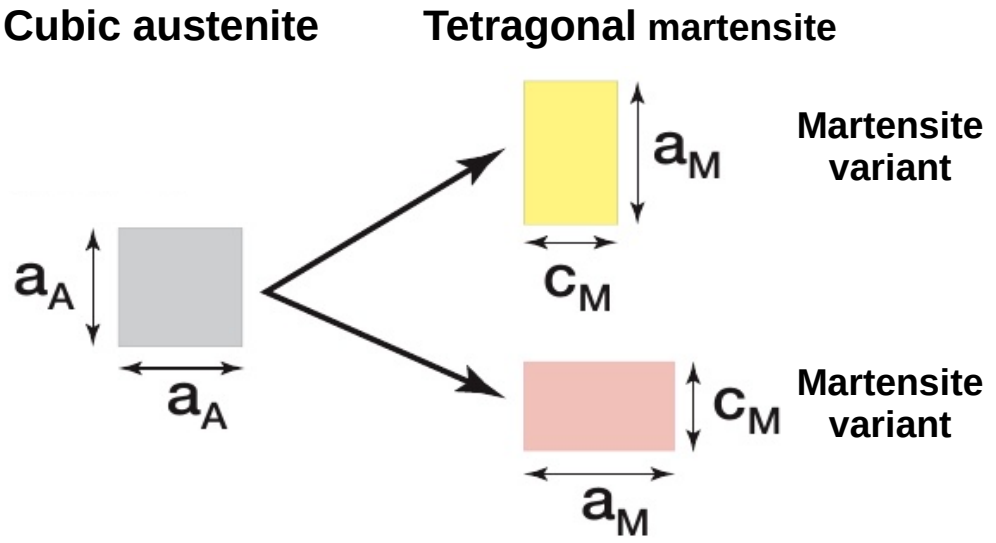

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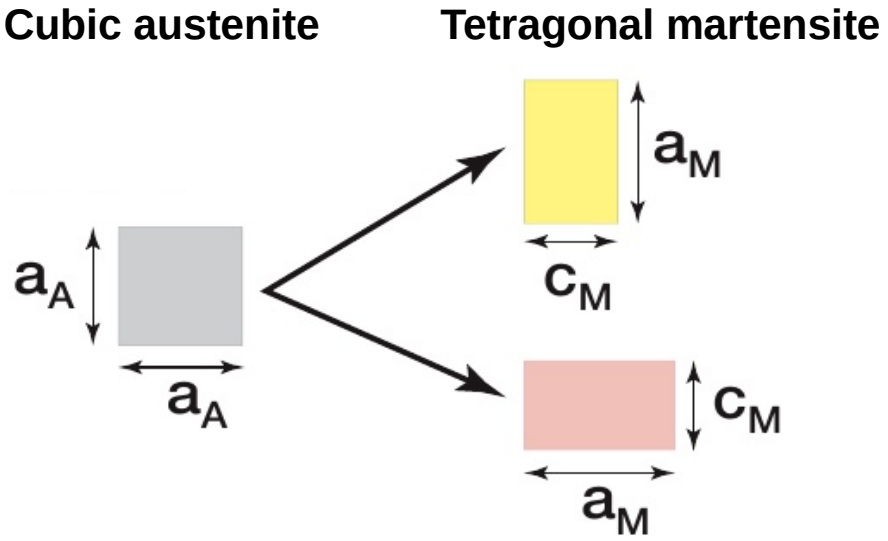

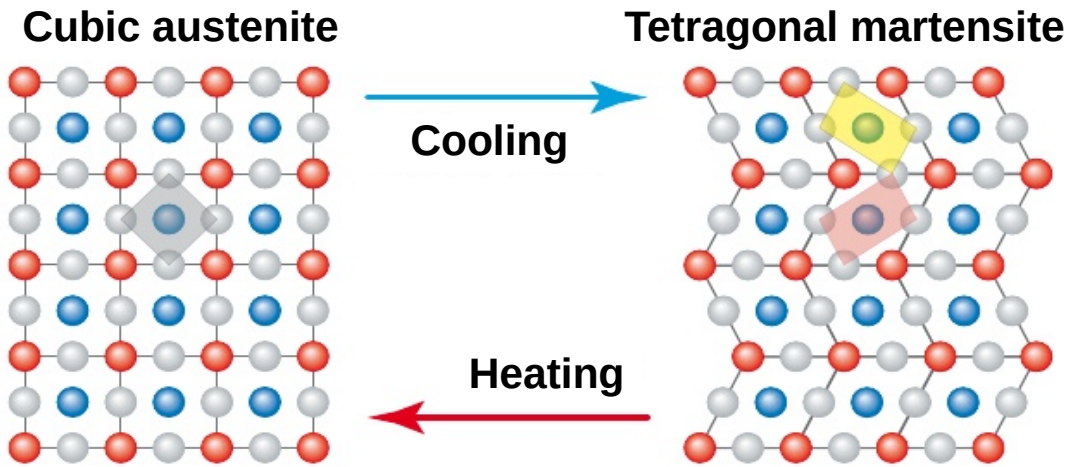

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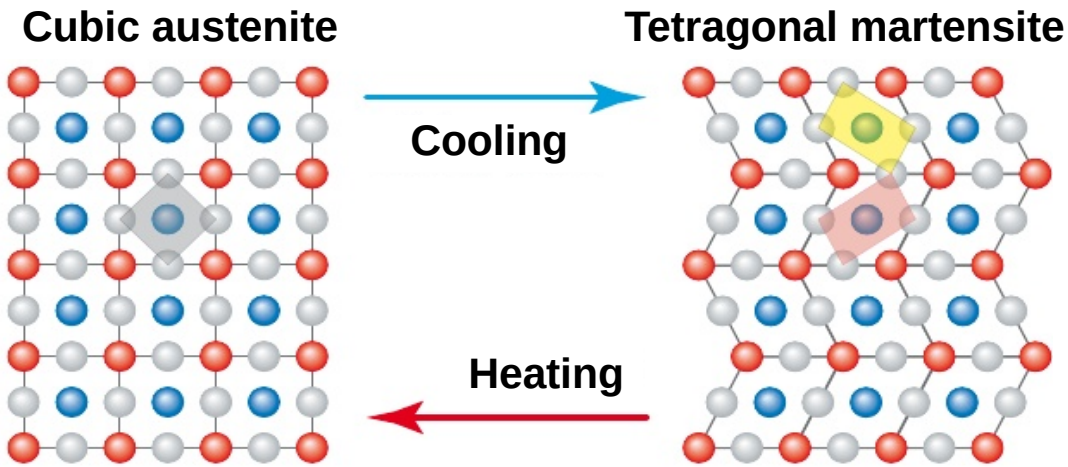

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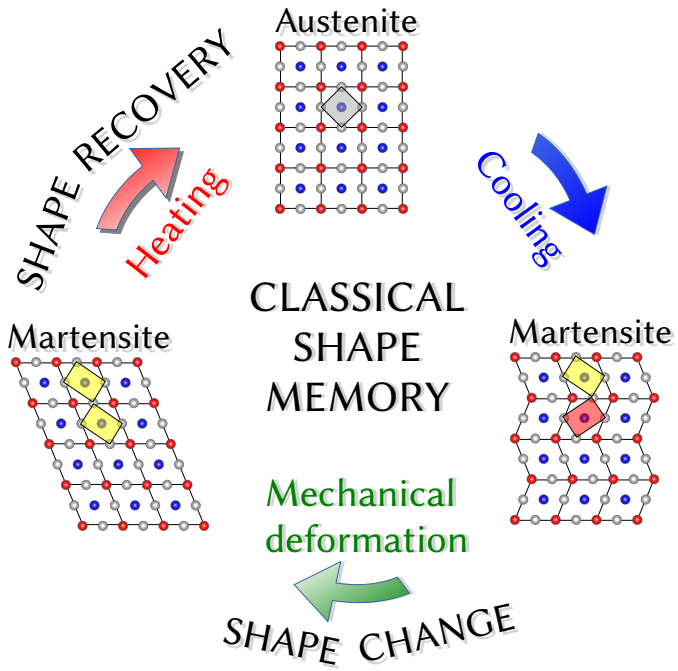

