The XXVIII International Scientific Conference of Young Scientists and Specialists
(AYSS-2024)

STRUCTURAL AND VIBRATIONAL PROPERTIES OF $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ AND $CoFe_2O_4$ FERRITE AT HIGH PRESSURE

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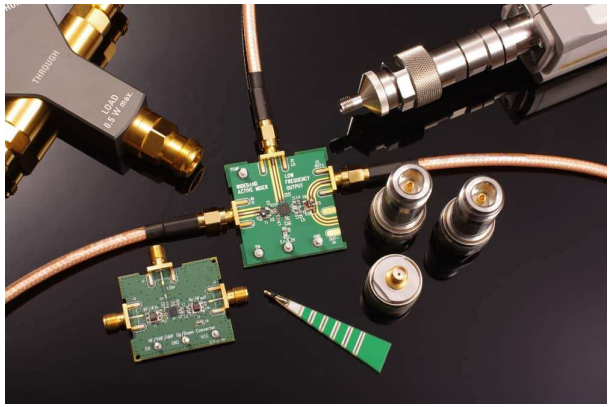
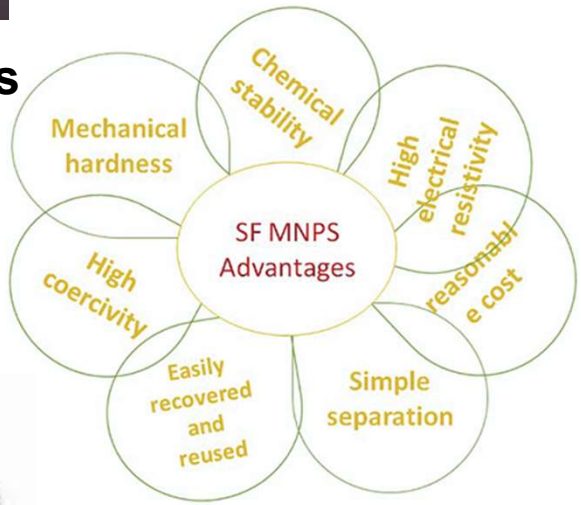
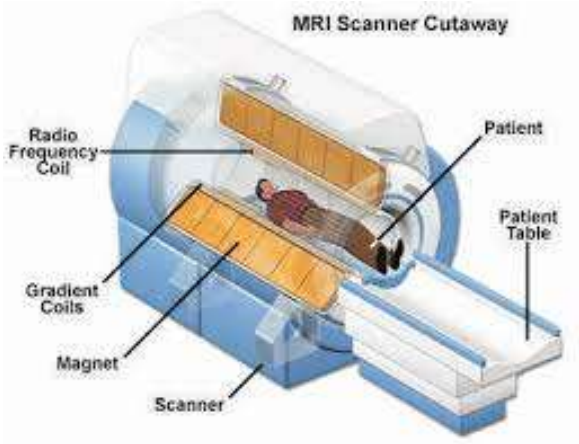


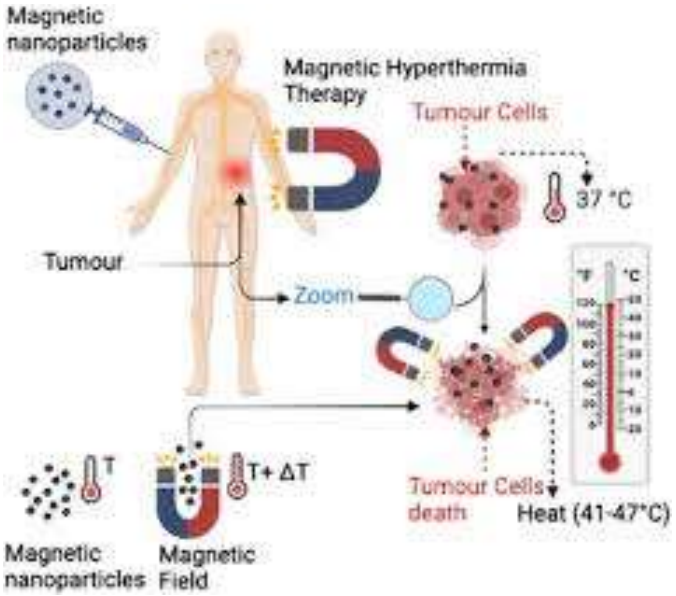
Radio Frequency Circuits

Data Storage Devices



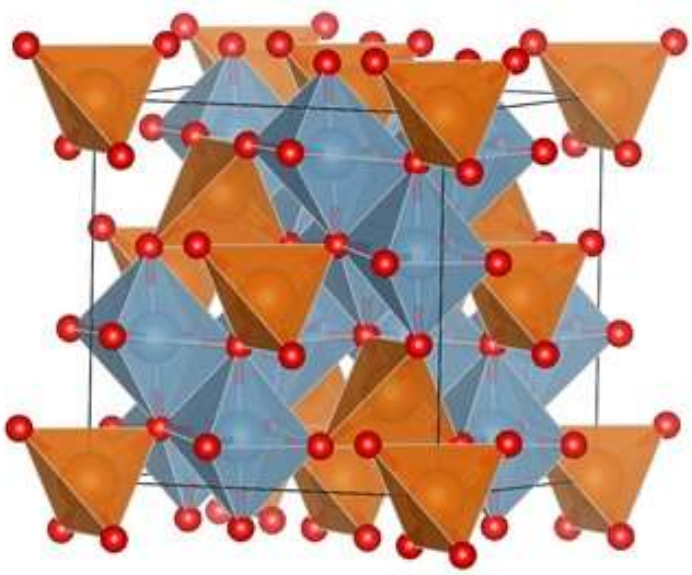


Magnetic Resonance Imaging



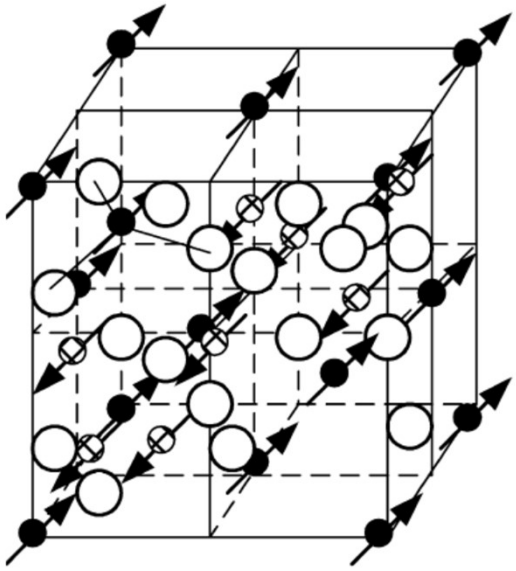
Magnetic Hyperthermia Therapy

The crystal and magnetic structures of AFe_2O_4 spinels



Based on the distribution of ions, there are the following types of the AFe_2O_4 spinels:

- **Normal spinel structure**
  $Me^{2+}[Fe_2^{3+}]O_4^{2-}$ (**$ZnFe_2O_4$**, $CdFe_2O_4$);
- **Inverse spinel structure**
  $Fe^{3+}[Me^{2+}Fe^{3+}]O_4^{2-}$ (Fe_3O_4, $NiFe_2O_4$ and $CoFe_2O_4$) ;
- **Mixed spinel structure**
  $Me_{1-\delta}^{2+}Fe_{\delta}^{3+}\left[Me_{\delta}^{2+}Fe_{2-\delta}^{3+}\right]O_4^{2-}$, where δ – is the inversion degree.
  $MgFe_2O_4$, $MnFe_2O_4$ and **$ZnFe_2O_4$ (nano)**.



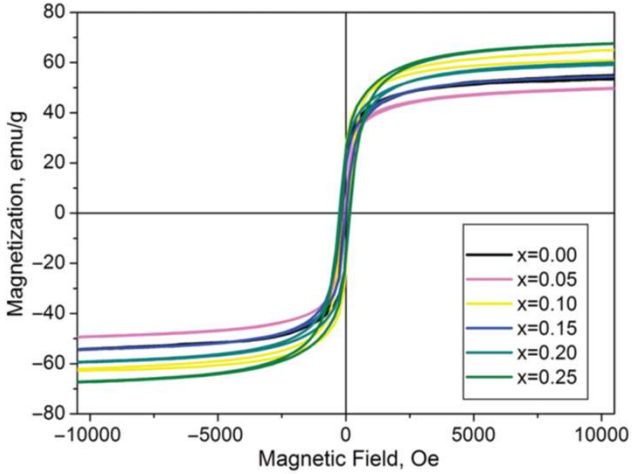
A: tetrahedral site

B: octahedral site

O: oxygen

Daliya S. Mathew, Ruey-Shin Juang

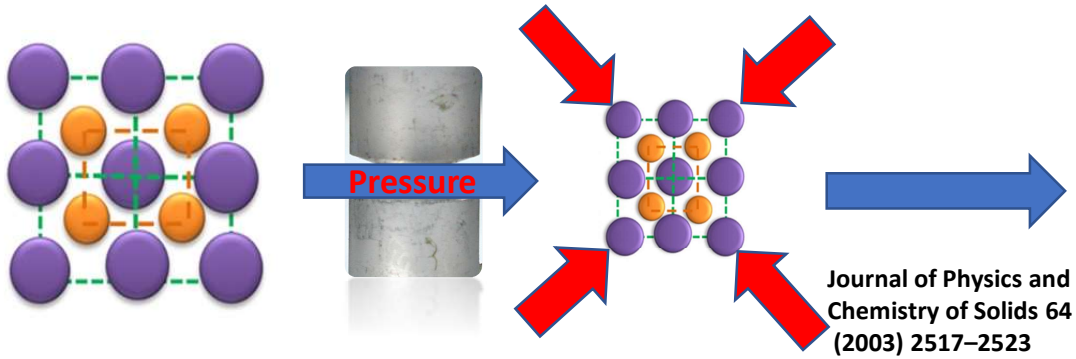
Chemical Engineering Journal 129 (2007) 51–65



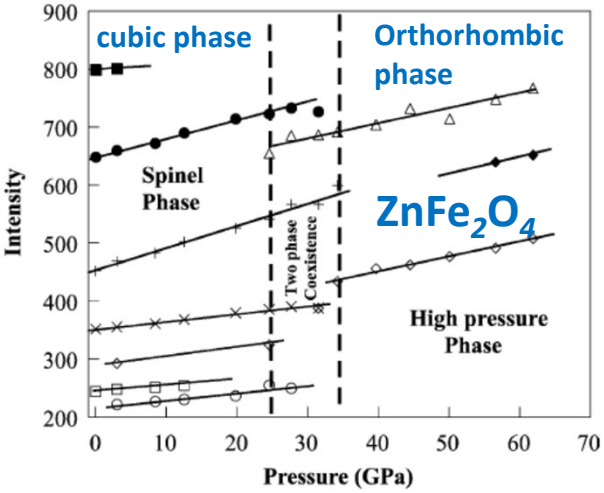
Magnetic hysteresis loops of the $Ni_{0.4}Zn_{0.6-x}Co_xFe_2O_4$ ferrite nanoparticles.

J. Nanosci. Nanotechnol. 16, 11094–11098, 2016

The AFe_2O_4 spinels under high pressure



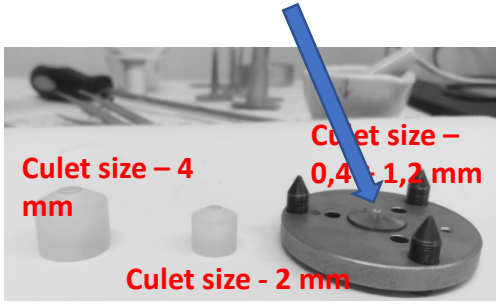
Journal of Physics and Chemistry of Solids 64 (2003) 2517–2523

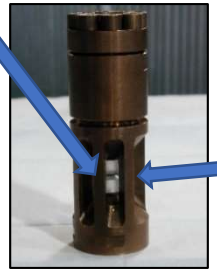


Pressure is direct method to change interatomic distances and valence angles.

