Магнитная структура соединений $Tb(Ni_{1-x}Mn_x)_2Si_2$

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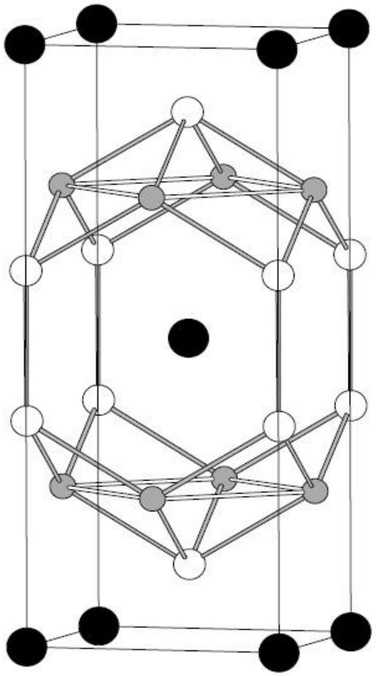
Crystal structure of RM_2X_2 compounds



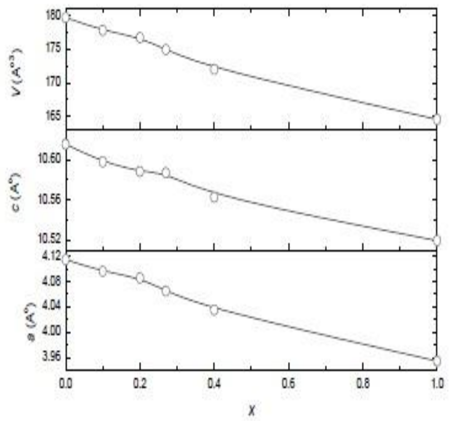
Space group is I/4mmm.
Structure type is $ThCr_2Si_2$
Elementary cell :
$a \approx 4$ Å
$c \approx 10$ Å
Black signs are R ions : (0, 0, 0),
gray signs are M atoms : (0, 0.5, 0.25),
white signs are X atoms : (0, 0, z), z ≈ 0.37

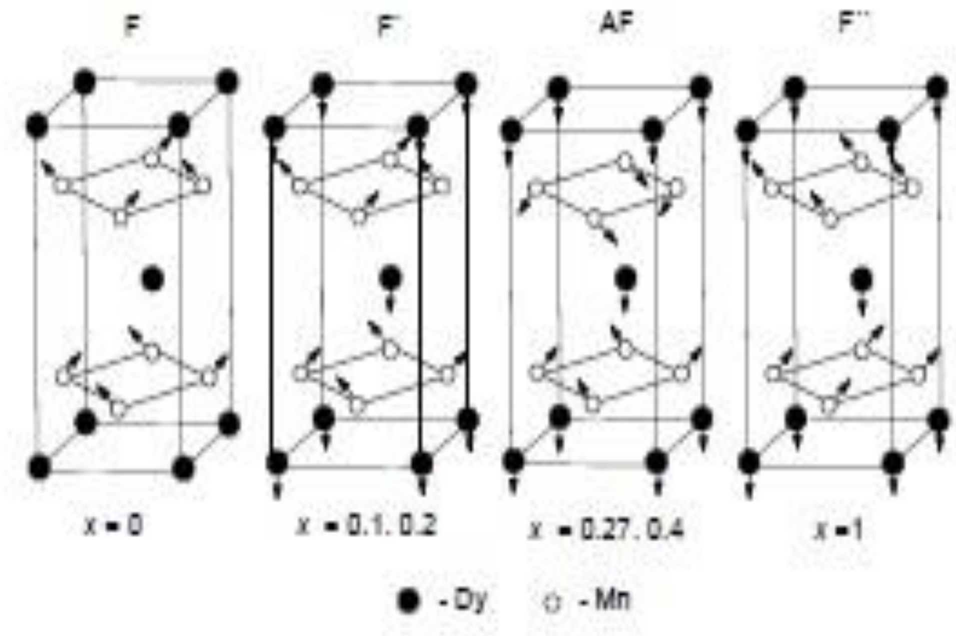
Motivation

Sequence of layers R – X – M – X- R forms a natural layered structure.

So, the RM_2X_2 compounds may be considered as a model object of quasi two-dimensional magnet and a model object of multilayered structures.

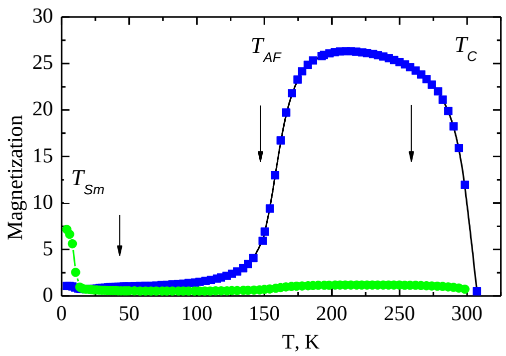
Dependency of magnetic ordering type on interatomic distance in $La_{1-x}Dy_xMn_2Si_2$