Martensite variant 1 Martensite variant 2 Cubic austenite

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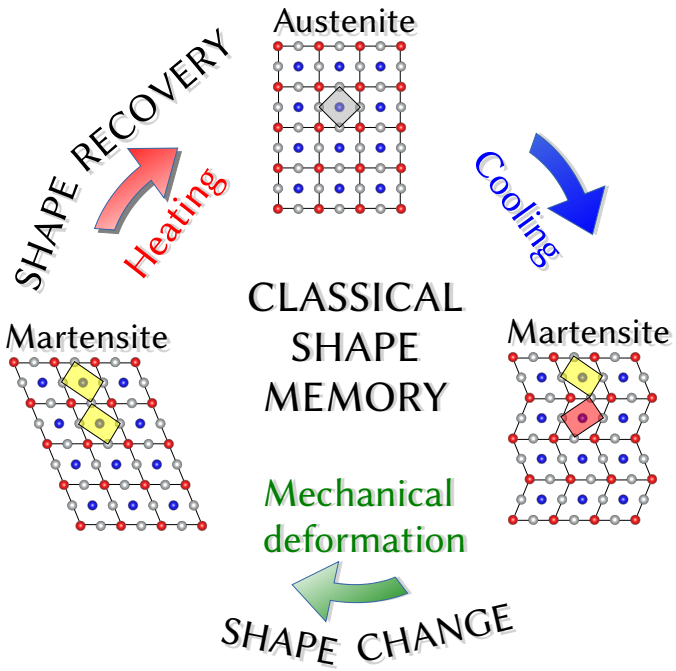

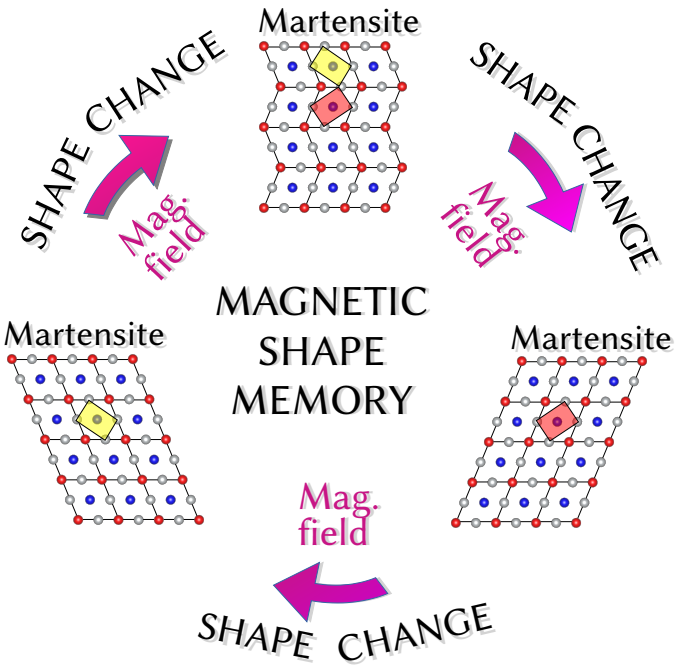

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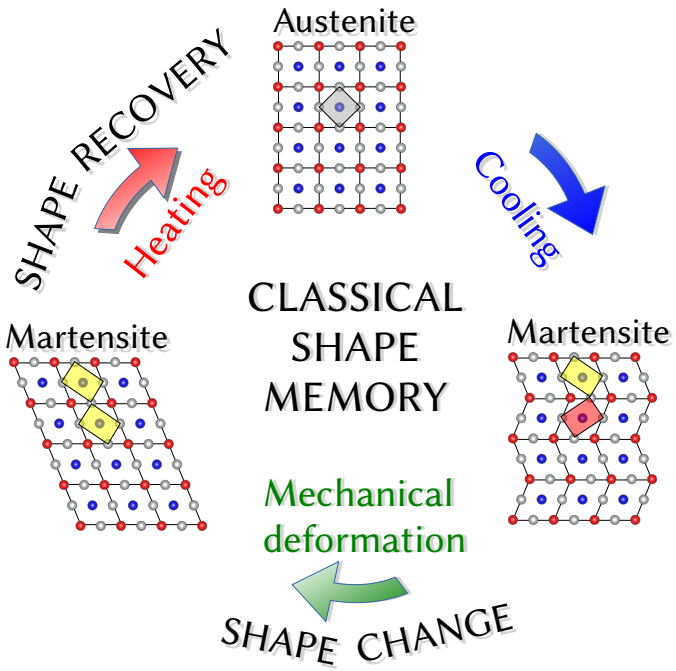

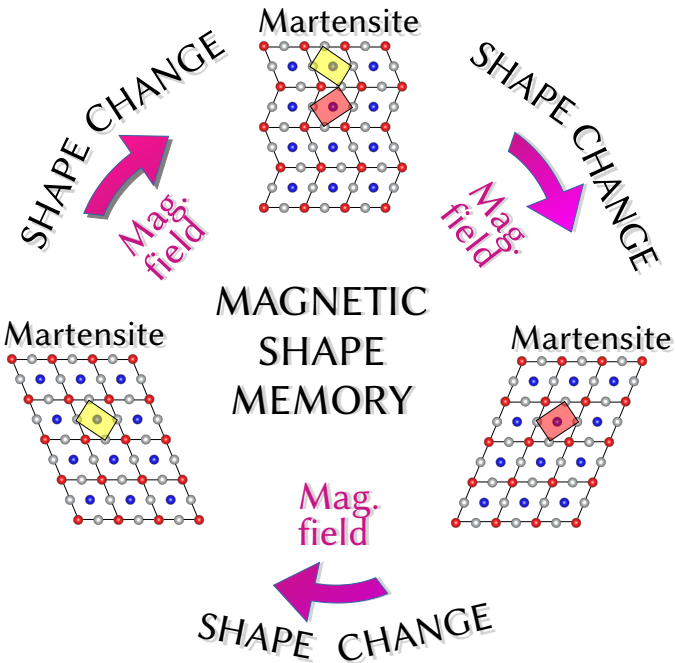

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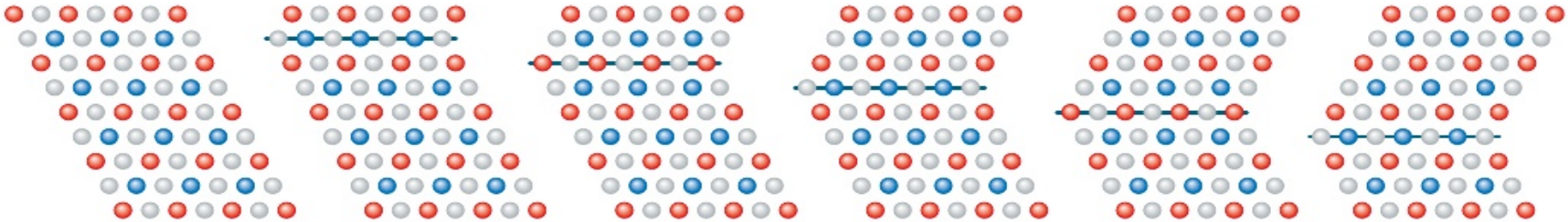

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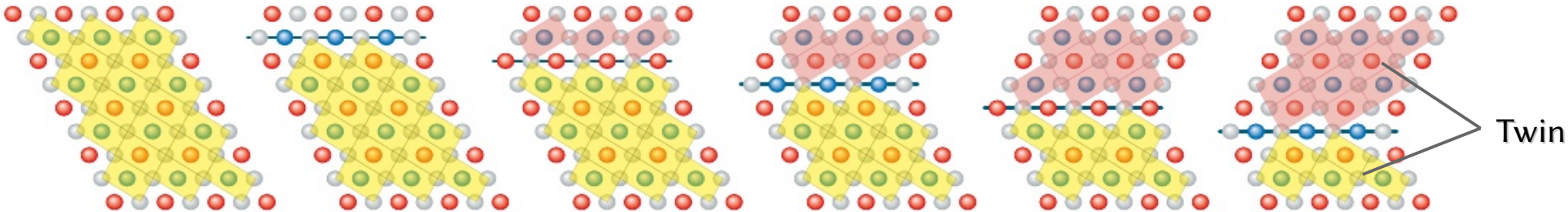

