Heredity and mutation of the chirality during the growth transition-metal monosilicides

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Chirality is everywhere

The geometric property of a rigid object (or spatial arrangement of point or atoms) of being non-superposable by pure rotation and translation on its image formed by inversion through a point; the symmetry group of such an object contains no symmetry operations of the second kind ($\bar{1}$, m, $\bar{3}$, $\bar{4}$, $\bar{6}$). When the object is superposable by pure rotation and translation on its inverted image, the object is described as being achiral; the symmetry group of such an object contains symmetry operations of the second kind.

Chirality is everywhere

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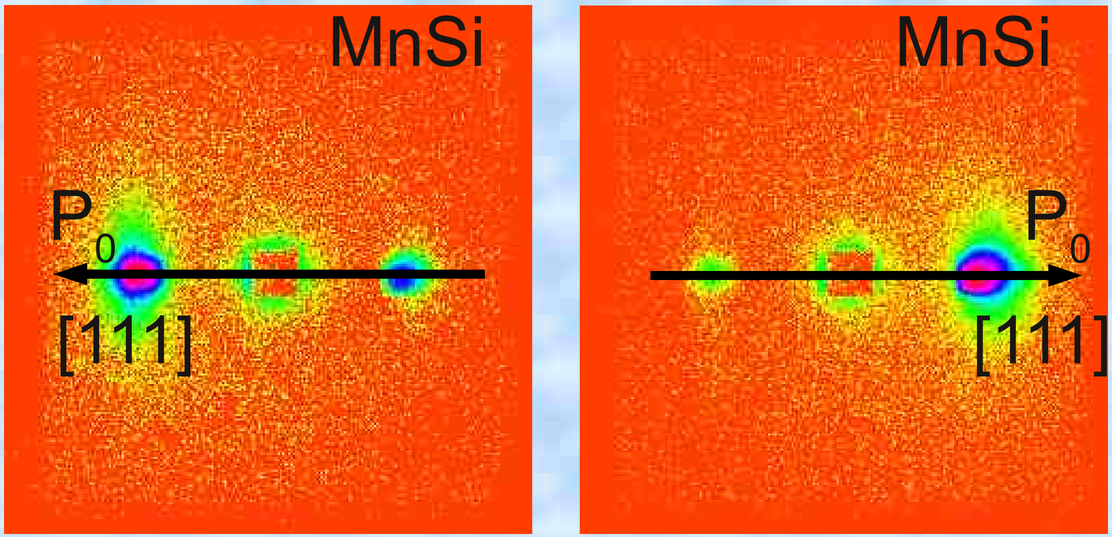
d translation on its
etry group of such an
kind ($\bar{1}$, m, $\bar{3}$, $\bar{4}$, $\bar{6}$).
translation on its
l; the symmetry group
second kind.

