The XXVI International Scientific Conference of Young Scientists and Specialists (AYSS-2022)

Phase transition of nanostructured zinc ferrite spinel at high pressure

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Plan

1. What are complex oxides of iron?

- Ferrites are perspective compounds
- Brief description of structure and physical properties of complex oxides of iron

2. Neutron diffraction experiment

- Experimental method
- Crystal and magnetic structure of $Zn_{0.34}Fe_{2.53}O_4$ in wide temperature range

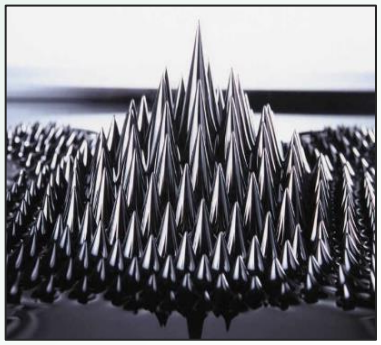
3. X-ray diffraction experiment

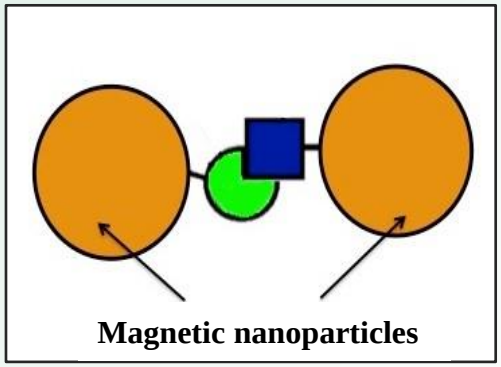
- Experimental method
- Crystal structure of $Zn_{0.34}Fe_{2.53}O_4$ in wide pressure range

Summary

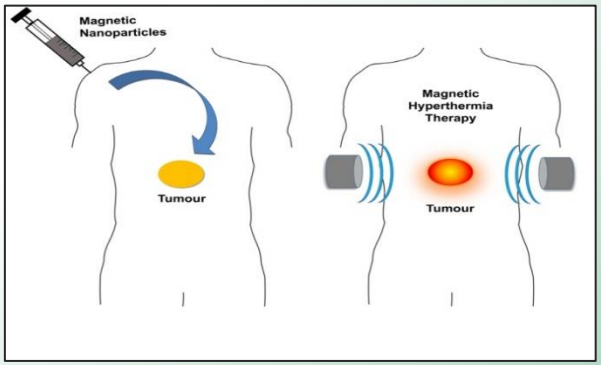
Complex iron oxides applications

- ✓Significant saturation magnetization
- ✓High electrical resistivity
- ✓Low electrical losses
- ✓High chemical stability