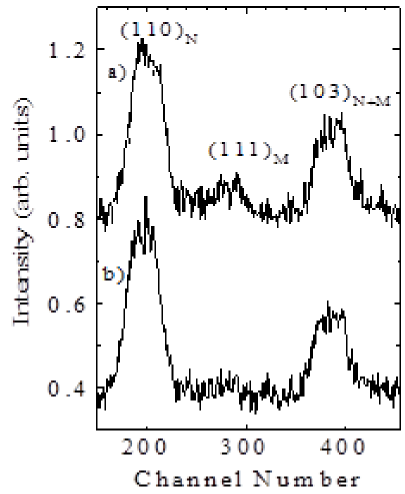


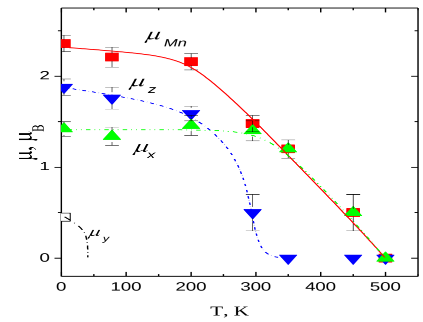


Ferro-antiferromagnetic transition occurs at critical concentration is x = 0.27

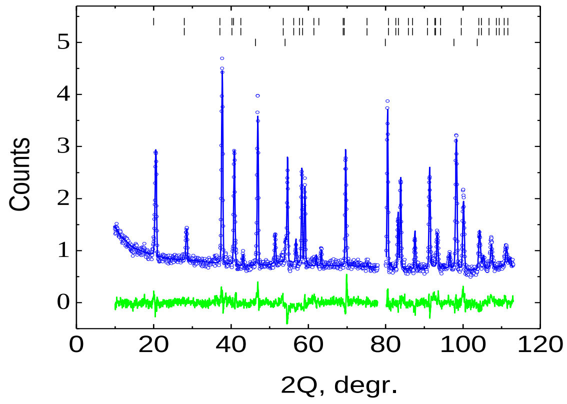
Dependency of magnetic ordering type on interatomic distance in $La_{0.75}Sm_{0.25}Mn_2Si_2$







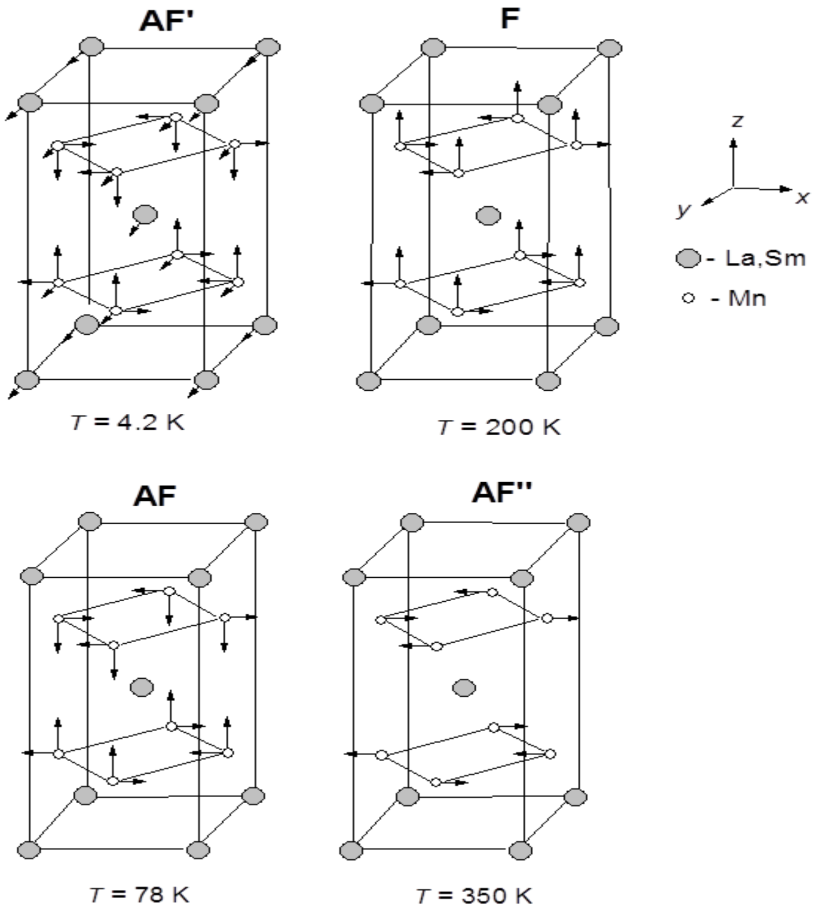
The part of the neutron diffraction pattern near the (111) magnetic peak:
a) 140K and b) 155 K