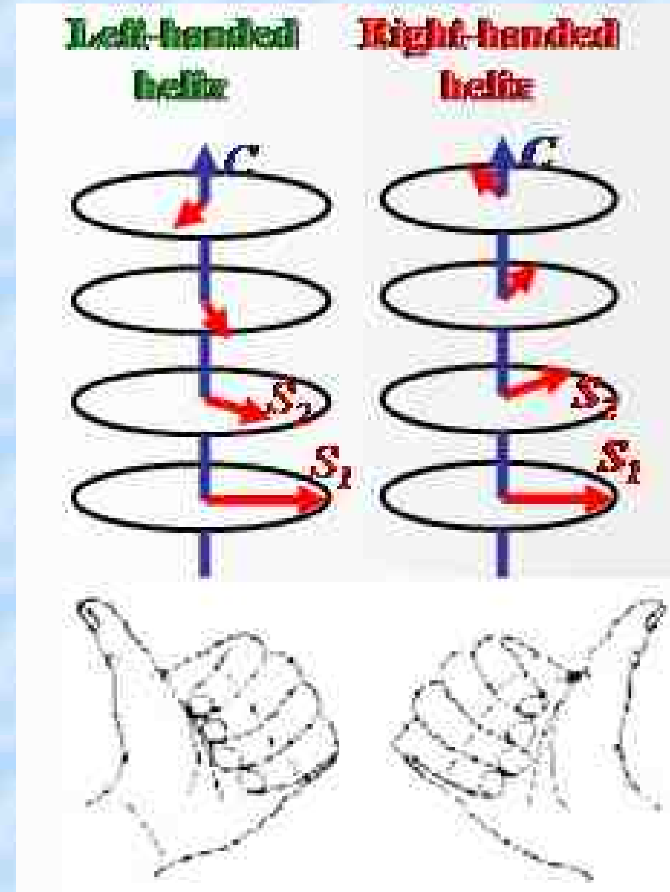
Narwhal

Magnetic chirality

$T < T_c = 29$ K, $d = 18$ nm



Tanaka et al, 1985



$$\gamma = \frac{n^l - n^r}{n^l + n^r}$$

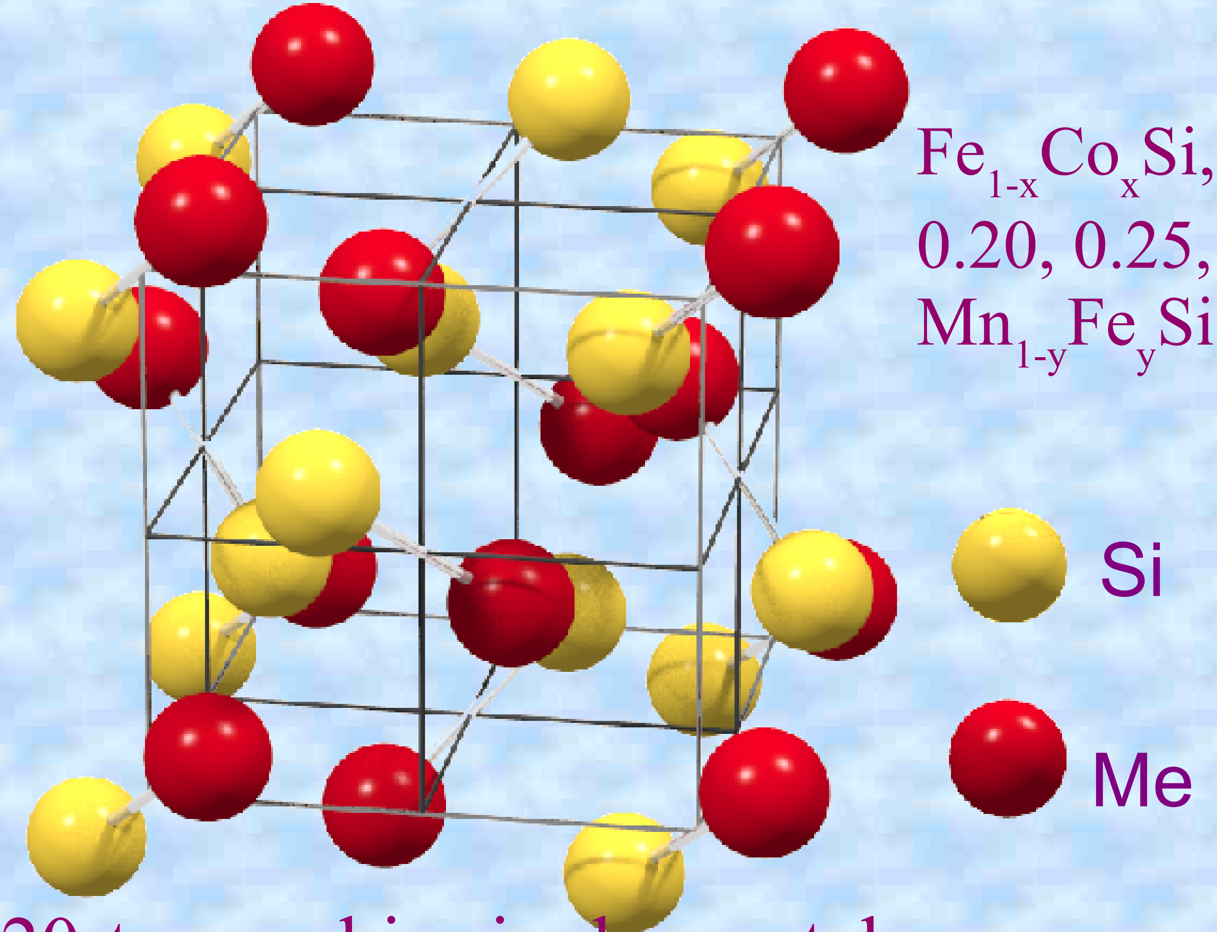
$$P_s = \gamma (\boldsymbol{P_0 e_Q}) = \gamma P_0 \cos \psi$$

$$P_s = \frac{I(\boldsymbol{k}, +P_0) - I(\boldsymbol{k}, -P_0)}{I(\boldsymbol{k}, +P_0) + I(\boldsymbol{k}, -P_0)}$$

$u_{Si} = 0.845$ (-0.154)