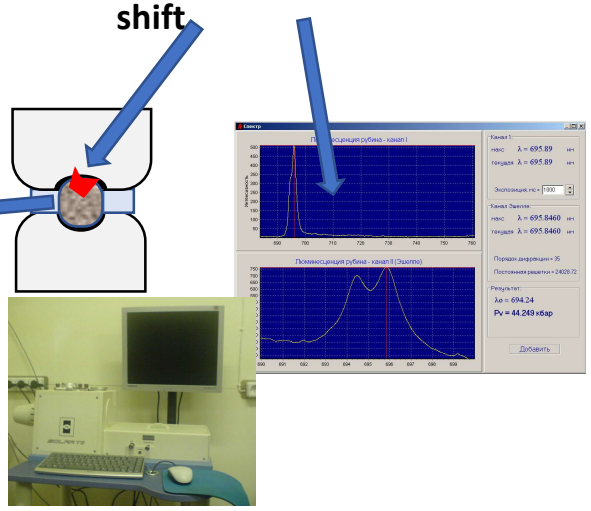
High pressure technique at Frank Laboratory of Neutron Physics of the Joint Institute for Nuclear Research

The high pressure cells with diamond and sapphire anvils





The pressure is measured by the ruby luminescence shift



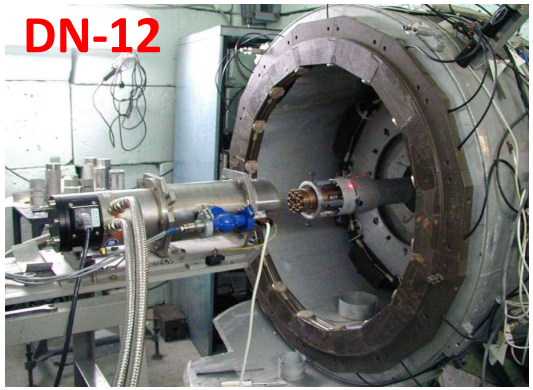
At present, the neutron physics laboratory manages to achieve the following pressure values:

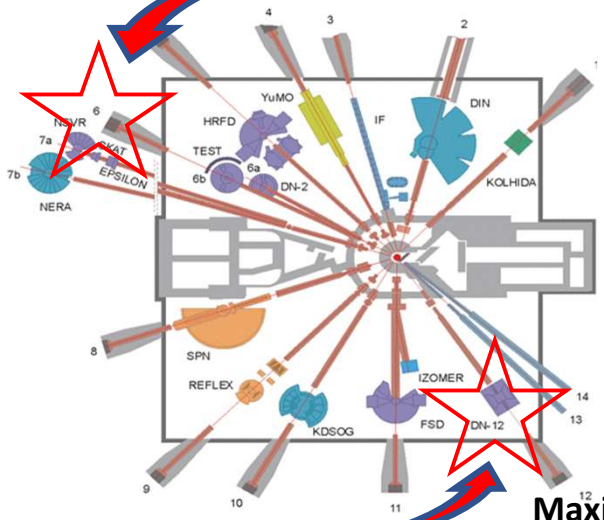
- for sapphire anvils the average maximum pressure is 8 GPa;
- for diamond anvils the average maximum pressure is 35 GPa.

Experimental techniques under extreme conditions

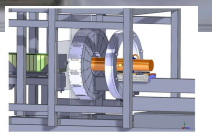
Neutron diffractometers at IBR-2 reactor, Joint Institute for Nuclear Research, Dubna

DN-12





DN-6



Maximum pressure ~ 8 GPa =80 000 atm.

Temperature range: 10 -320 K

Maximum pressure ~ 35 GPa

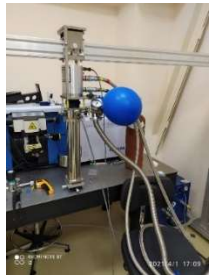
Temperature range: 4 -320 K

X – ray diffractometers Xeuss , FLNP JINR (Dubna, Russia)

Maximum pressure ~ 35 GPa

Temperature is 300 K

LabRAM spectrometer Horiba, FLNP JINR (Dubna, Russia)



Maximum pressure ~ 35 GPa

Temperature range: 15 -300 K

Crystal structure of nanostructured $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ ferrite under high pressure

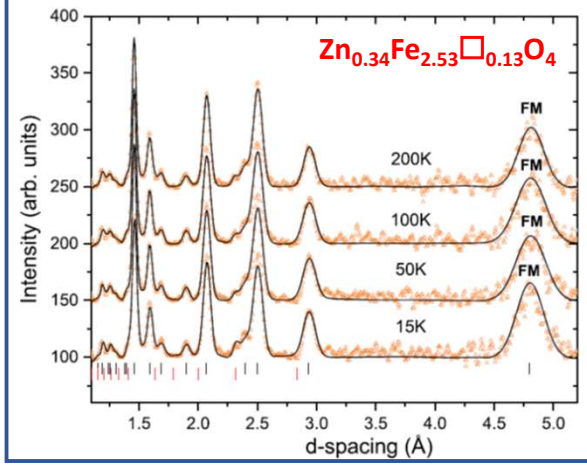
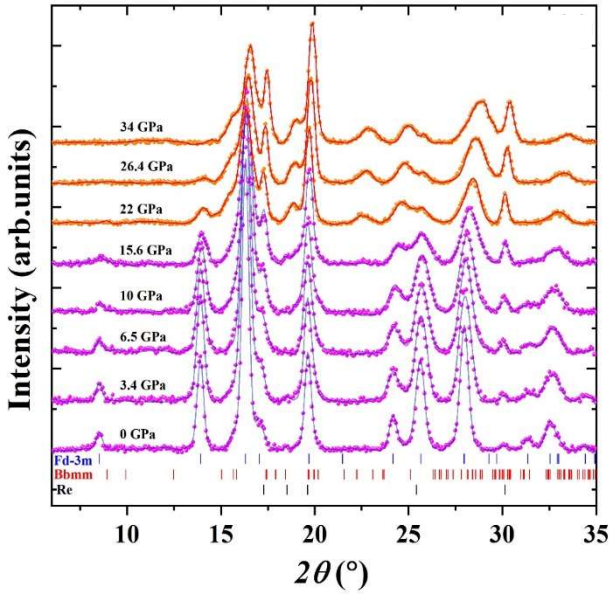