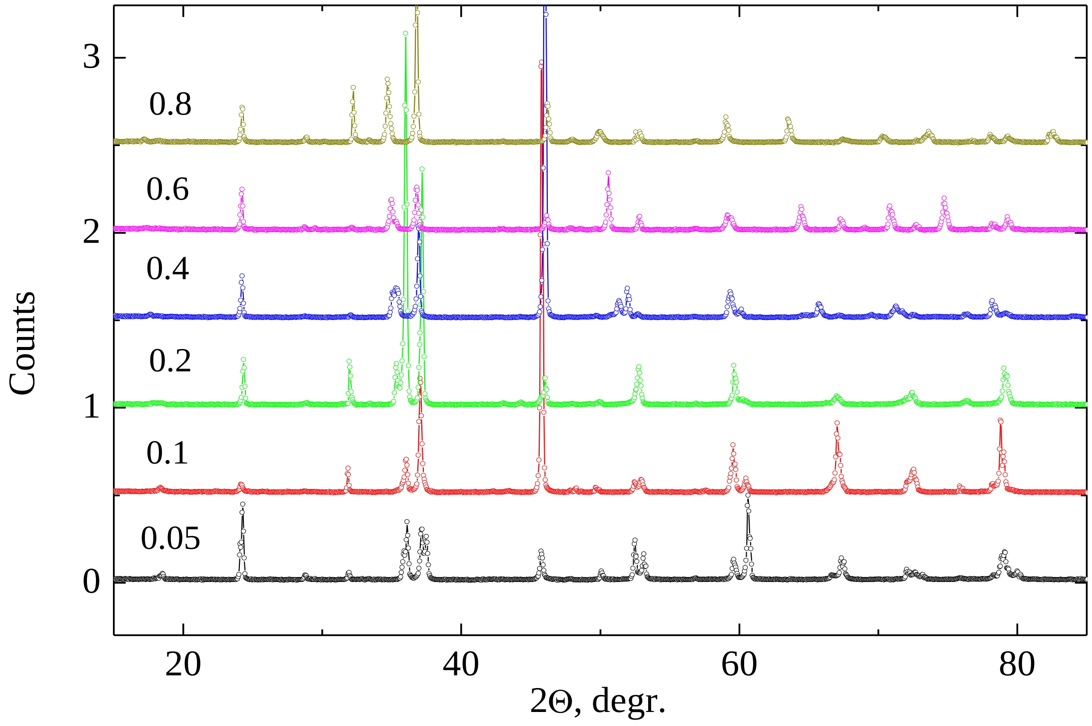
T, K	a, nm	c,nm	z	R_N %	R_M %	Mag. state
4.2	0.4058(2)	1.059(5)	0.378(9)	7.3	9.7	AF
78	0.4049(1)	1.058(3)	0.379(6)	10.3	13.2	AF
200	0.4077(2)	.058(1)	0.378(5)	8.2	8.3	F
295	0.4081(1)	.060(1)	0.378(1)	6.5	6.3	F
350	0.4086(5)	.065(1)	0.376(2)	11.0	15.1	AF'
450	0.4088(3)	.061(2)	0.376(3)	10.5	16.3	AF"
500	0.4095(6)	.064(2)	0.379(1)	9.6	-	Para.

$d_{cr} \approx 2.86$ Å

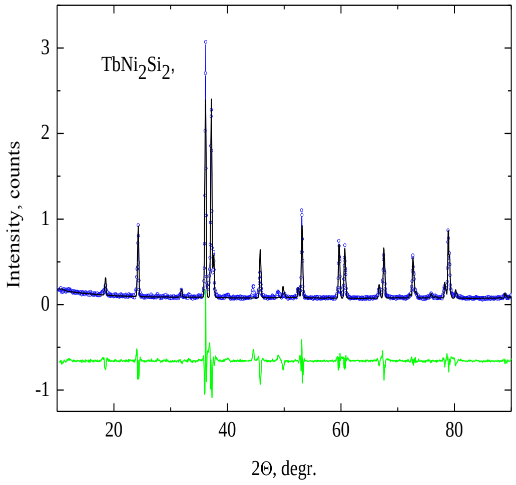
Magnetic structures in $La_{0.75}Sm_{0.25}Mn_2Si_2$