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Twin boundary, (101) plane

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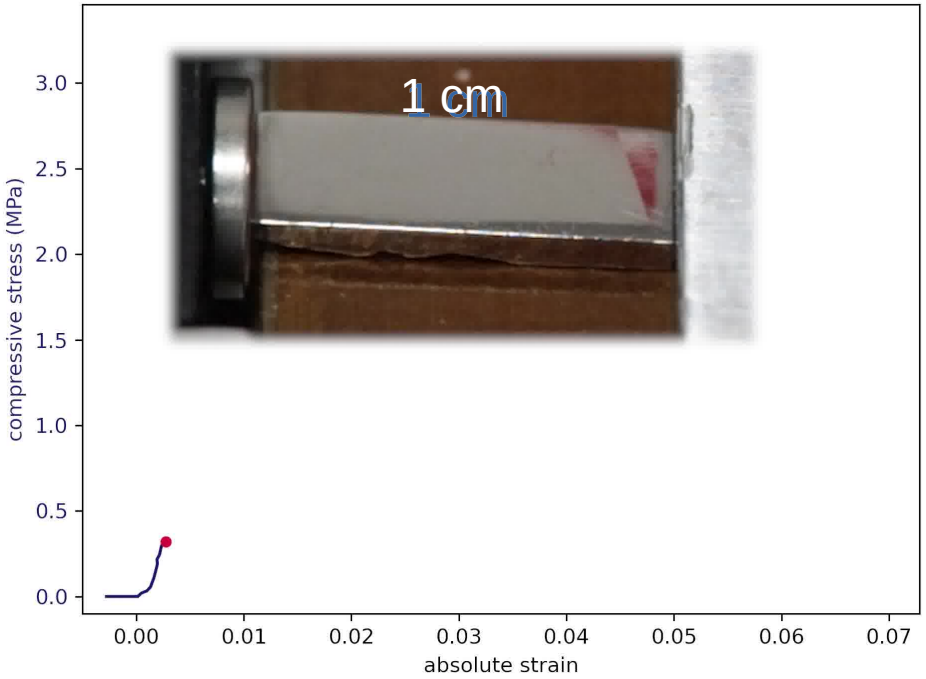

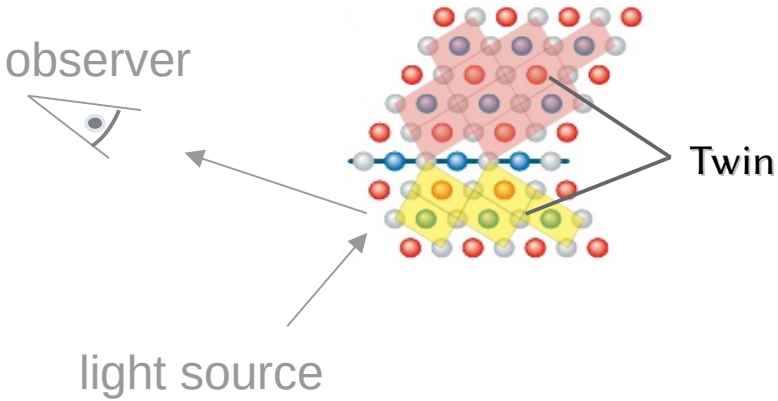

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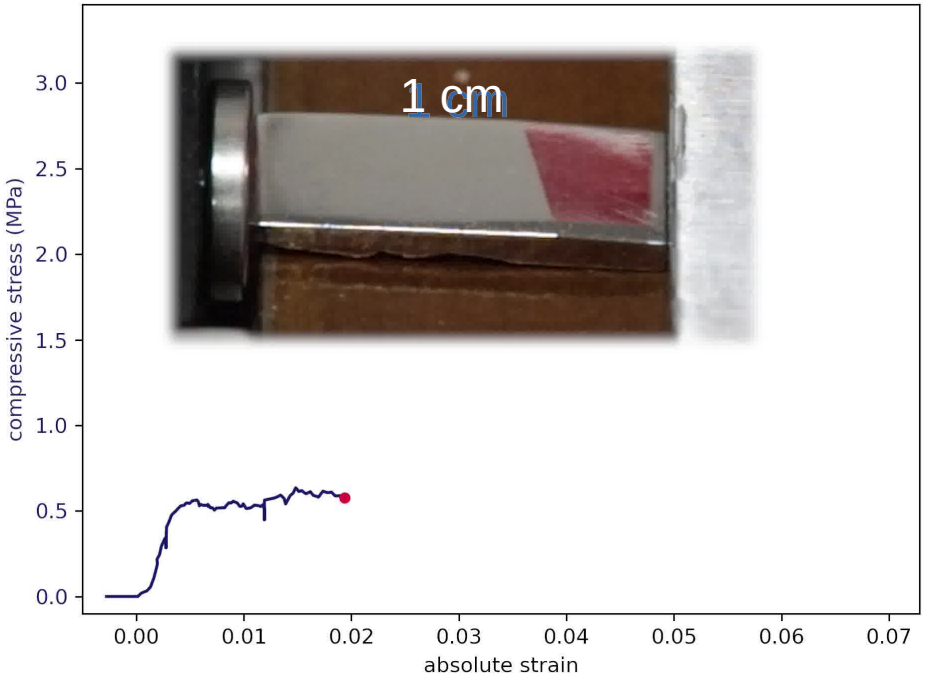

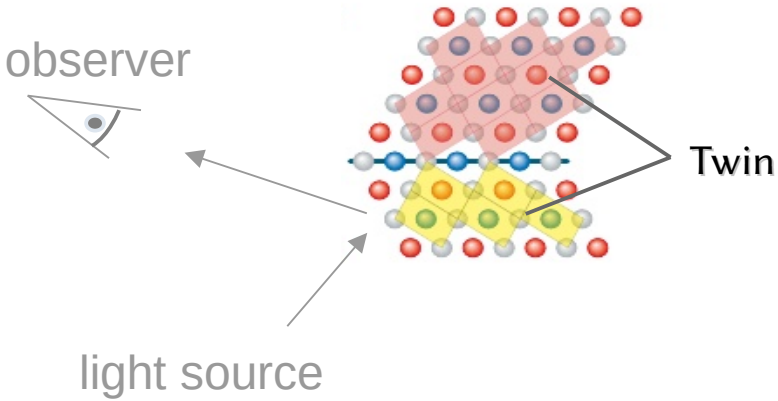

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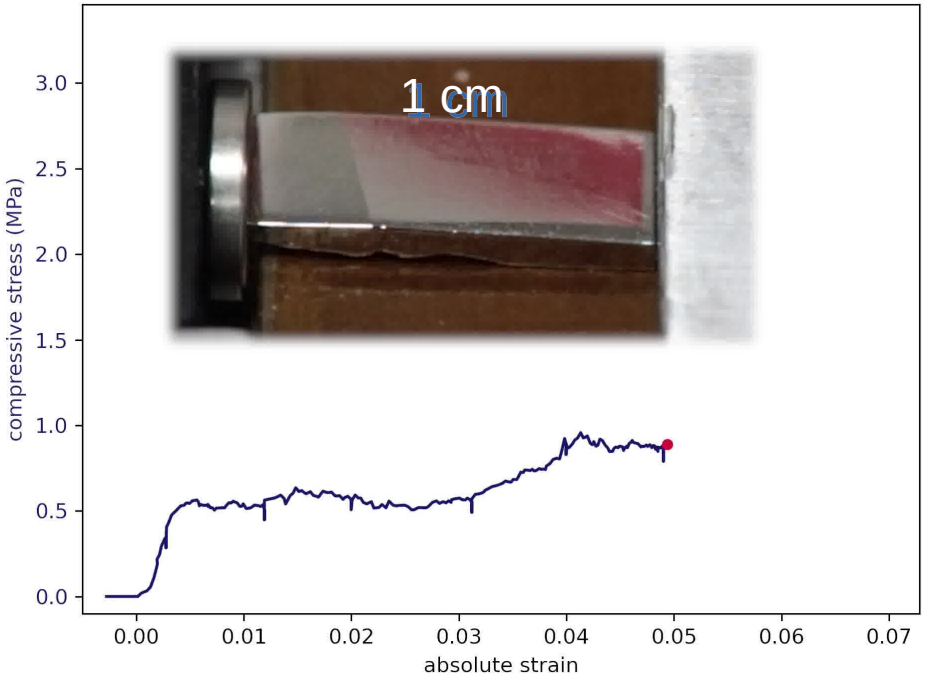