Fig. 4 Neutron diffraction patterns of $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ nanoparticles measured in temperature range from 15 to 250 K and processed by the Rietveld method. Experimental points, calculated profiles by the Rietveld method, and positions of Bragg peaks are shown. The "FM" signs the diffraction peak (111) with strongest magnetic contribution. Weak peaks indicated by red ticks are due to aluminum holder

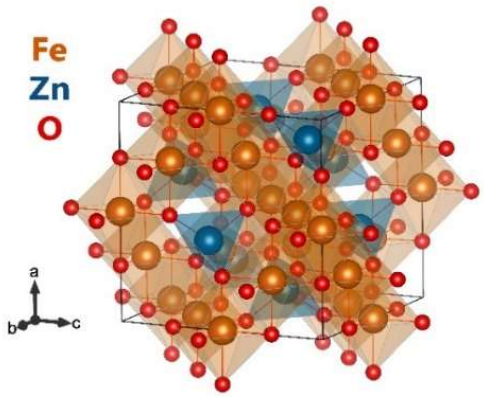
Atomic occupations		
A site:	Zn	0.18
	Fe	0.82
B site:	Zn	0.16
	Fe	1.71
	Vacancy	0.13 (2)
Calculated atomic coordinates		
O: x		0.257 (2)

N. M. Bedozerova · S. E. Kichanov · D. P. Kozlenko · O. Kaman · Z. Jirák · E. V. Lukin · B. N. Savenko J Nanopart Res (2020) 22:121



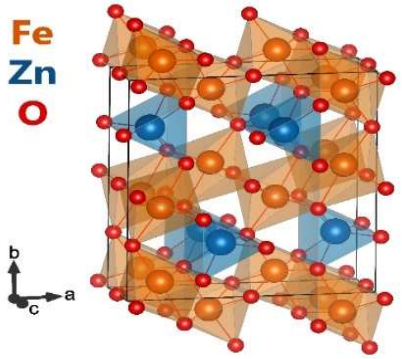
X-ray diffraction patterns of $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ nanoparticles at selected pressures. Experimental data points, calculated profiles using the Rietveld method.

Cubic $Fd\bar{3}m$

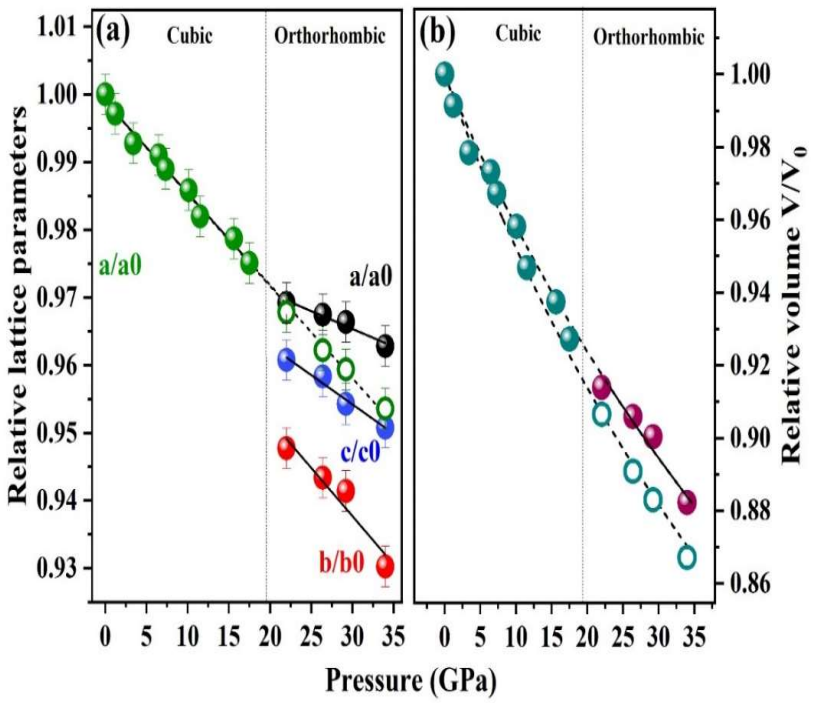


18 ≤ P ≤ 34 GPa

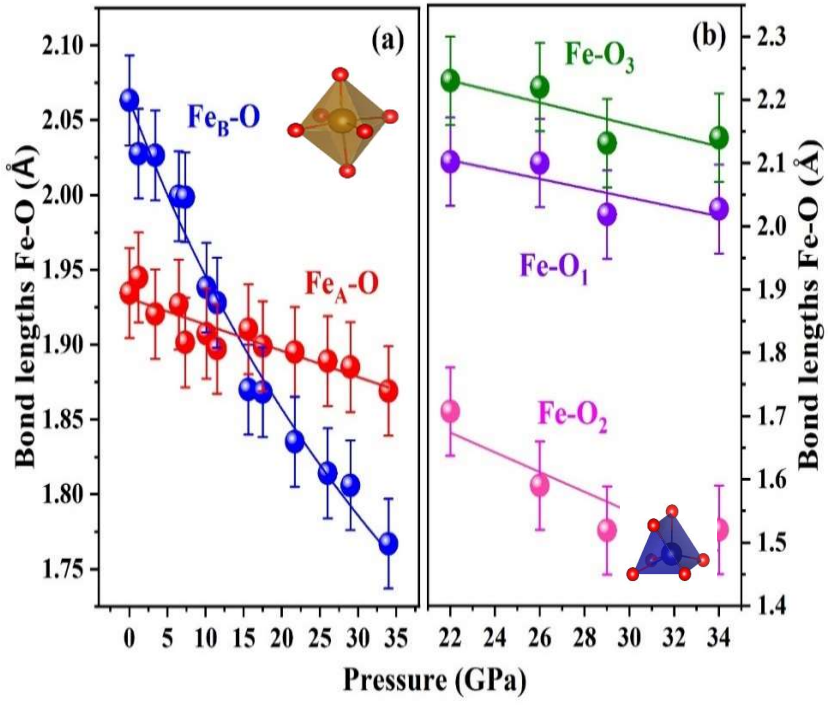
Orthorhombic Pbmm



Crystal structure of nanostructured $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ ferrite under high pressure