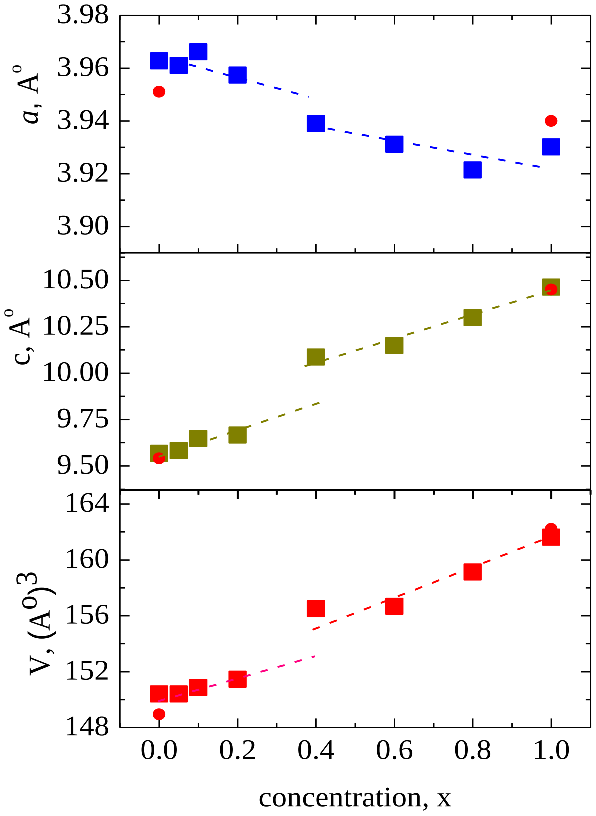


X-ray diagrams of $Tb(Ni_{1-x}Mn_x)_2Si_2$ compounds

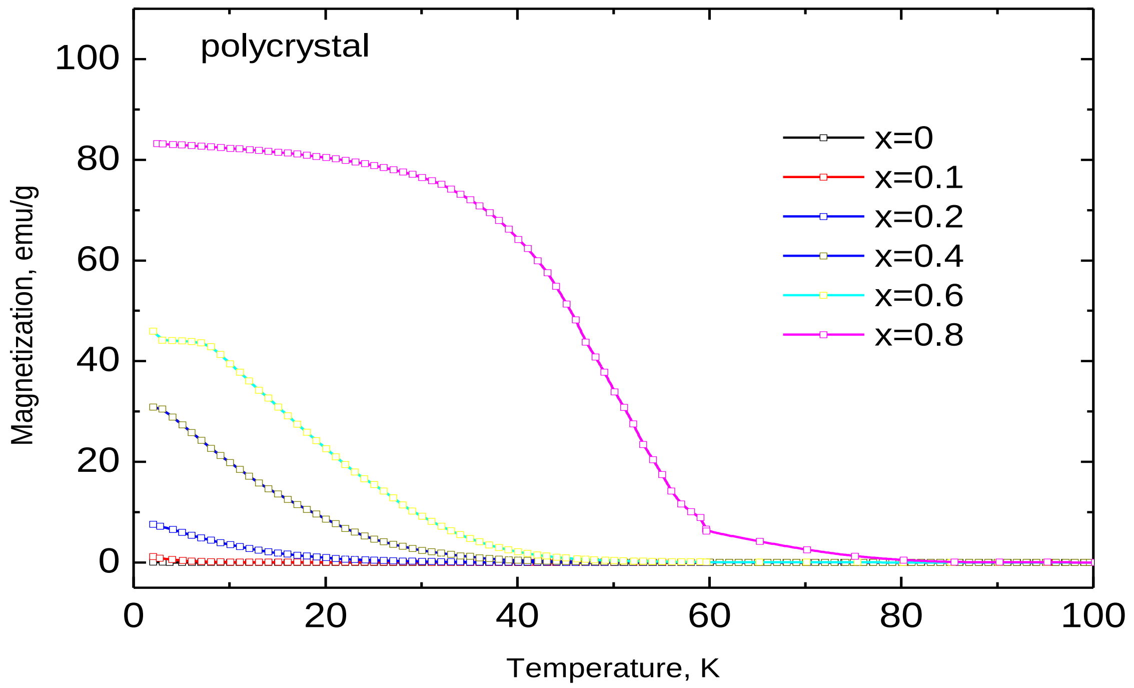


Concentration dependency of lattice parameters in $Tb(Ni_{1-x}Mn_x)_2Si_2$ compounds

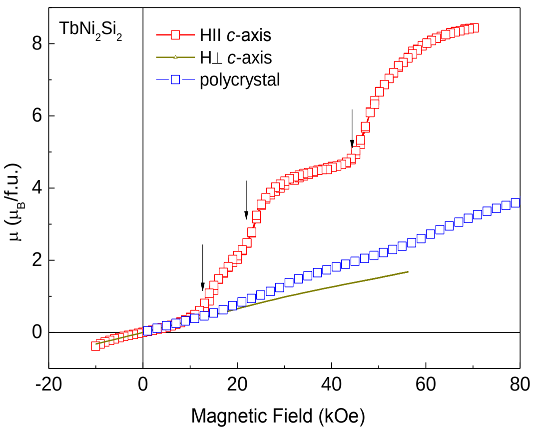


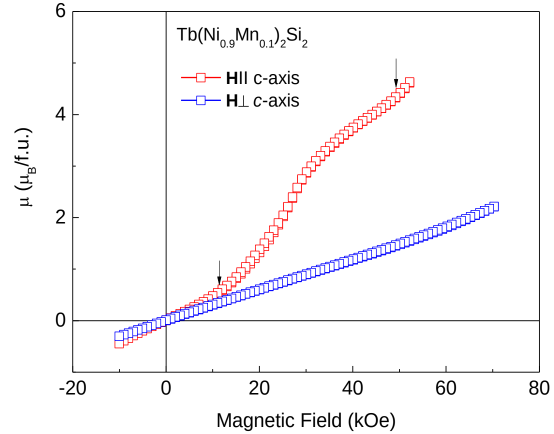


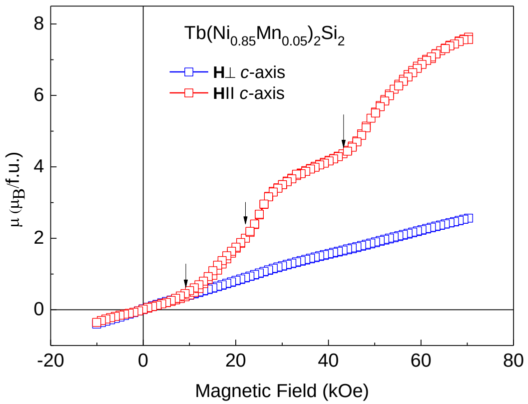
Temperature dependencies of magnetization of $Tb(Ni_{1-x}Mn_x)_2Si_2$ compounds at 50 Oe