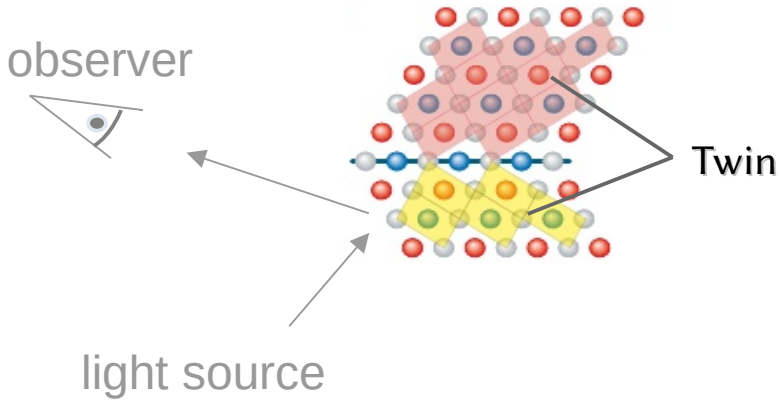

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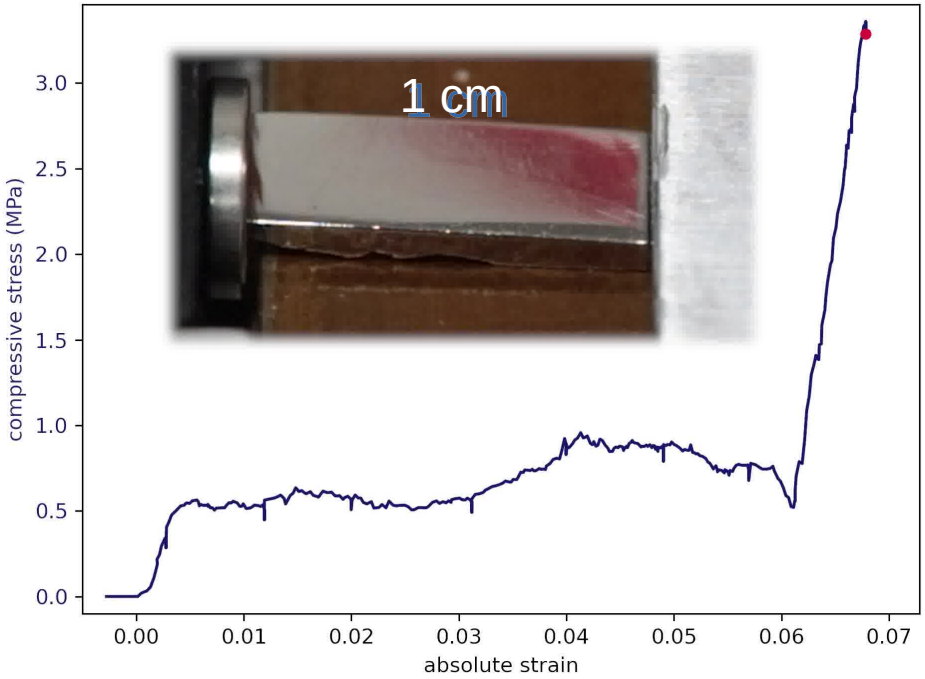

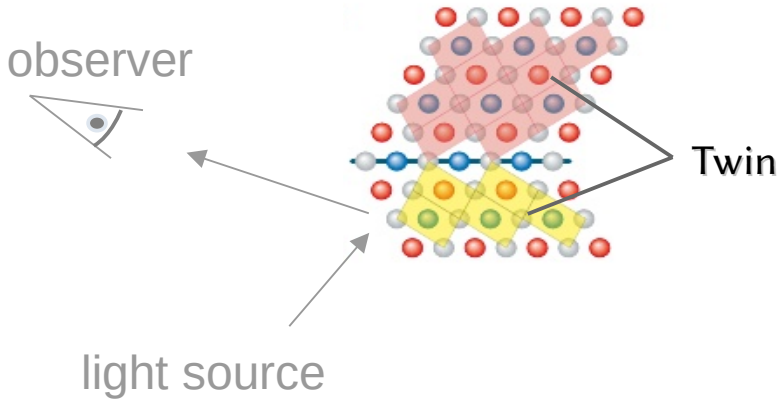

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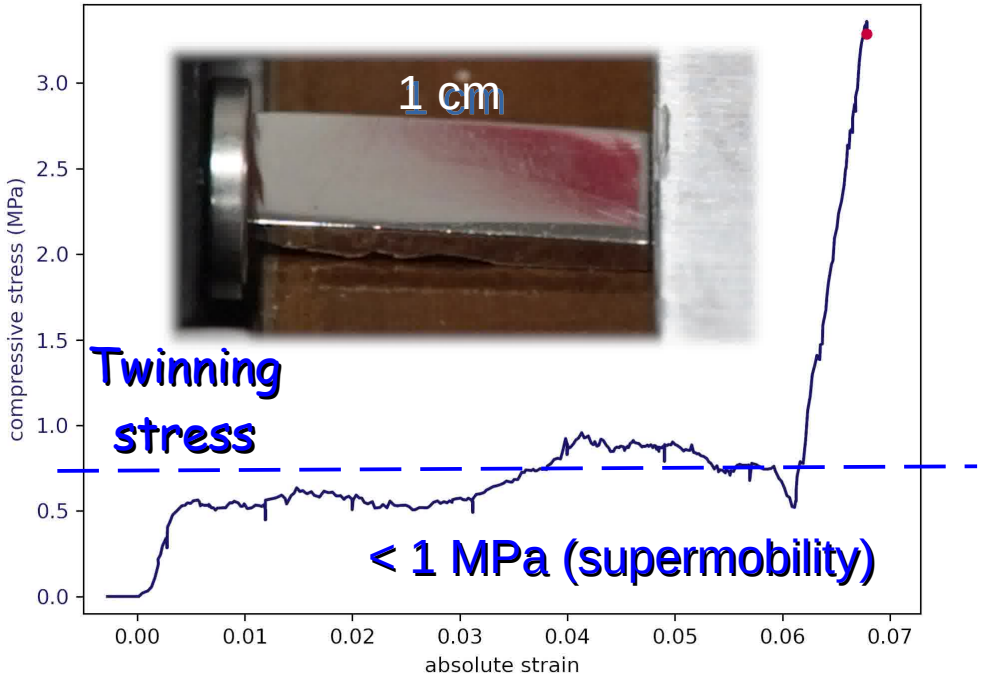