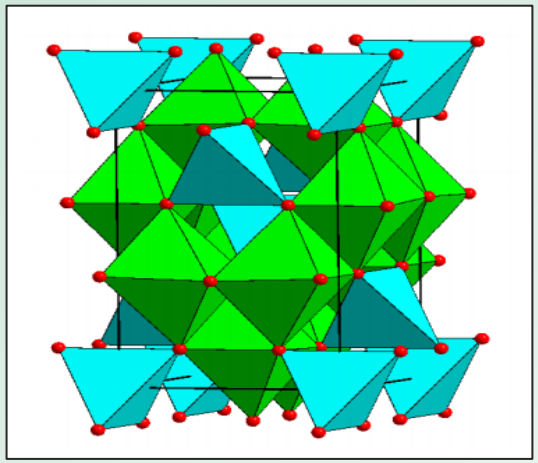




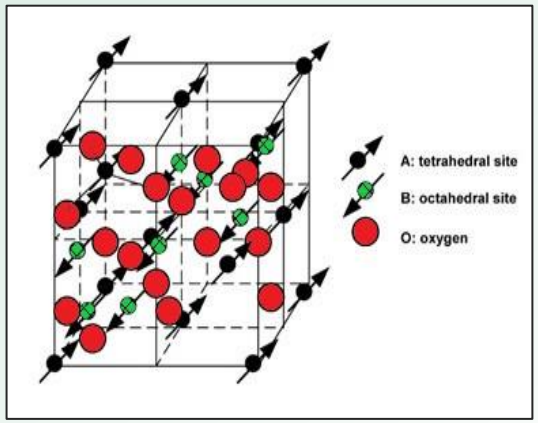
Magnetic nanoparticles



Structure and properties of complex iron oxides



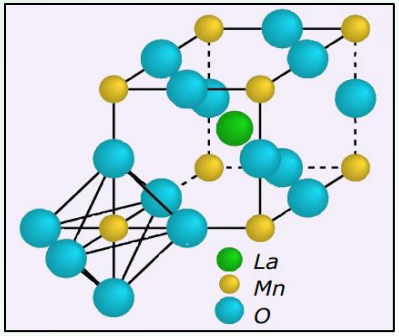
The spinel structure (AB_2O_4) is represented by the densest face-centered cubic lattice. Metal cations are distributed between two crystallographic positions: **tetrahedral (A-site)** and **octahedral (B-site).**



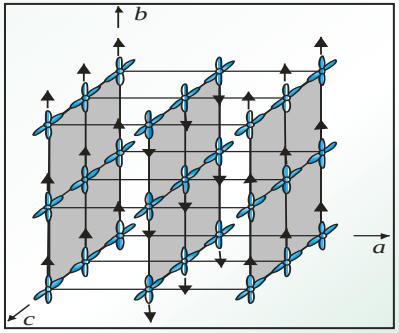
The magnetic properties of spinel ferrites is forming by the exchange interaction between the electrons of the ions in the A and B sublattices. Usually, the **A - B interaction** is the strongest. The **A - A interaction** is almost ten times weaker, and the **B - B interaction** is the weakest. The dominant interaction A - B leads to **ferrimagnetic ordering**.

Experimental method: Neutron Diffraction

- Neutron is **sensitivity to the light atoms** such as oxygen. It is give as opportunity to determine location of oxygen with precision.