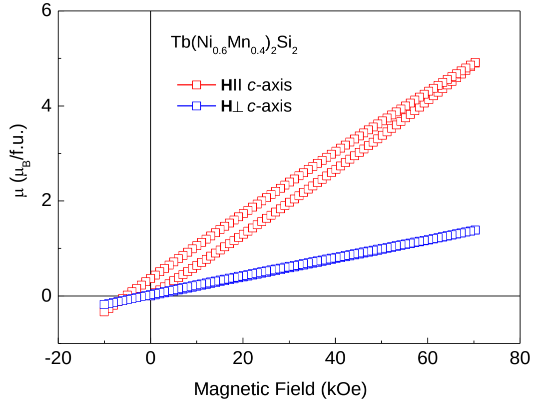


Magnetization curves for $Tb(Ni_{1-x}Mn_x)_2Si_2$ along and across *c*-axis

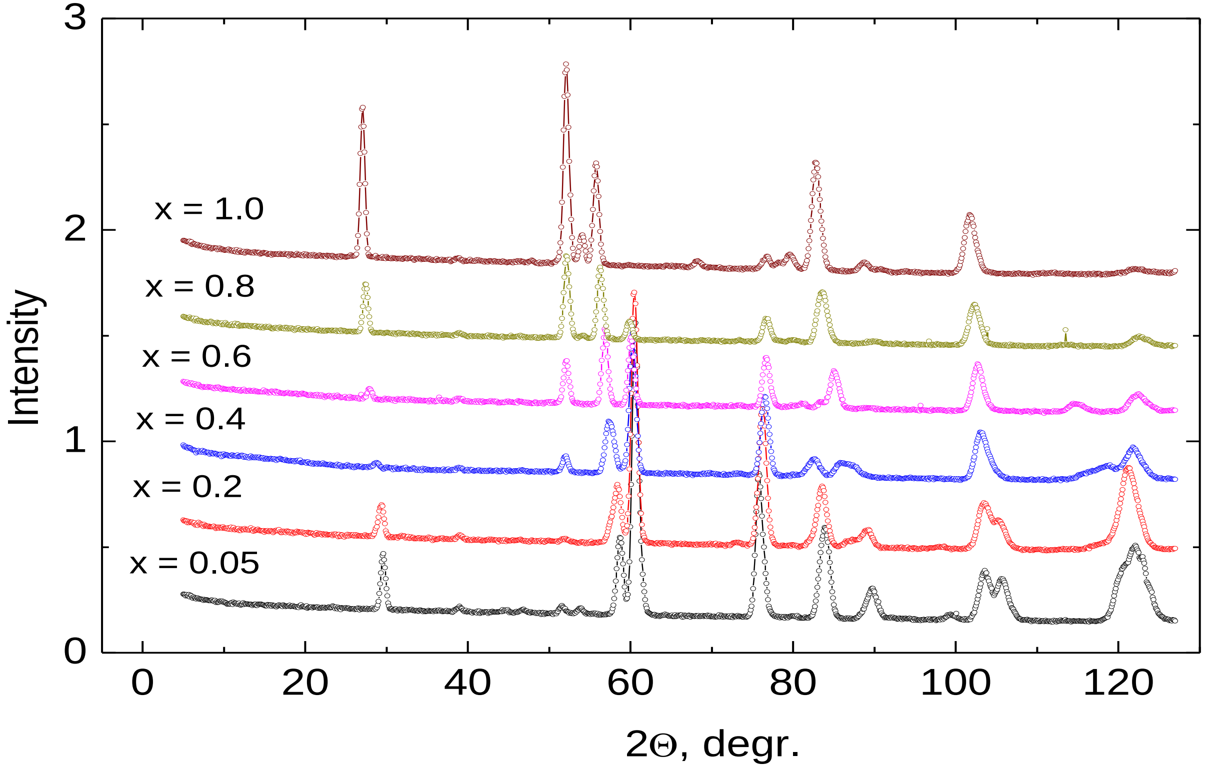




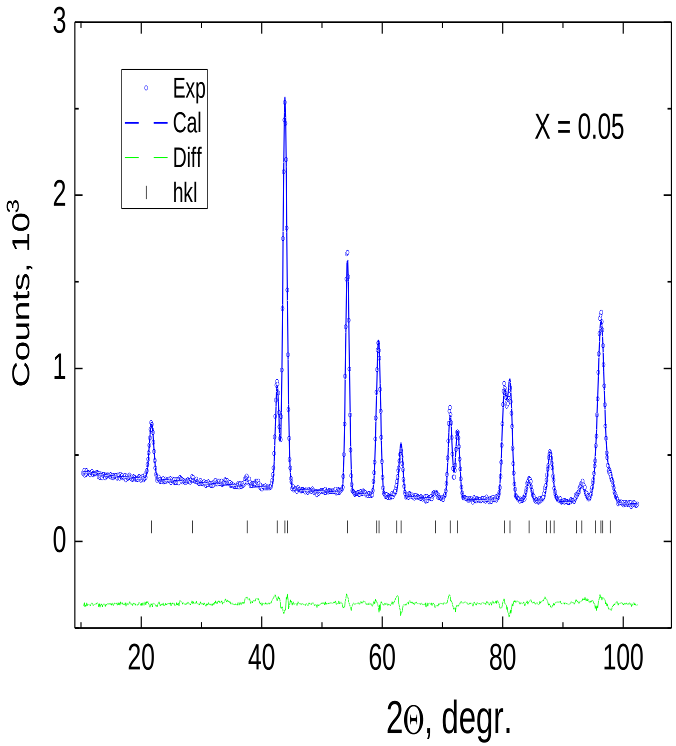


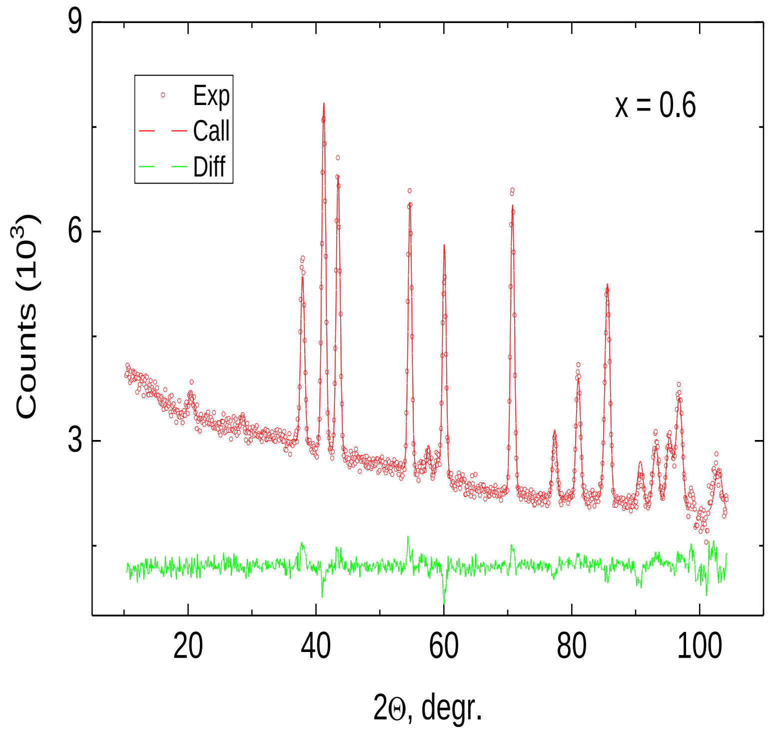