$u_{Mn} = 0.138$

Monosilicides of transition metals

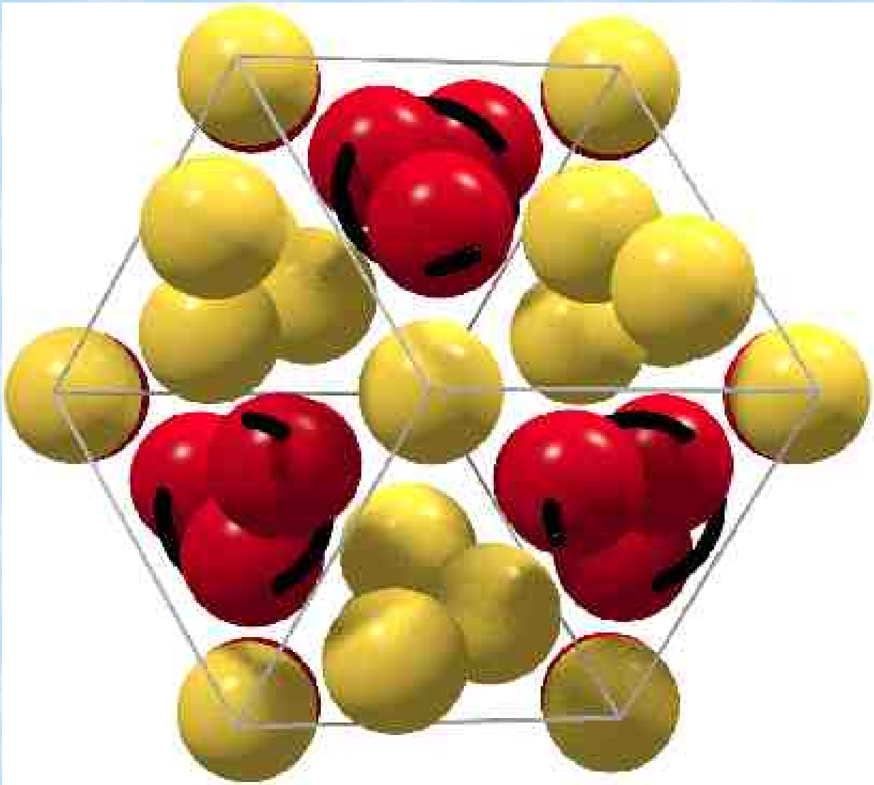


$Fe_{1-x}Co_xSi$, x = 0, 0.08, 0.1, 0.15, 0.20, 0.25, 0.30, 0.35, 0.5;
$Mn_{1-y}Fe_ySi$, y = 0, 0.06, 0.08, 0.1

Bòren, 1933

- B20-type cubic single crystal
- Space group $P2_13$
- a = 4.55 Å
- 4 Me and 4 Si <u>atoms</u> are inside a unit cell
- positions (u,u,u), (1/2+u,1/2-u,u), (1/2-u,-u,1/2+u),
- (-u,1/2+u,1/2+u) with u_{Mn} = 0.138 and u_{si} = 0.845

Monosilicides of transition metals



$$\vec{r}_1=(u,u,u)$$

$$\vec{r}_2=(\frac{1}{2}+u,\frac{1}{2}-u,-u)$$

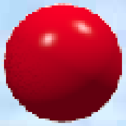
$$\vec{r}_3=(-u,\frac{1}{2}+u,\frac{1}{2}-u)$$

$$\vec{r}_4=(\frac{1}{2}-u,-u,\frac{1}{2}+u)$$

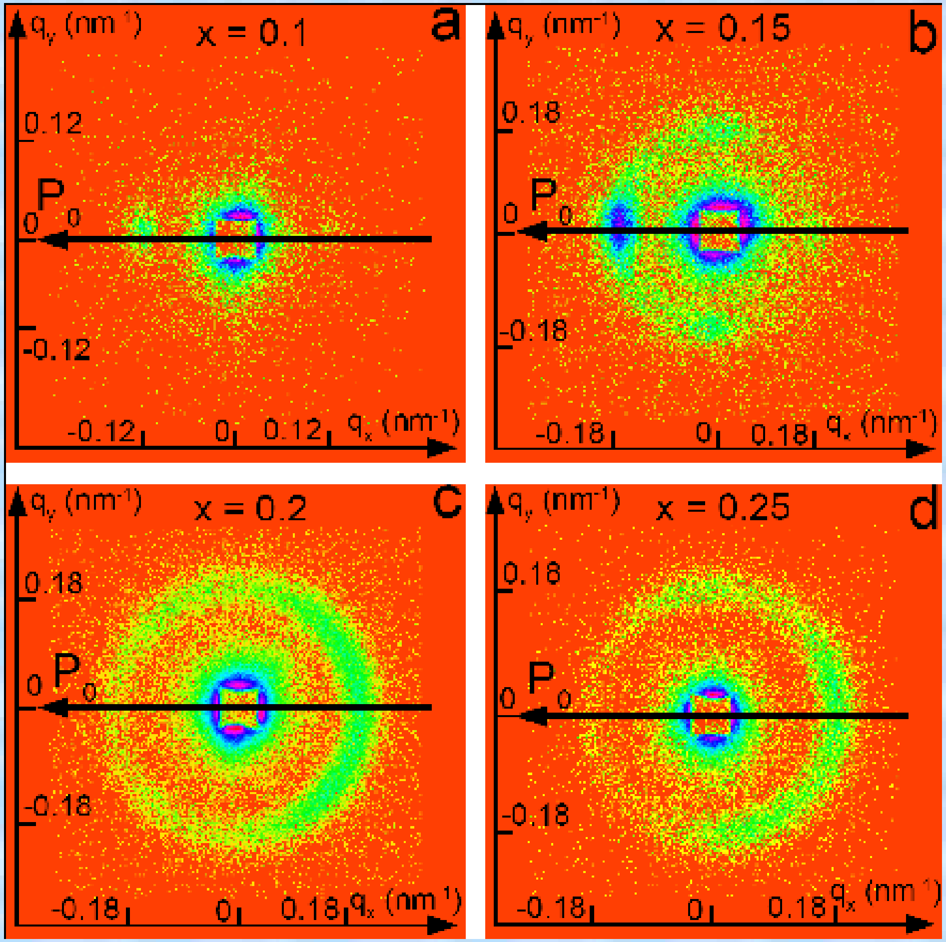
$$\vec{C}=[\vec{r}_2\times\vec{r}_3]+[\vec{r}_3\times\vec{r}_4]+[\vec{r}_4\times\vec{r}_2]$$