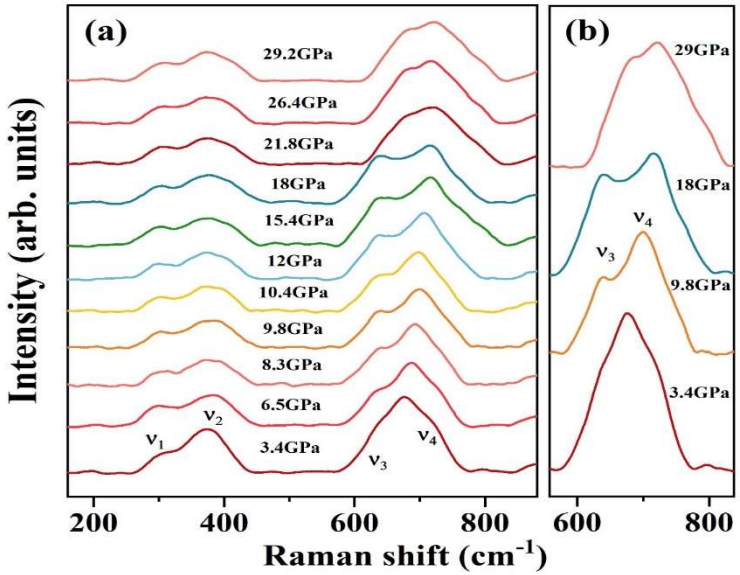


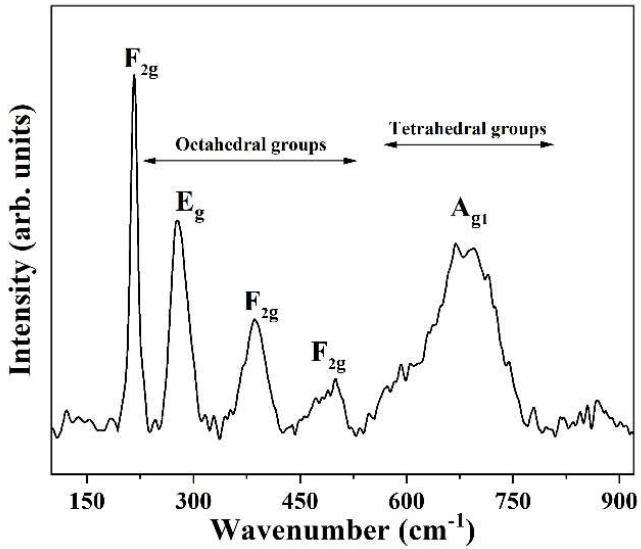
The pressure dependence of the unit cell parameters (a) and the unit cell volume (b) of cubic and orthorhombic phases of the nanostructured $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ ferrite. Solid lines represent a linear fit of the experimental data.

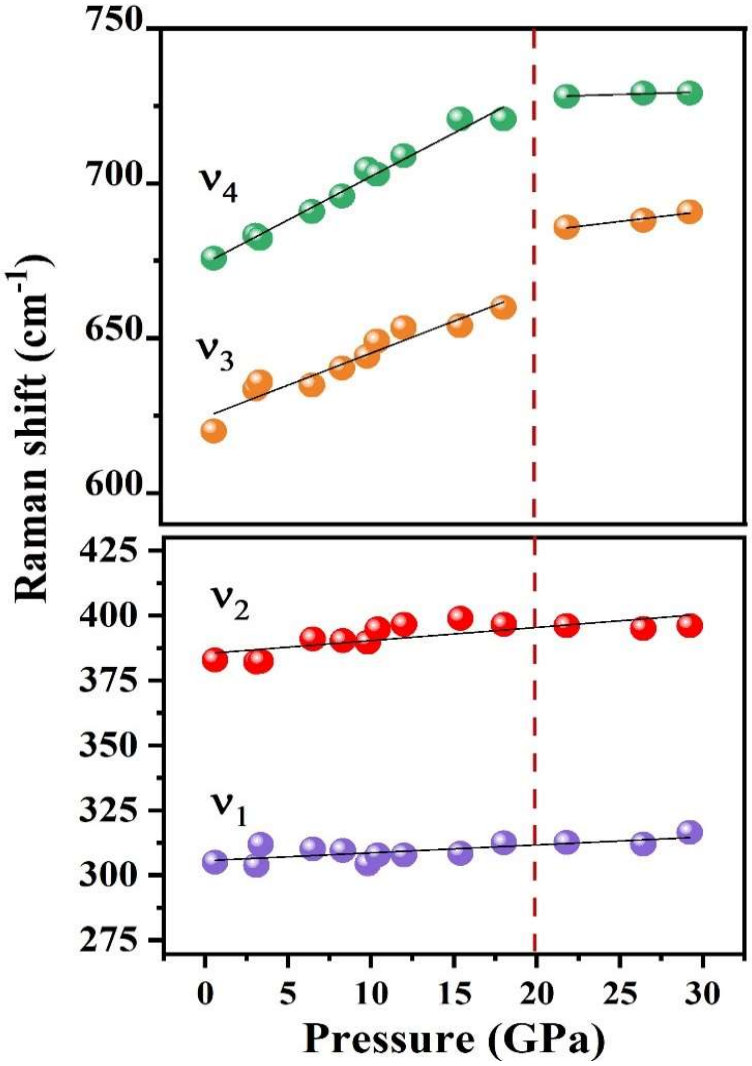


Pressure dependences of Fe–O bond lengths in $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ ferrite for the cubic (a) and pressure-induced orthorhombic (b) spinel phases. Solid lines represent a linear fit of the experimental data.