Neutron diffraction patterns of $Tb(Ni_{1-x}Mn_x)_2Si_2$ at 293 K

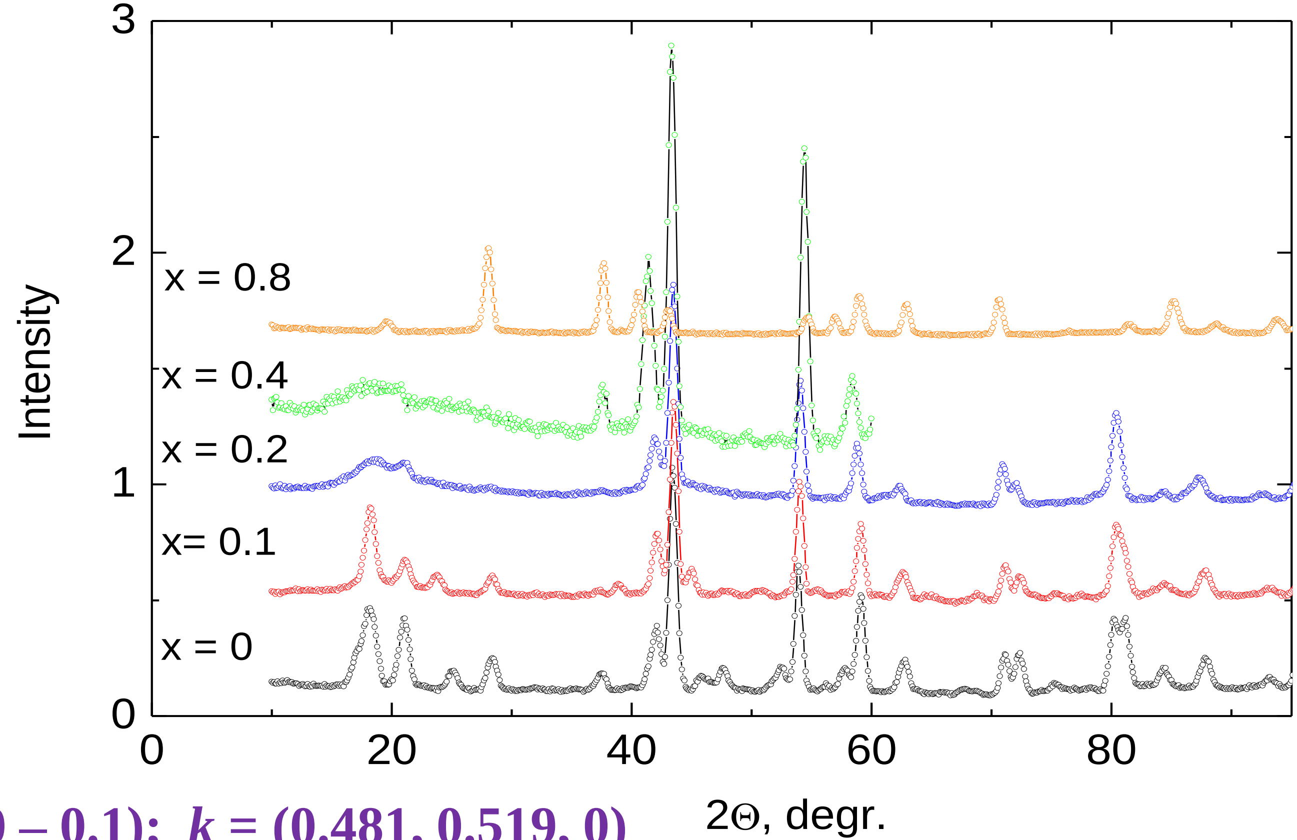


Observed and calculated neutron diagrams of $Tb(Ni_{1-x}Mn_x)_2Si_2$ at 293 K





Neutron diffraction patterns of $Tb(Ni_{1-x}Mn_x)_2Si_2$ at 4.2 K



x = (0 – 0.1); *k* = (0.481, 0.519, 0)