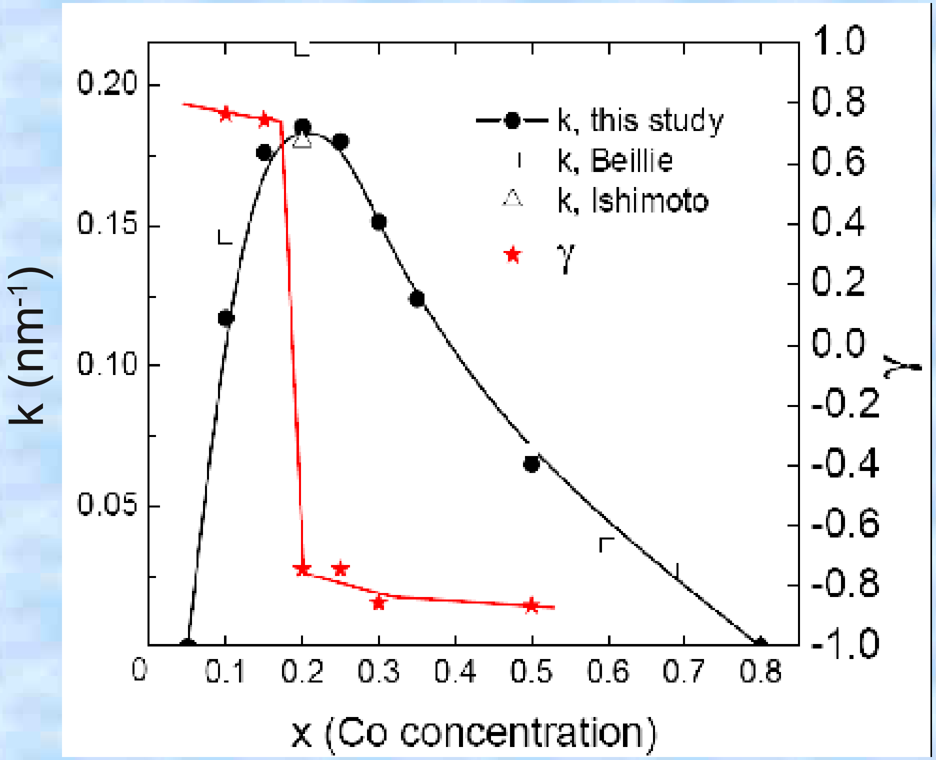
$$\vec{C}=(\frac{1}{4}+u+4u^2,\frac{1}{4}+u+4u^2,\frac{1}{4}+u+4u^2)$$