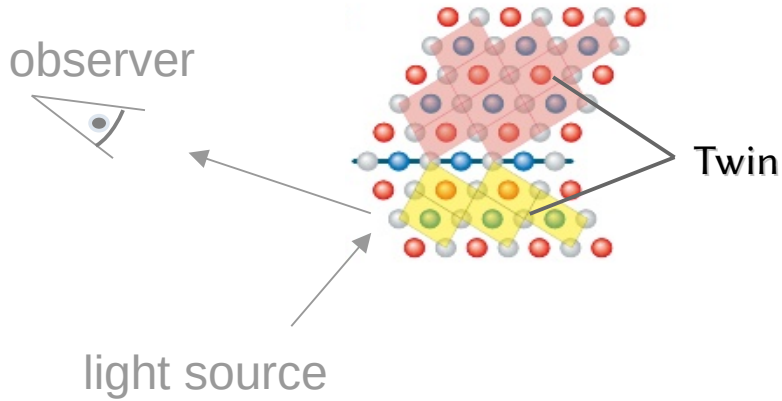

Martensite variant 1 | Martensite variant 2 | Twin boundary, (101) plane

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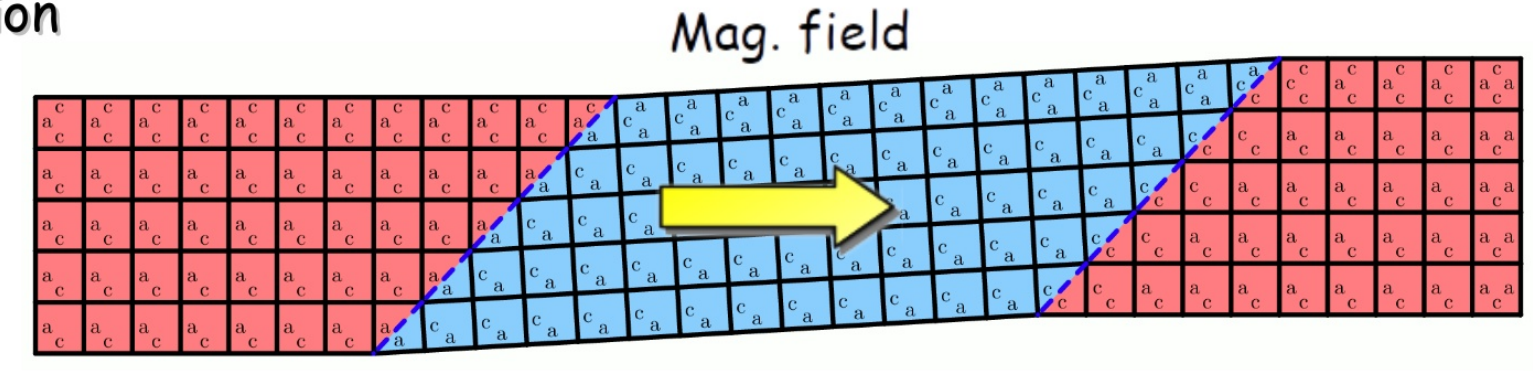

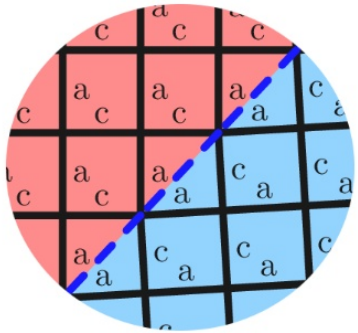

$$W_{MECH} = \sigma_{TW} \cdot \varepsilon_0$$

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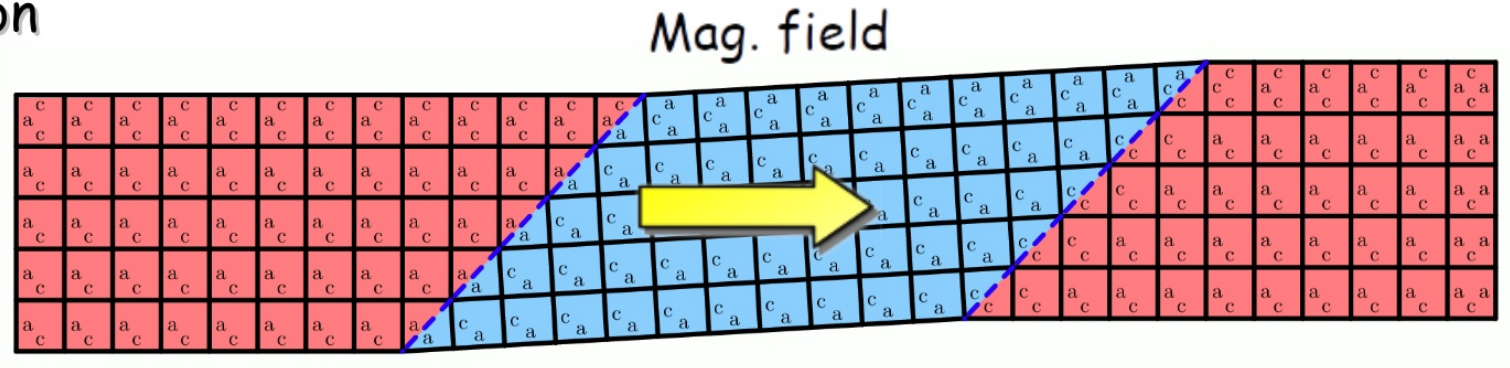

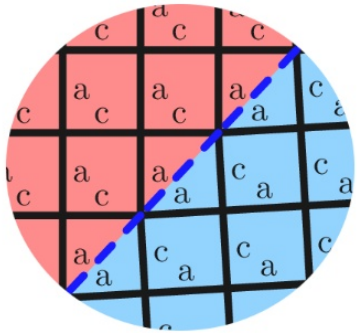

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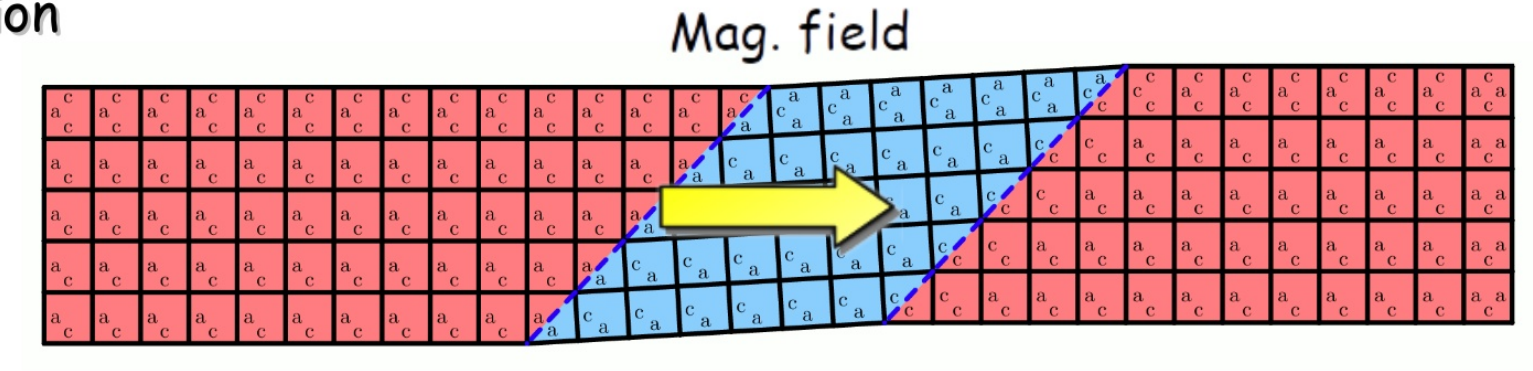

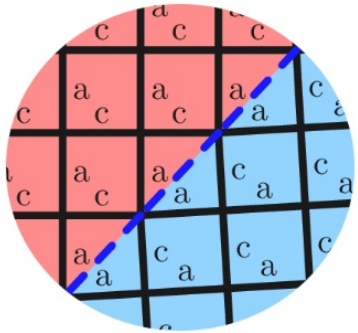

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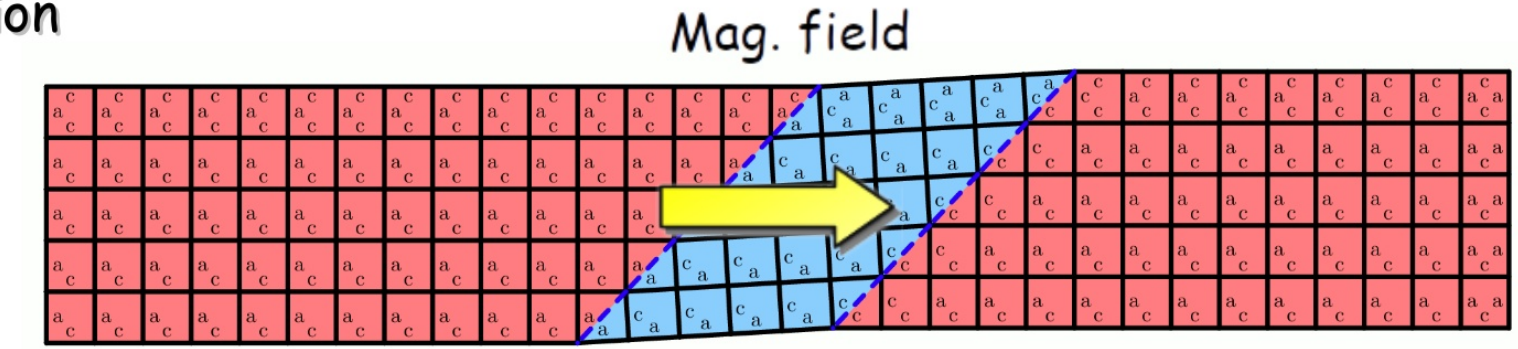