Symmetry analysis

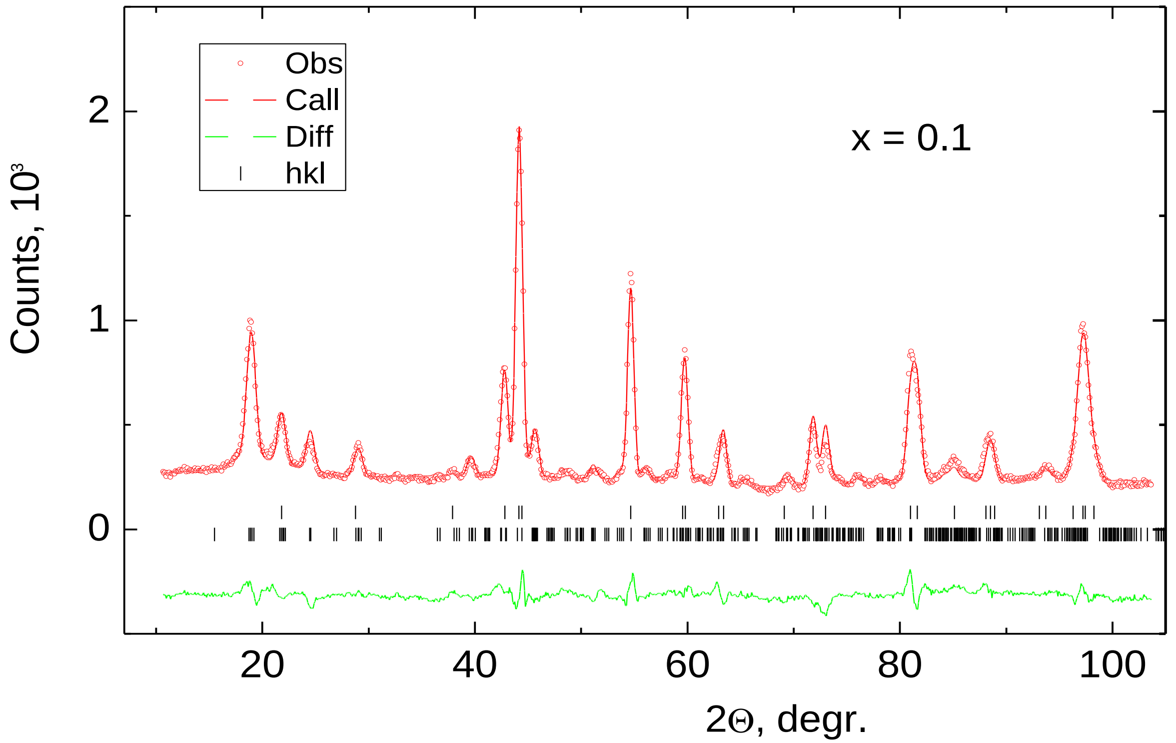
$$\vec{k}_8 = \frac{2\pi}{a}\left(\frac{1-2\mu}{2},\frac{1+2\mu}{2},0\right)$$

Irreducible representations for ***{k₈}***.

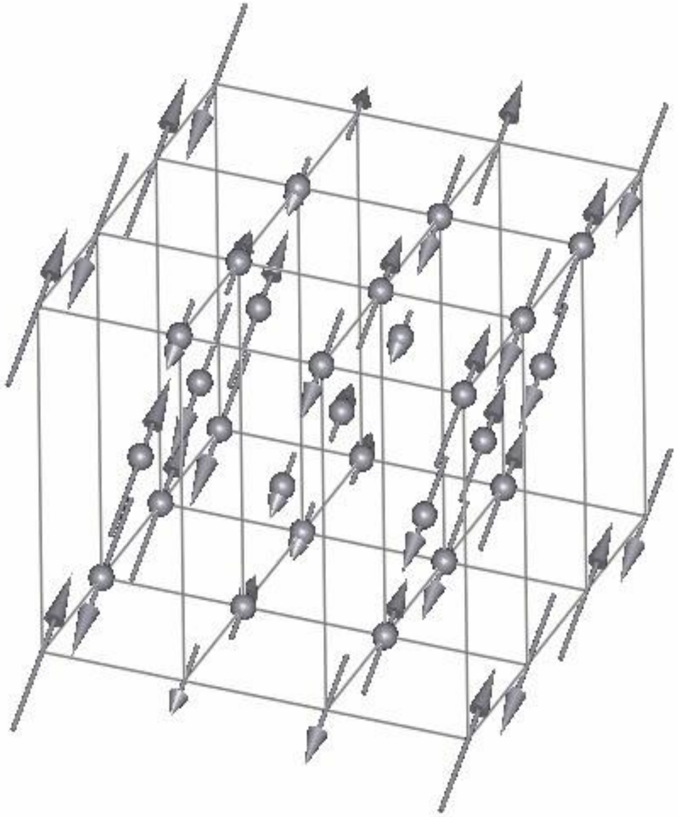
T175	h_1	h_{13}	h_{28}	h_{40}	T175	h_1	h_{13}	h_{28}	h_{40}
τ_1	1	1	1	1	τ_3	1	−1	1	−1
τ_2	1	1	−1	−1	τ_4	1	−1	−1	1

Representations	Position *2(a)*	
	1(0 0 0)	2(1/2 1/2 1/2)
τ_2	1 -10	-11 0
τ_3	0 0 1	0 0-1
τ_4	1 1 0	-1-10