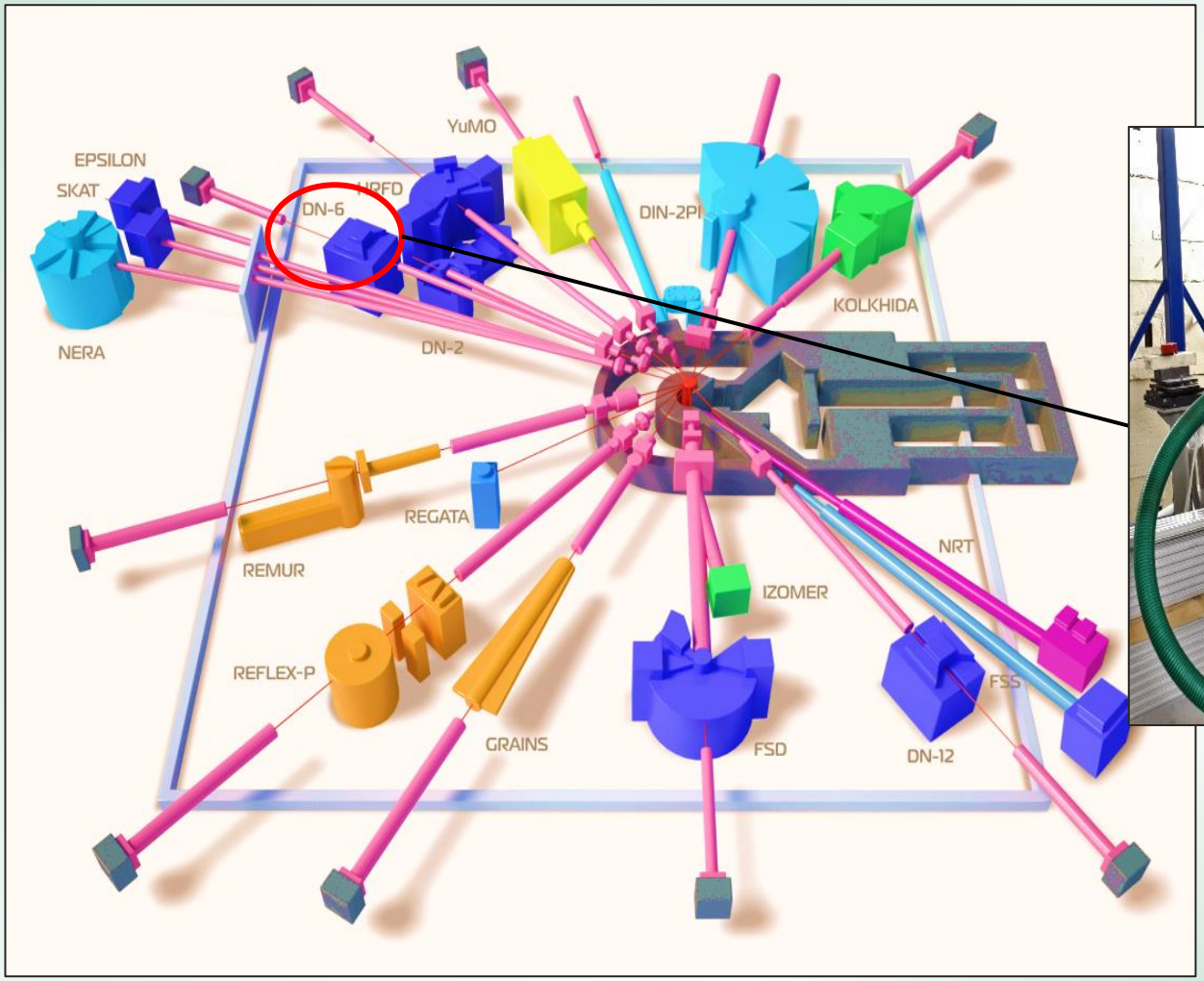


- Another advantage of the neutron is **sensitivity to the magnetic structure** and dynamics of the magnetic substance.

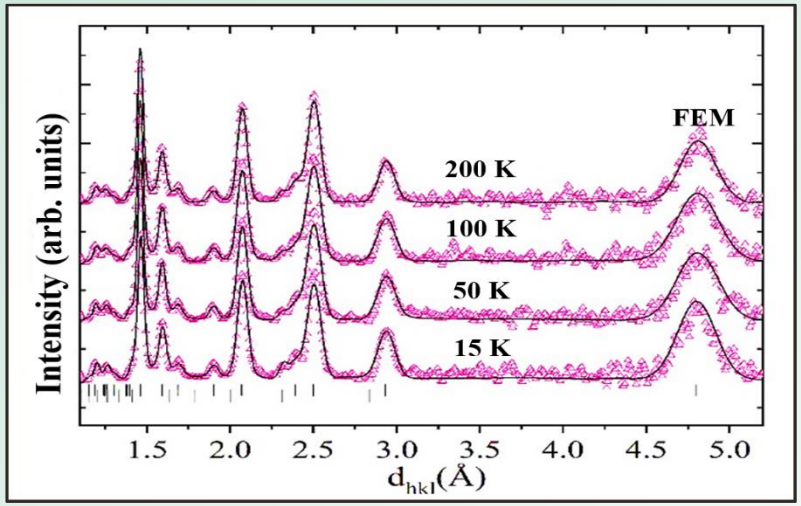


- An important is the **high penetrating power of neutrons**, which gives opportunities for working with high-pressure cells and devices for changing the temperature on the sample.

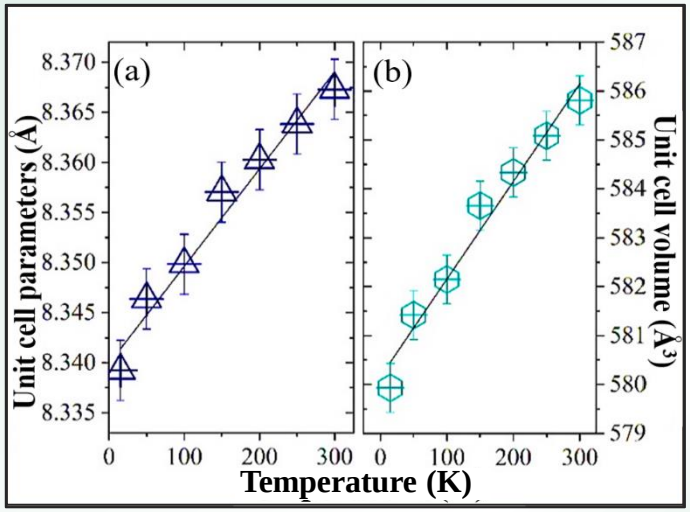
Experimental method: Neutron diffractometer DN-6