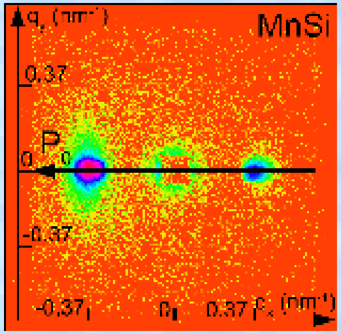
 Si, $u_{si} = 0.845$

 Me, $u_{Mn} = 0.138$

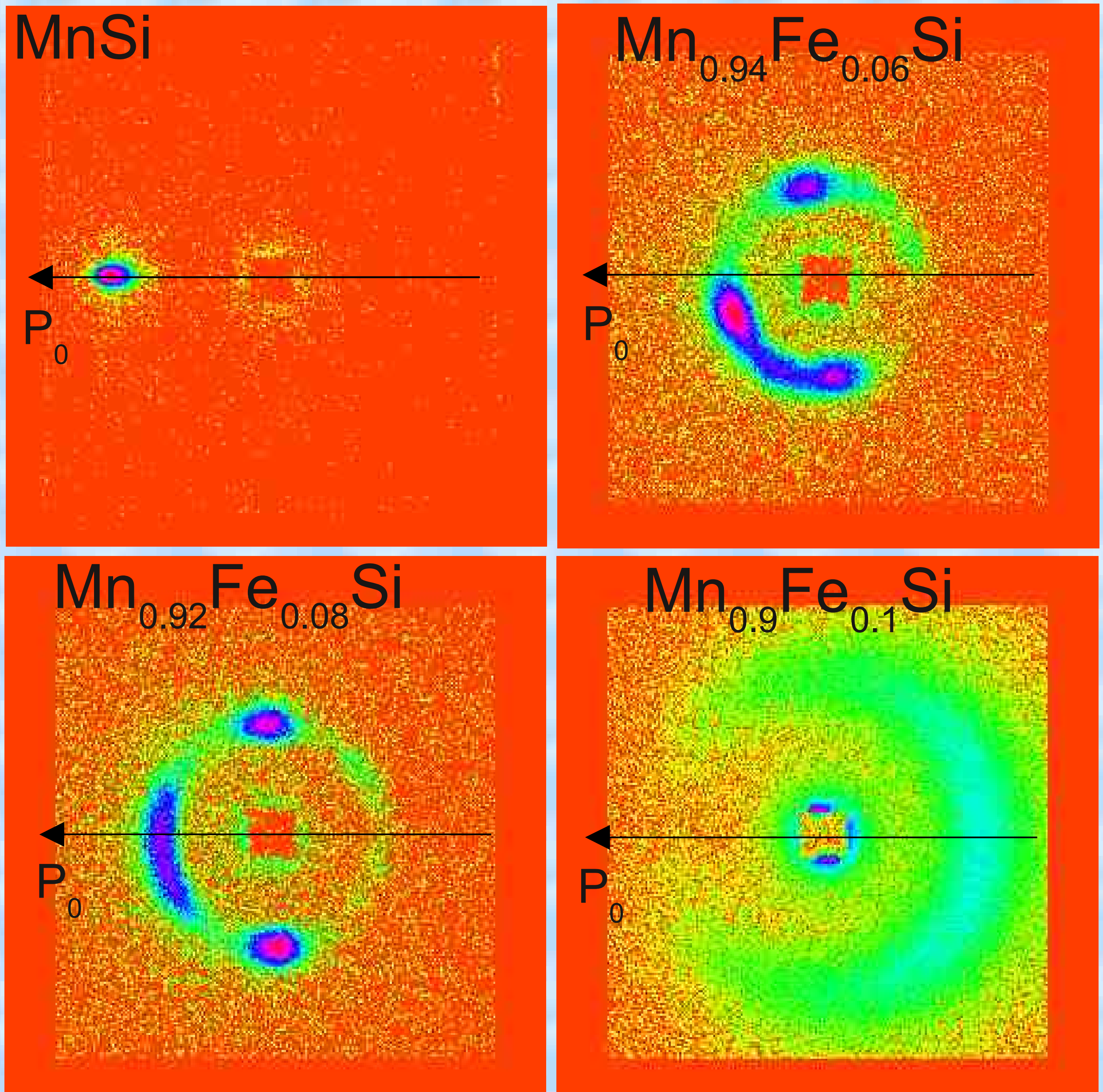
Magnetic chirality of $Fe_{1-x}Co_xSi$







Magnetic chirality of $Mn_{1-y}Fe_ySi$

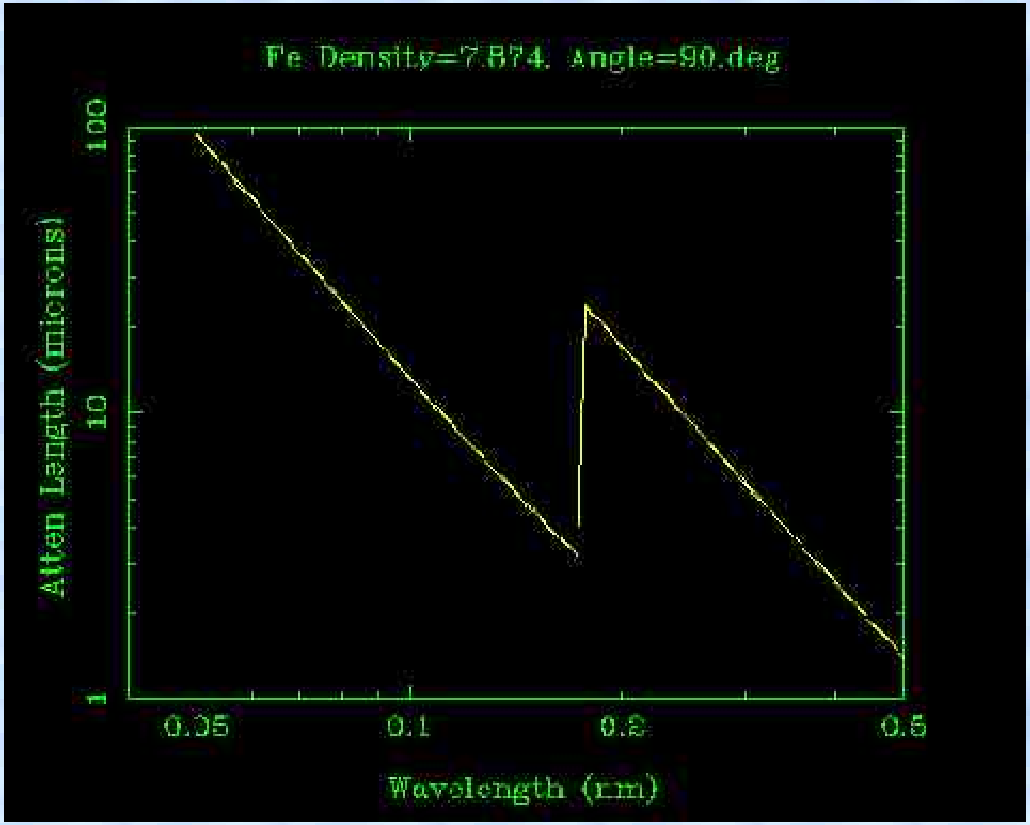


Flack parameter

$$I(hkl) - I(\bar{h}\bar{k}\bar{l}) = 0$$ Friedel's law

$$I(hkl) - I(\bar{h}\bar{k}\bar{l}) = (1-2x)\left[|F(hkl)|^2 - |F(\bar{h}\bar{k}\bar{l})|^2\right]$$