Raman spectroscopy of nanostructured $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ ferrite under high pressure

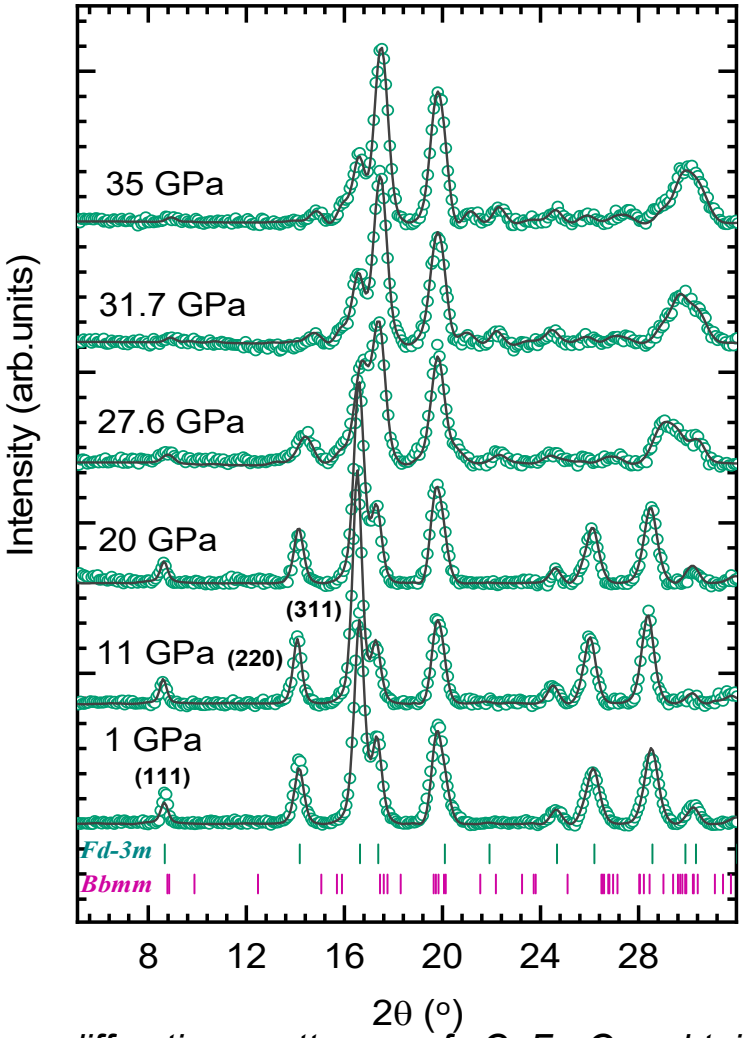




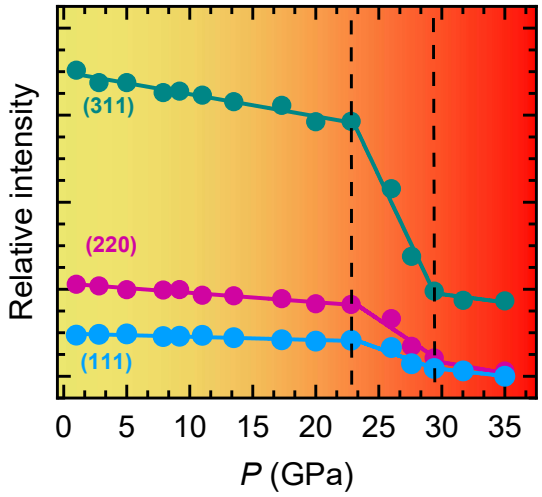


Pressure-induced phase transition in nanostructured cation-deficient $Zn_{0.34}Fe_{2.53}\square_{0.13}O_4$ ferrite *Physica B: Condensed Matter 690 (2024) 416210*

Crystal structure of $CoFe_2O_4$ ferrite under high pressure

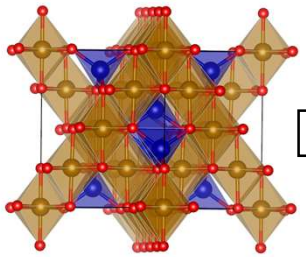


X-ray diffraction patterns of $CoFe_2O_4$ obtained at selected pressures and room temperature and refined using the Rietveld method are shown. Experimental points and calculated profiles are presented.



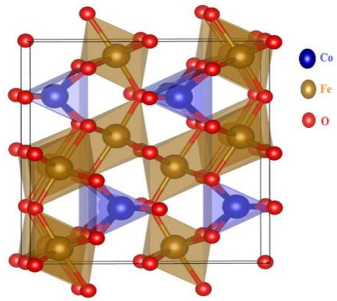
Pressure-induced evolution of the relative intensities of the selected diffraction peaks of $CoFe_2O_4$ ferrite.