Crystal structure of ferrite $Zn_{0.34}Fe_{2.53}O_4$ in wide temperature range

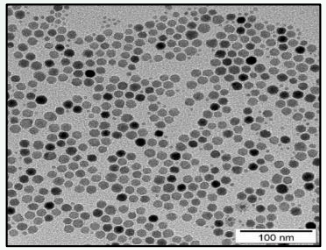


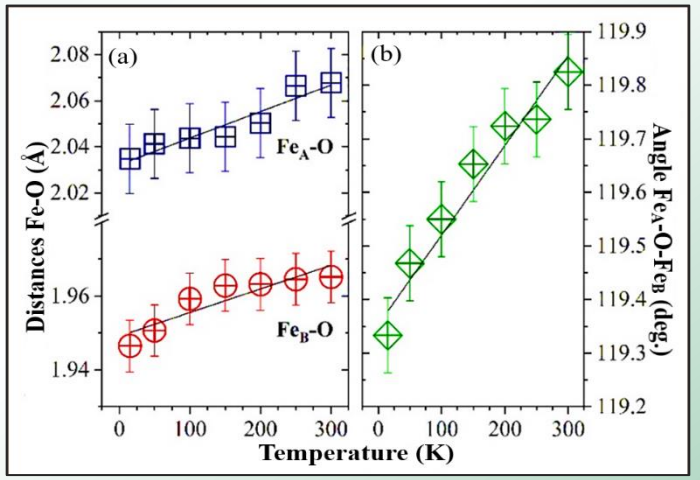
T, K



$(Fe^{3+}_{0.82}Zn^{2+}_{0.18})[Fe^{3+}_{1.44}Fe^{2+}_{0.27}Zn^{2+}_{0.16}\square_{0.13}]O_4$

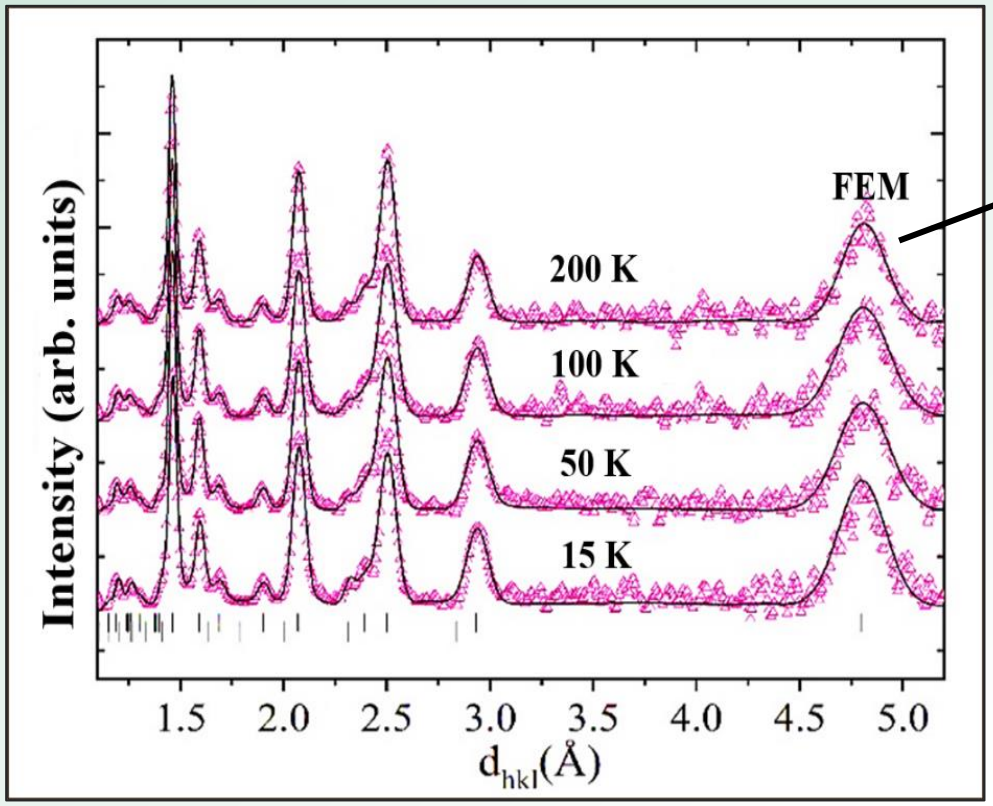
Unit cell parameters		
a, Å		8.331(3)
α, K^{-1}		$1.26(2) \cdot 10^{-5}$
Atomic occupations		
A site:	Zn	0.18(1)
	Fe	0.82(2)
B site:	Zn	0.16(1)
	Fe	1.71(3)
	vacancy	0.13(2)