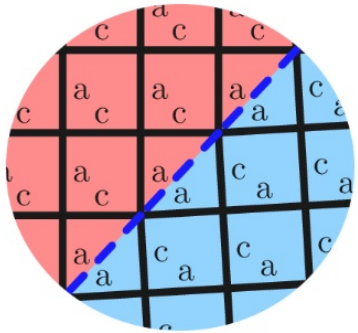

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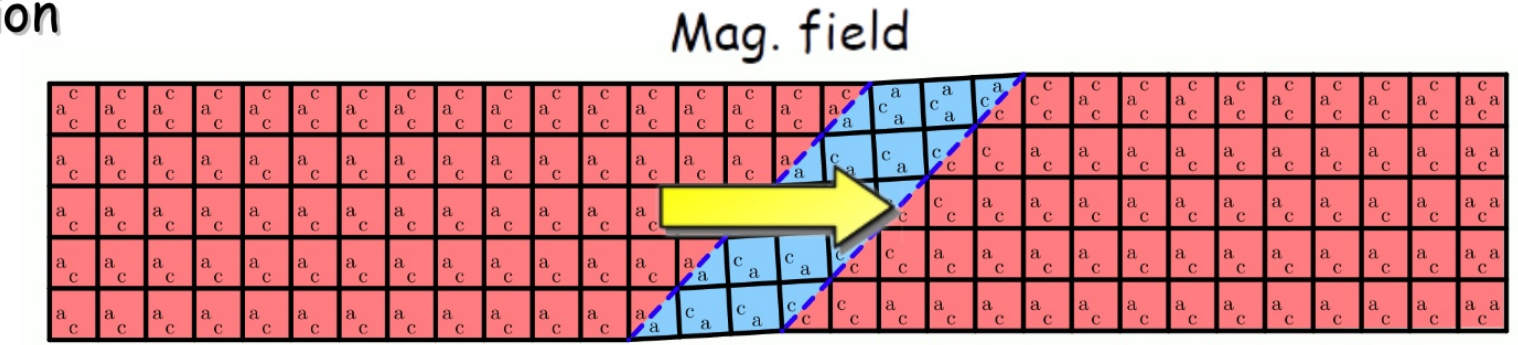

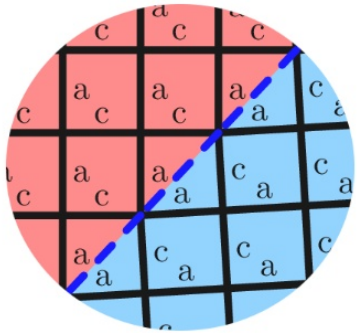

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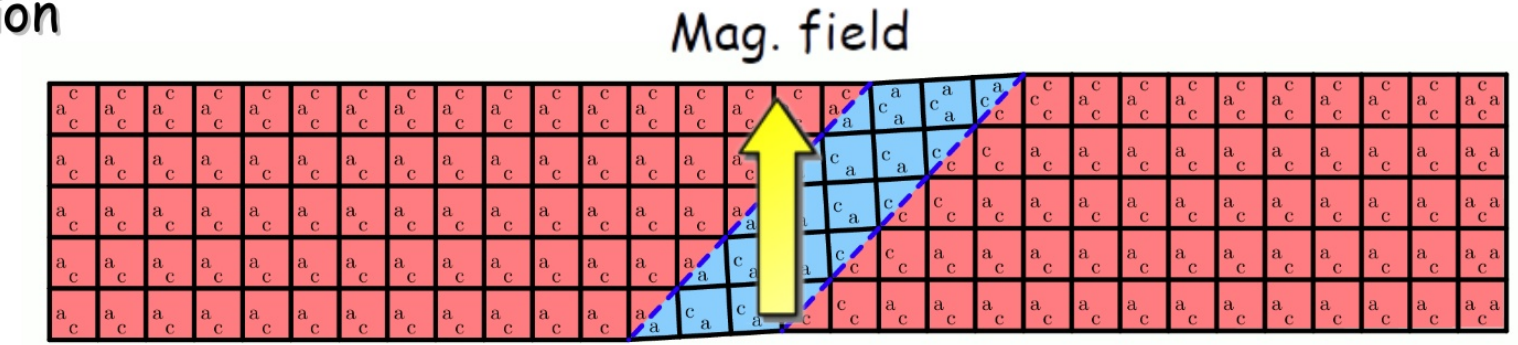

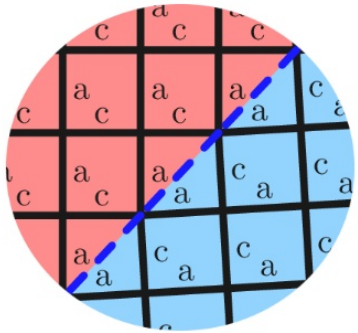

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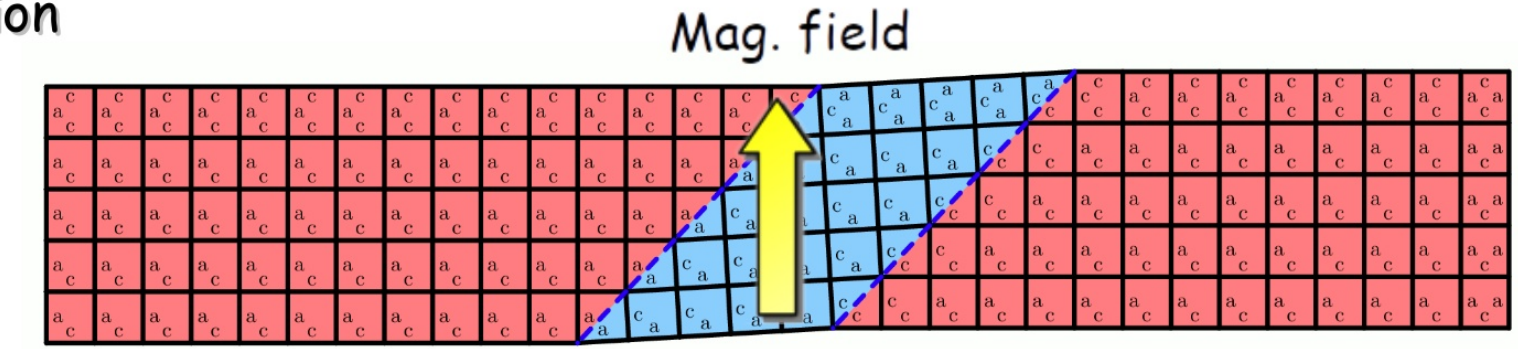

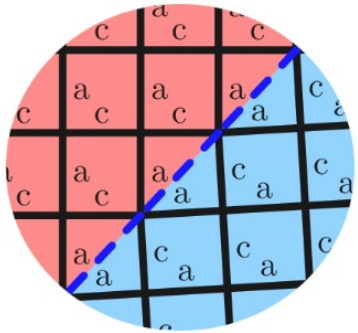

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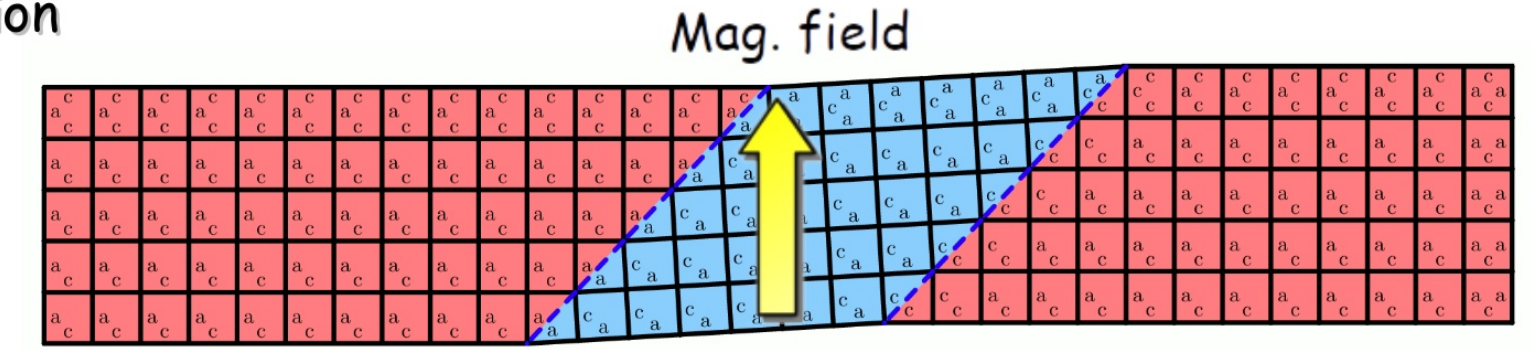