The cubic structure $Fd\bar{3}m$

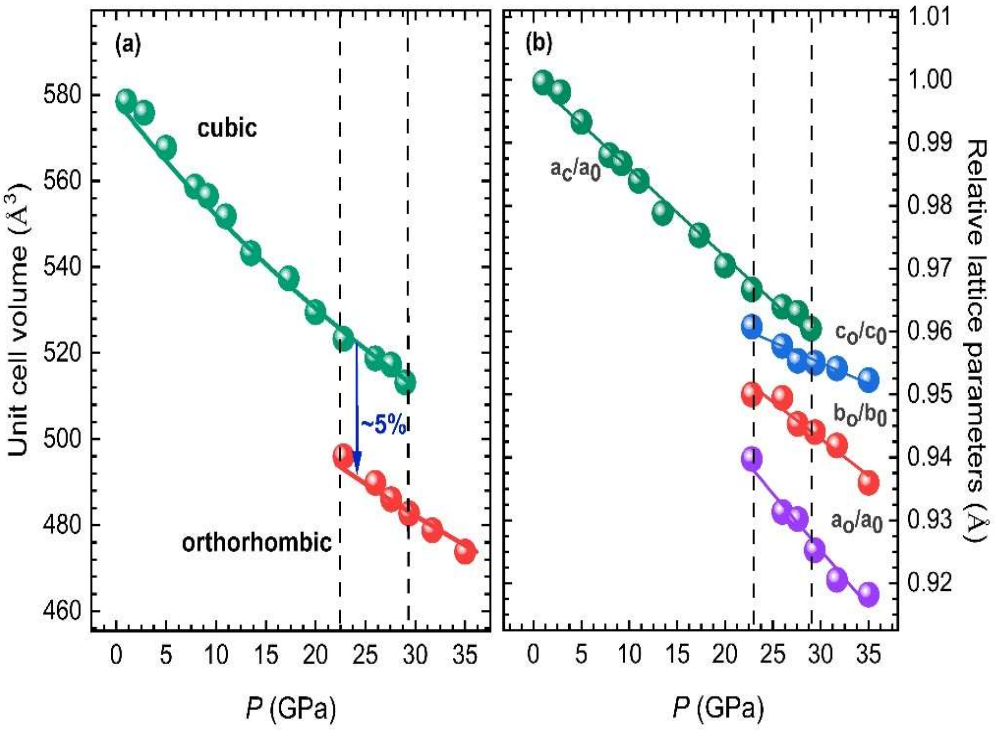


$22 \leq P \leq 35$ GPa

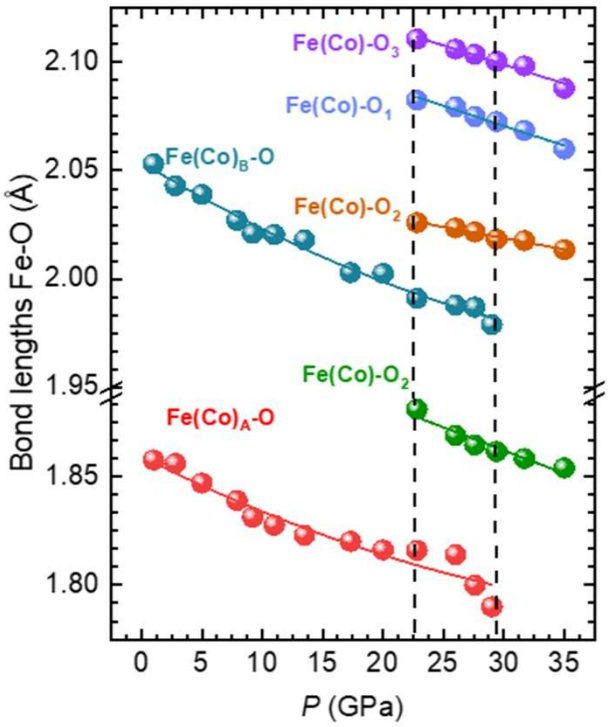
The orthorhombic structure Bbmm



Crystal structure of $CoFe_2O_4$ ferrite under high pressure

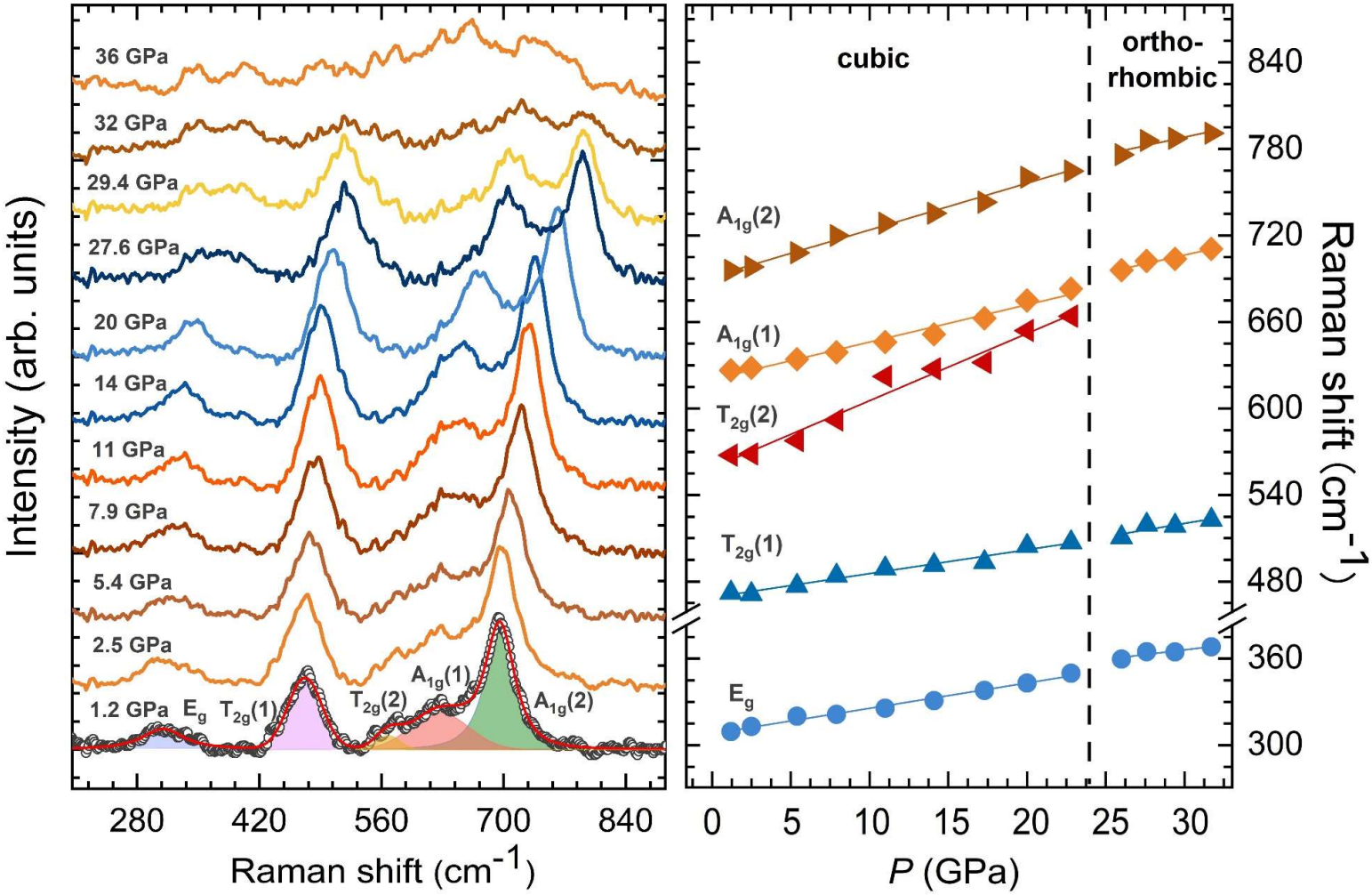


The pressure dependence of the unit cell parameters (a) and the unit cell volume (b) of cubic and orthorhombic phases of the nanostructured $CoFe_2O_4$ ferrite. Solid lines represent a linear fit of the experimental data.