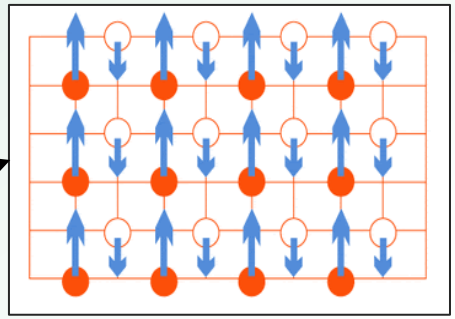




Belozerova N.M., Kichanov S.E., Kozlenko D.P., et al., Neutron diffraction study of the crystal and magnetic structures of nanostructured $Zn_{0.34}Fe_{2.53}O_4$ ferrite. *Journal of Nanoparticle Research*, 22(5), 1-9 (2020).

Magnetic structure of ferrite $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ in wide temperature range





Magnetic moment			
T=15 K		T=300 K	
M_A, μ_B	3.1(4)	M_A, μ_B	2.7(4)
M_B, μ_B	3.9(4)	M_B, μ_B	3.6(4)

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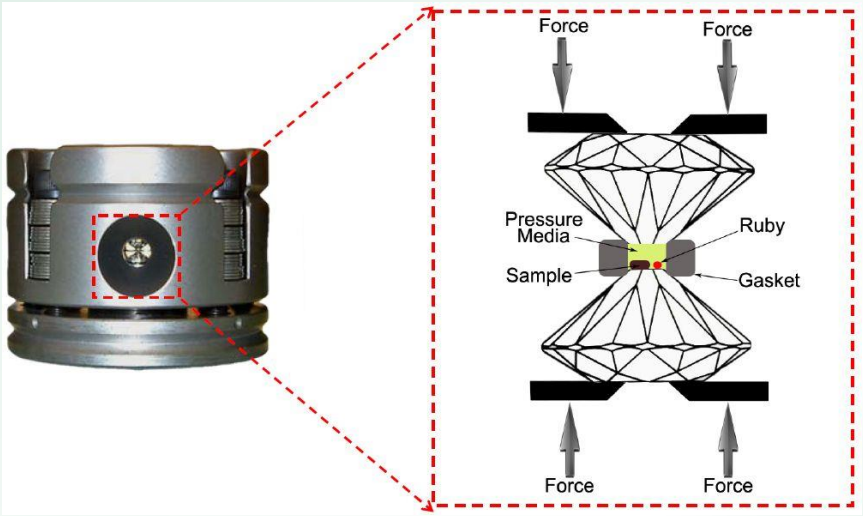
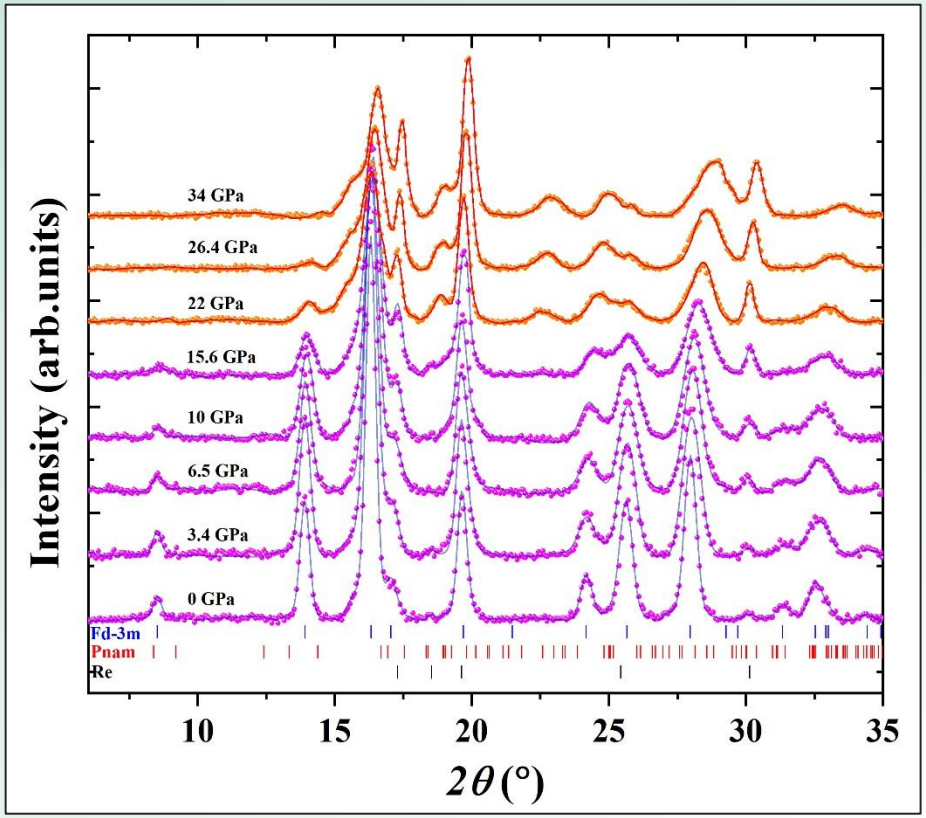
Experimental methods: X- ray diffraction under high pressure