$$F(\boldsymbol{Q}) = \sum_j (f_j + i f_j'')\exp(i\boldsymbol{Q}\boldsymbol{r}_j)$$



Structure

PRL 102, 037204 (2009) PHYSICAL REVIEW LETTERS week ending 23 JANUARY 2009

Crystal Handedness and Spin Helix Chirality in $Fe_{1-x}Co_xSi$

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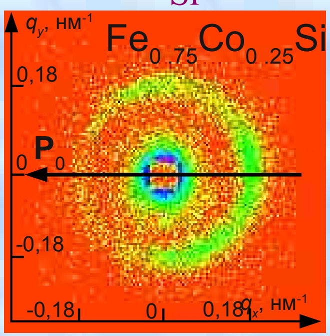
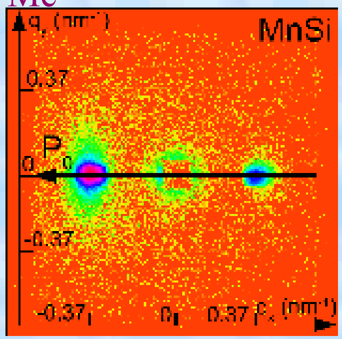
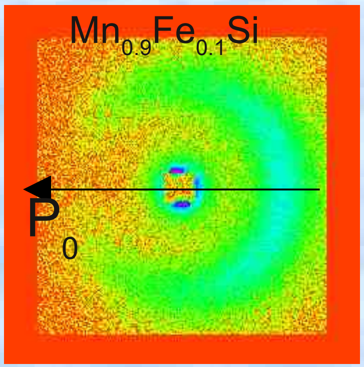
D. Menzel,[3] J. Schoenes,[3] and H. Eckerlebe[4]