Pressure dependences of Fe–O bond lengths in $CoFe_2O_4$ ferrite for the cubic and orthorhombic spinel phases. Solid lines represent a linear fit of the experimental data.

Raman spectroscopy of $CoFe_2O_4$ ferrite under high pressure

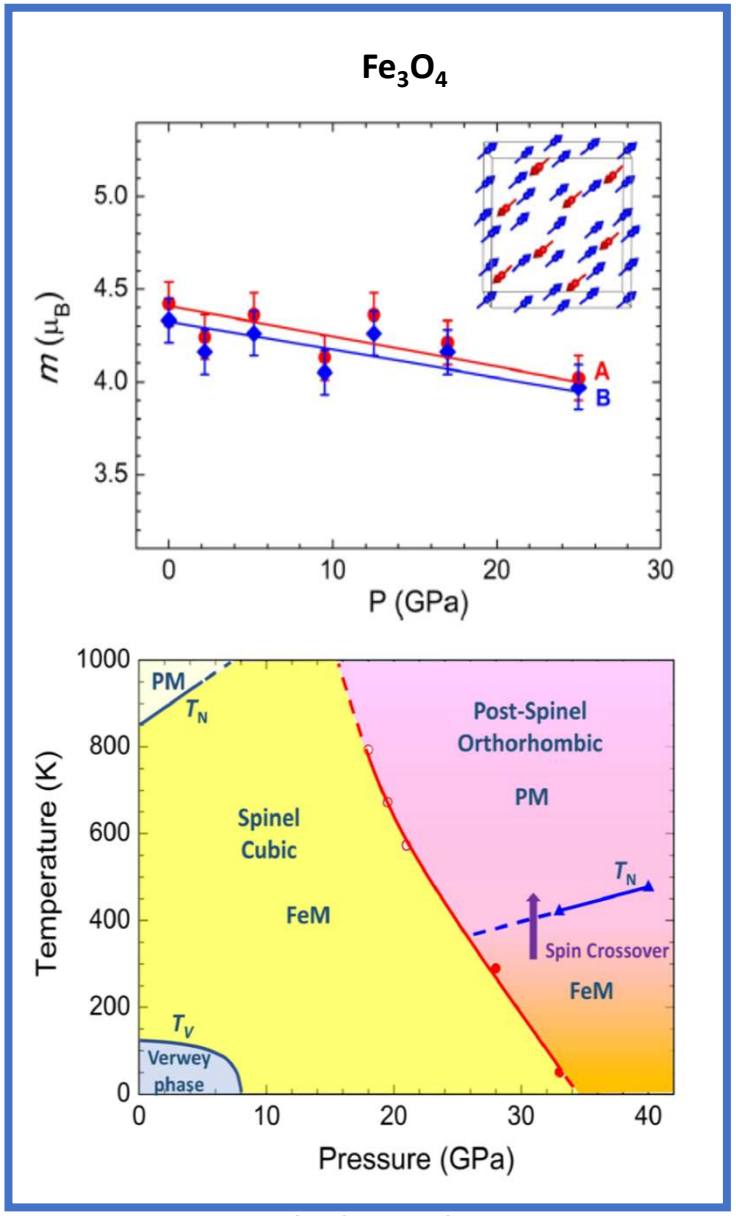


Selected Raman spectra of $CoFe_2O_4$ measured at high pressure.

Pressure dependencies of the observed frequencies of vibrational modes of the $CoFe_2O_4$ ferrite

In the progress of publication in the journal Modern Physics B

Conclusion



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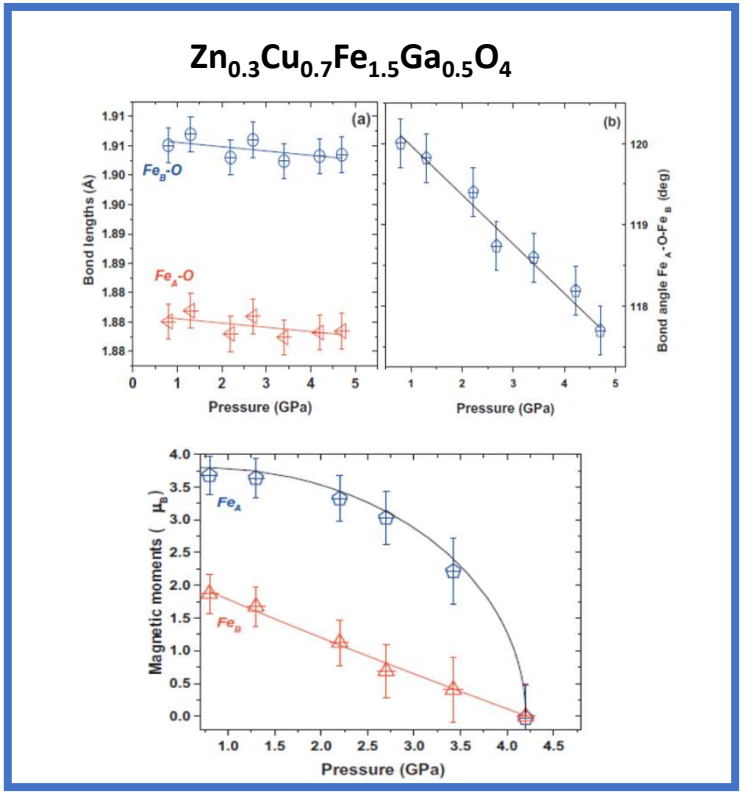

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Thank you for your attention!