Observed and calculated neutron diagrams of $Tb(Ni_{0.9}Mn_{0.1})_2Si_2$ at 4.2 K



Magnetic structure of $Tb(Ni_{0.9}Mn_{0.1})_2Si_2$ at 4.2 K

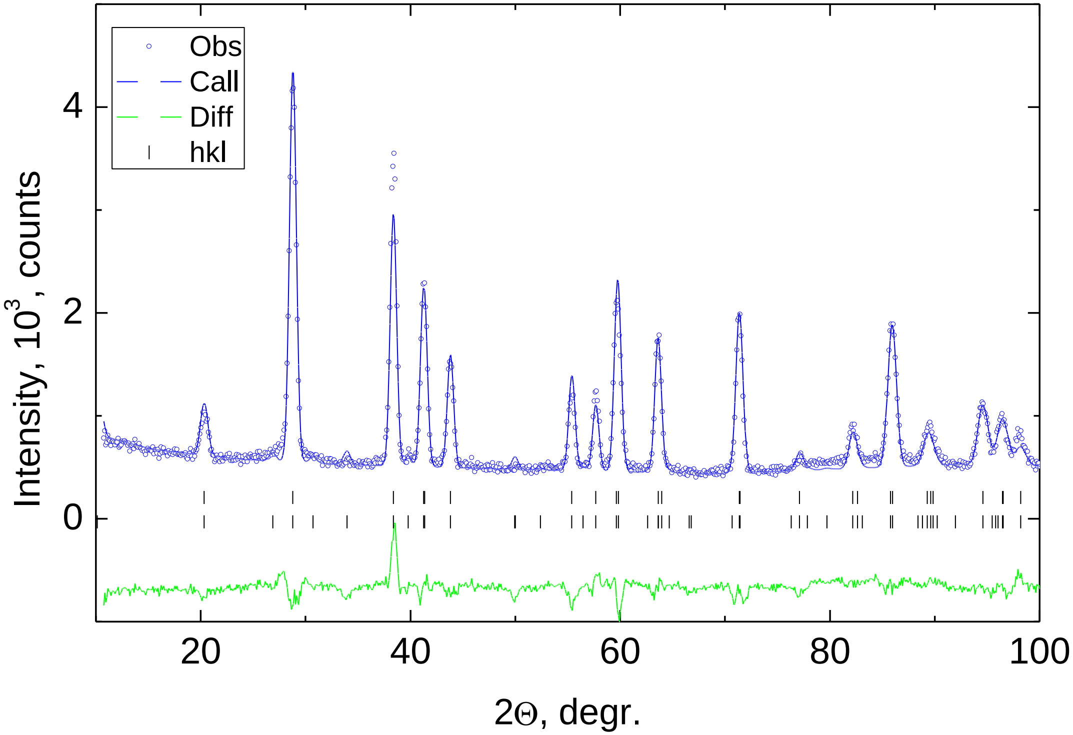


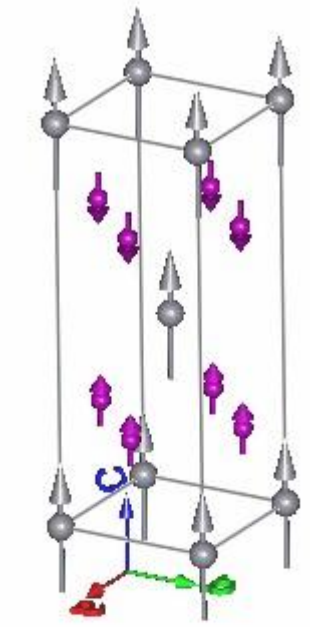
Basis functions, k = 0

Representations	Position 2(a)	
	1(0 0 0)	2(1/2 1/2 1/2)
τ_3	0 0 1	0 0 1
τ_9	1 $\bar{1}$ 0 1 1 0	1 1 0 1 1 0

Representations	Position 4(d)			
	1(0 1/2 1/4)	2(0 1/2 3/4)	3(1/2 0 3/4)	4(1/2 0 1/4)
τ_3 τ_6	0 0 1 0 0 1	0 0 1 0 0 $\bar{1}$	0 0 1 0 0 1	0 0 1 0 0 $\bar{1}$
τ_9	1 $\bar{1}$ 0 1 1 0	1 $\bar{1}$ 0 1 1 0	1 $\bar{1}$ 0 1 1 0	1 $\bar{1}$ 0 1 1 0
τ_{10}	1 $\bar{1}$ 0 $\bar{1}$ $\bar{1}$ 0	$\bar{1}$ 1 0 1 1 0	1 $\bar{1}$ 0 $\bar{1}$ $\bar{1}$ 0	$\bar{1}$ 1 0 1 1 0

Observed and calculated neutron diagrams of $Tb(Ni_{0.2}Mn_{0.8})_2Si_2$ at 4.2 K





Conclusion

For the $La_{1-x}R_xMn_2Si_2$ compounds the type of the Mn-Mn interlayer magnetic ordering changes from ferromagnetic to antiferromagnetic And becomes again ferromagnetic with increasing *R* content.

The changes in the type of the interlayer Mn-Mn ordering in $La_{1-x}R_xMn_2Si_2$ are caused by both the existence of the critical intralayer Mn-Mn distance.

Commensurate-incommensurate magnetic phase transition occurs in $Tb_{1-x}R_xMn_2Si_2$ at $x \approx 0.2$ through short-range phase.

Thank you for attention!