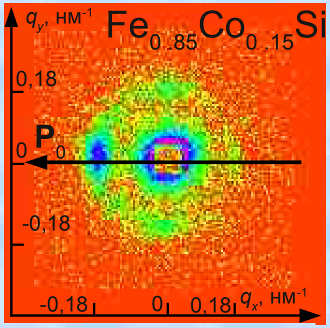
$u_{Si} = 0.846$ $u_{Me} = 0.138$

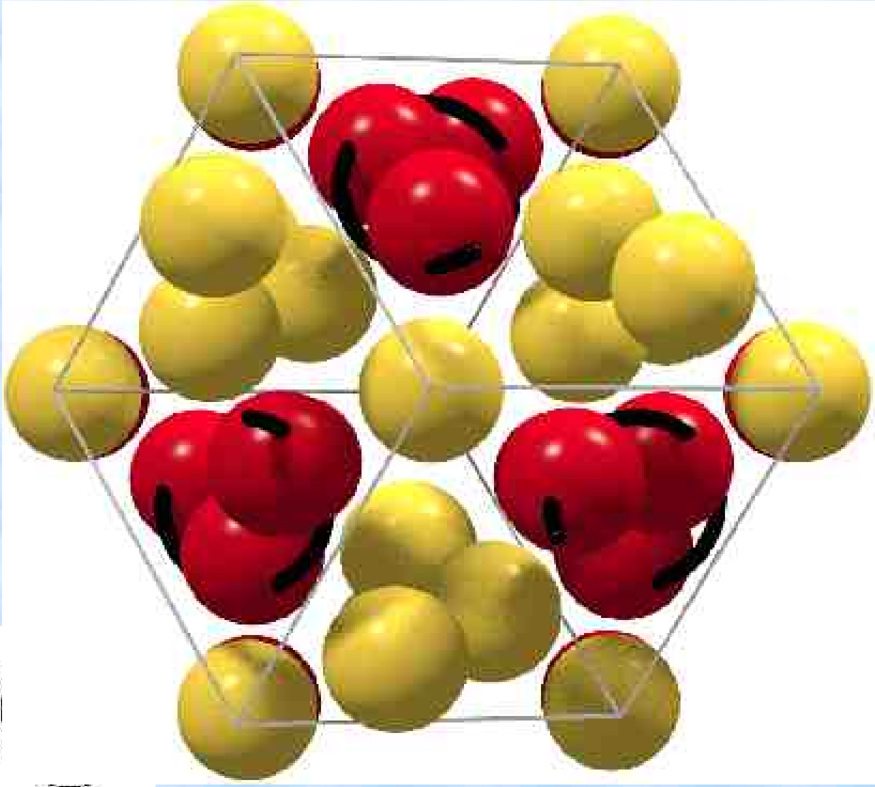


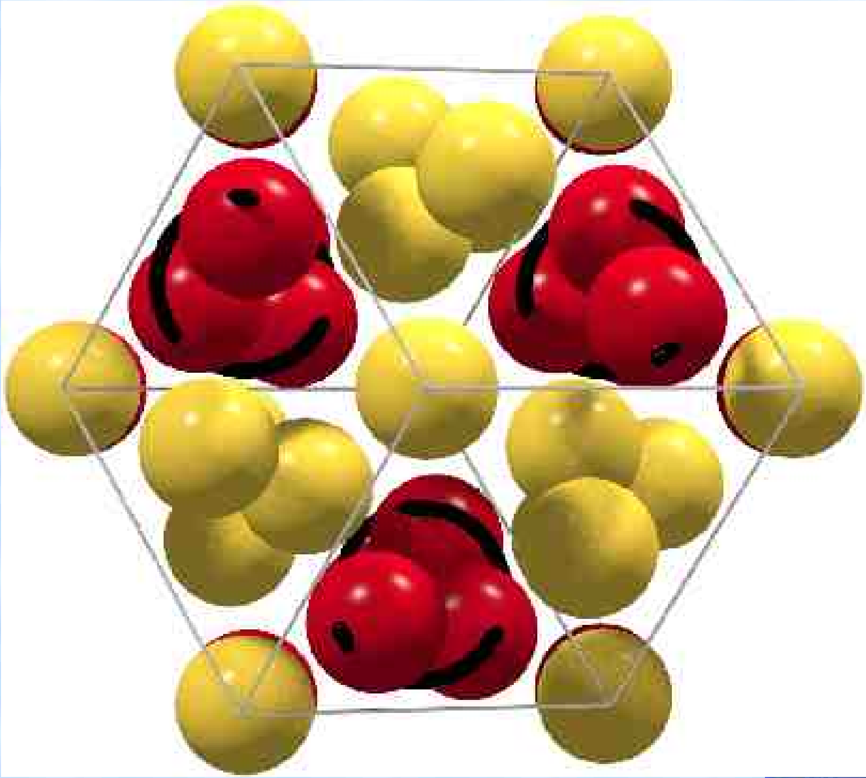


$u_{Si} = 0.155$ $u_{Me} = 0.863$

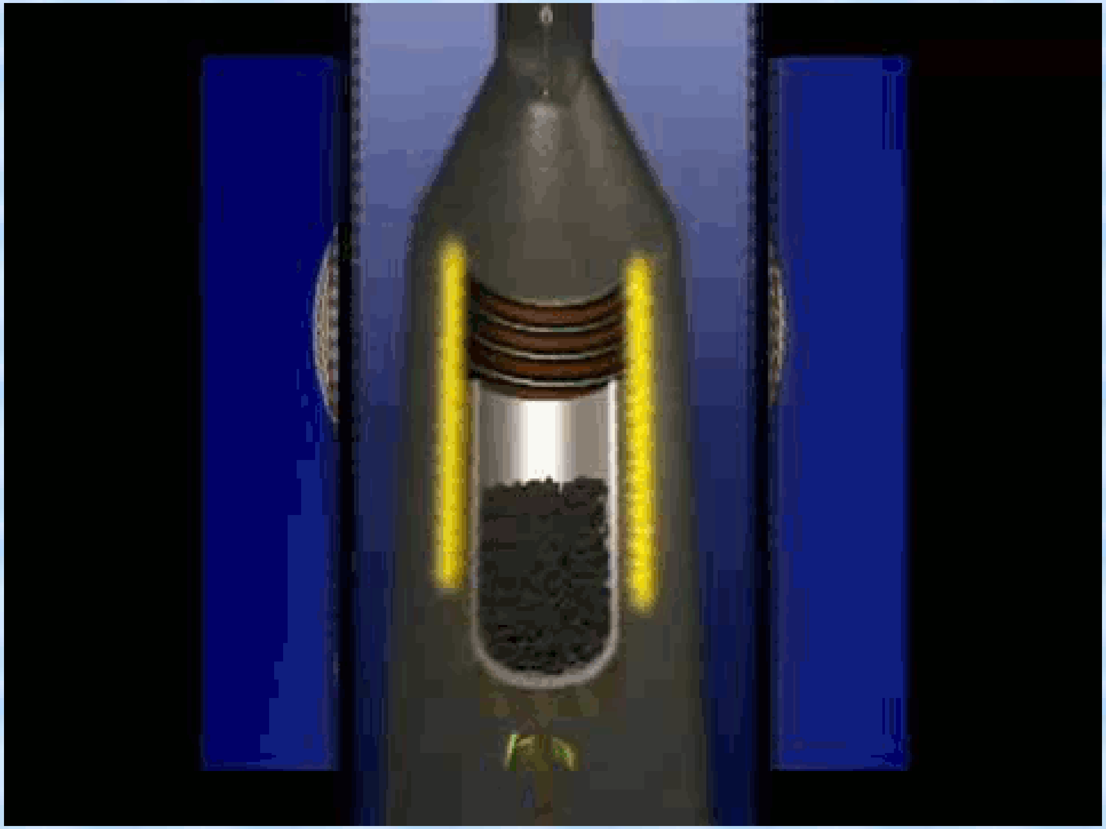








Czochralski growth

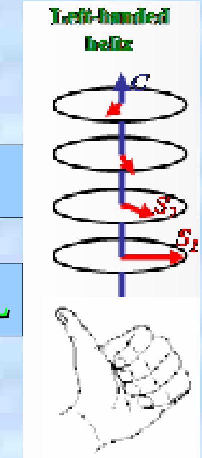


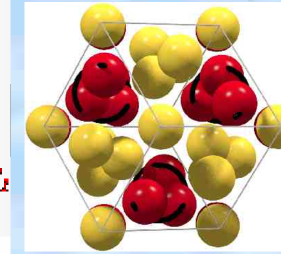
Magnetic chirality of FeCoSi

P: x = 0.08 L

F1: x = 0.08 L

F2: x = 0.10 L | x = 0.15 L | x = 0.20 L | x = 0.30 L | x = 0.50 L

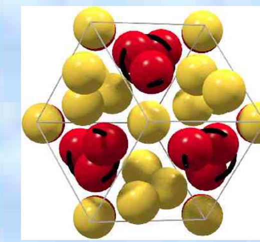




P: x = 0.25 R

F1: x = 0.50 R

F2: x = 0.10 R | x = 0.15 R | x = 0.20 R | x = 0.25 R | x = 0.30 R | x = 0.50 R | x = 0 R



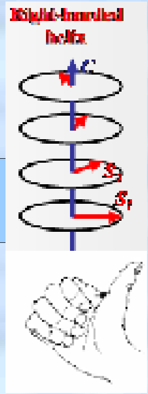