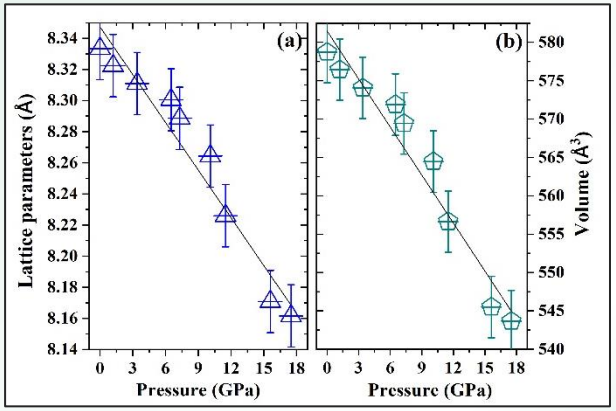


Maximum pressure is 50 GPa

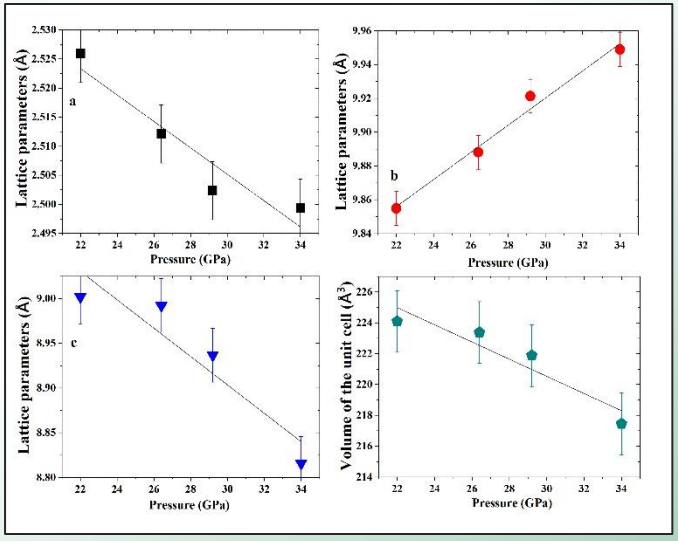
Crystal structure of ferrite $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ in wide temperature range



Fd-3m



Pnam



Summary

1. **Crystal structure** of ferrite $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ presented by the mixed spinel cubic structure with space group Fd-3m **remains stable** in all studied temperature. The most important parameters of crystal structure were obtained.
2. The presence of **vacancies** in octahedral positions of the crystal structure of nanostructured ferrite $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ was established.
3. **Magnetic structure** of nanostructured ferrite $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ presented by **ferrimagnetic** ordering **remains stable** in wide temperature range.
4. **Phase transition** from initial phase with cubic structure (Fd-3m) to high pressure phase with orthorhombic structure (Pnam) was found in ferrite $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ at pressure above 18GPa.

Thank you for attention!

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RESEARCH PAPER

Neutron diffraction study of the crystal and magnetic structures of nanostructured $Zn_{0.34}Fe_{2.53}O_4$ ferrite

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