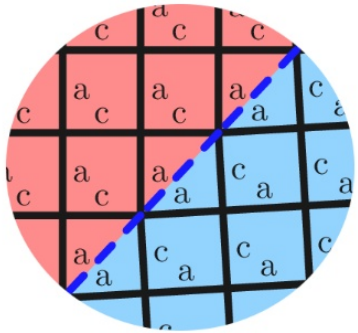

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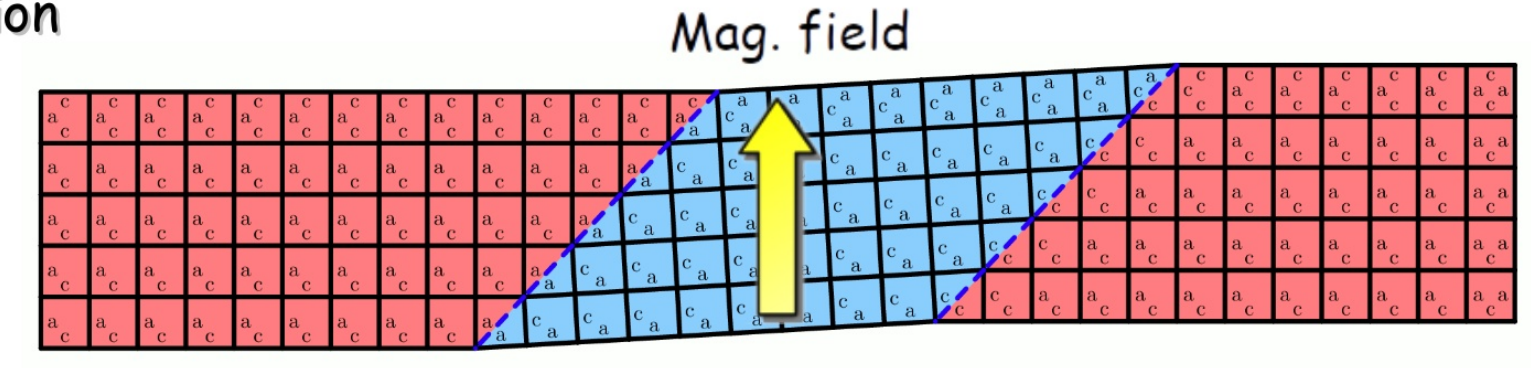

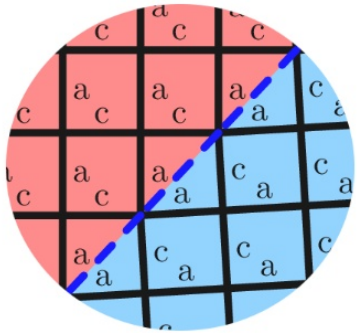

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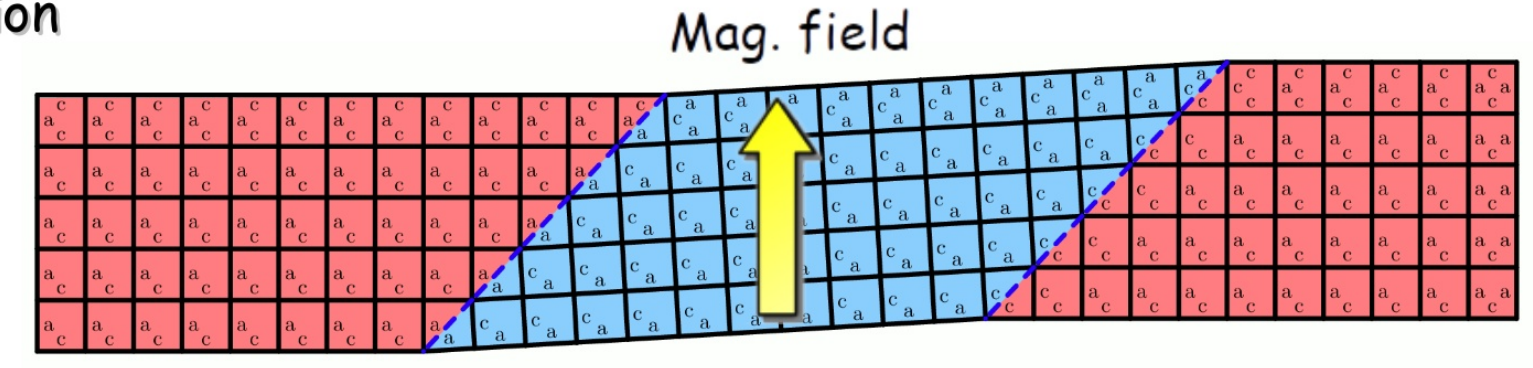

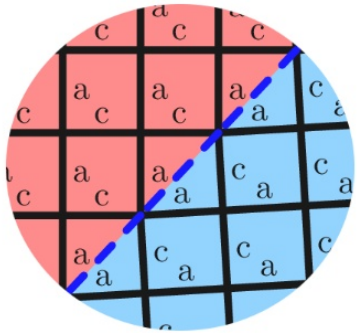

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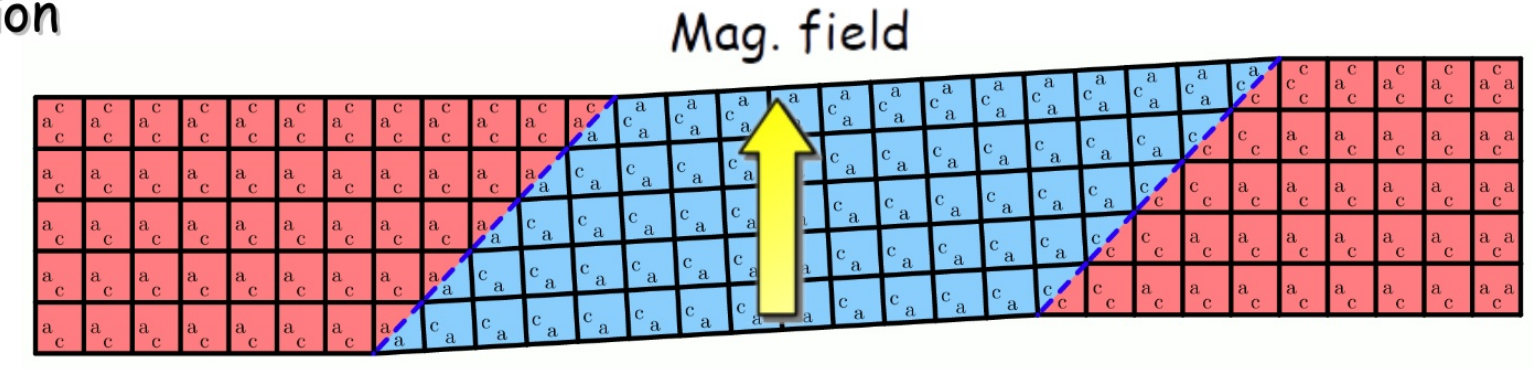
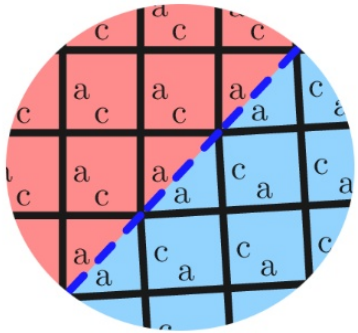
$$\sigma_{TW} < K_U/\varepsilon_0$$