P: x = 0.10 L

F1: x = 0.10 R

F2: x = 0.10 R | x = 0.15 L | x = 0.20 R | x = 0.25 R | x = 0.30 R | x = 0.50 R | x = 0 R

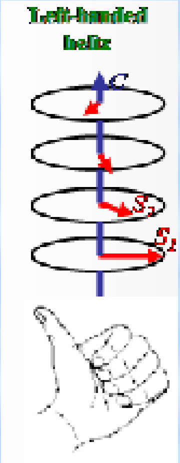
L, R — magnetic chirality

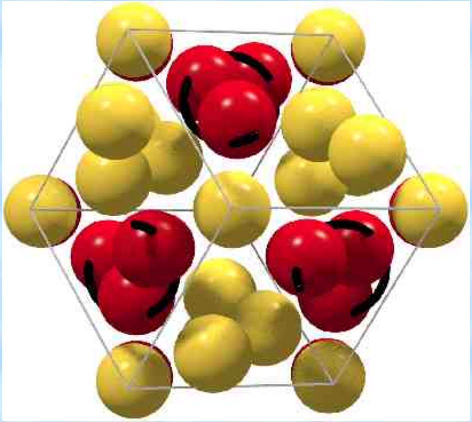
Magnetic chirality of MnSi



F1 | FeCoSi with x_{Co} = 0.50 R L

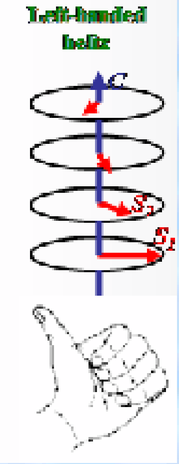
F2 | MnSi L L | MnSi L L | MnSi L L





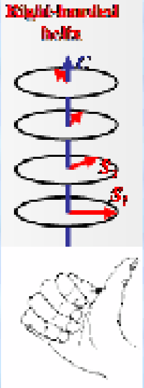
L, R — magnetic chirality

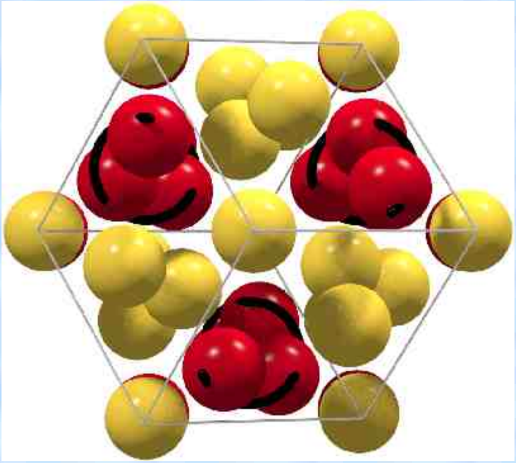
L, R — structural chirality



F1 | FeCoSi with x_{Co} = 0.08 L R

F2 | MnSi R R | MnSi R R | MnSi R R





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YOU for your attention