Motivation





$$W_{MECH} = \sigma_{TW} \cdot \varepsilon_0$$

$$\Delta W_{MAG} = K_U$$

$$\Delta W_{MAG} > W_{MECH}$$

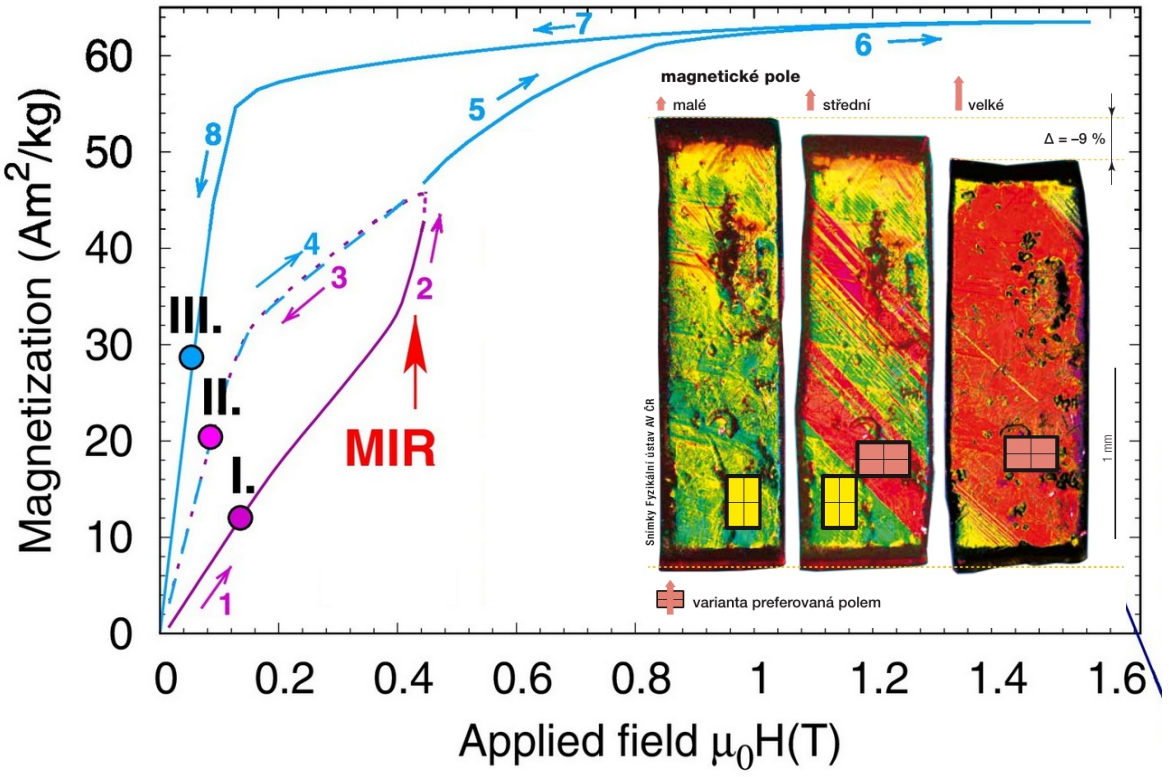
$$\sigma_{TW} < K_U/\varepsilon_0$$

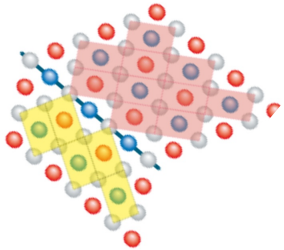
Ni_2MnGa ($Ni_{50}Mn_{25}Ga_{25}$) with the Heusler $L2_1$ structure as the prototype MSM alloy

Magnetic Shape Memory Effect

Mart. reorientation
MIR, ~ 0.01 -1 T

Mart. transformation
MIM, ~ 1-100 T

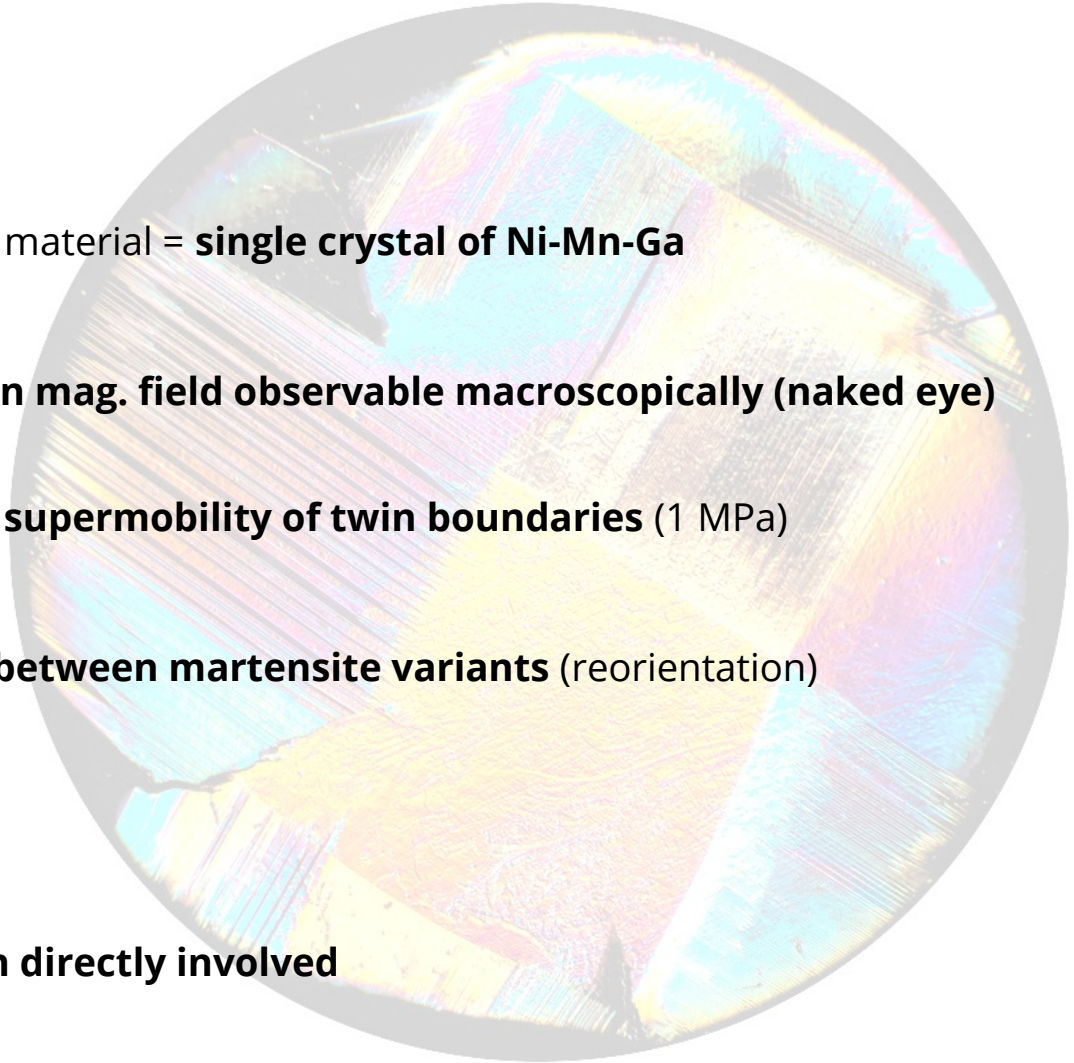




Martensite variant 1 | Martensite variant 2 | Twin boundary, (101) plane

Rameš, M., et al., Scripta Materialia 142 (2018): 61-65.

Summary I



- Prototype magnetic shape material = **single crystal of Ni-Mn-Ga**
- **Deformation up to 12% in mag. field observable macroscopically (naked eye)**
- Key enabler of the effect = **supermobility of twin boundaries** (1 MPa)
- Key principle = **switching between martensite variants** (reorientation) of tetragonal lattice
  - mechanically
  - **by magnetic field** (3 MPa)
- **No phase transformation directly involved**