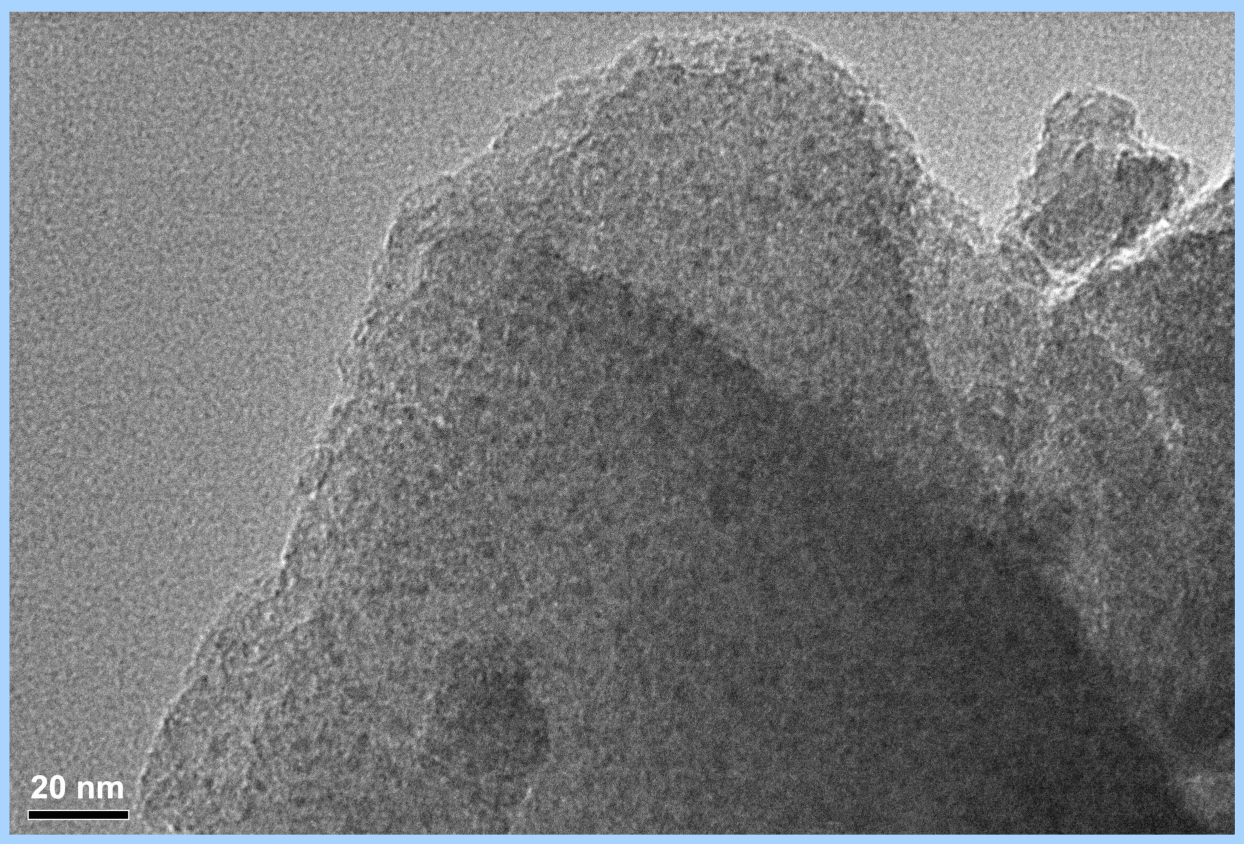
Magnetic properties of ultrafine non-interacting γ-Fe2O3 nanoparticles dispersed in a silica matrix

Vojislav Spasojević[1]*, Vladan Kusigerski[1], Marin Tadić[1], Dragana Marković[1]

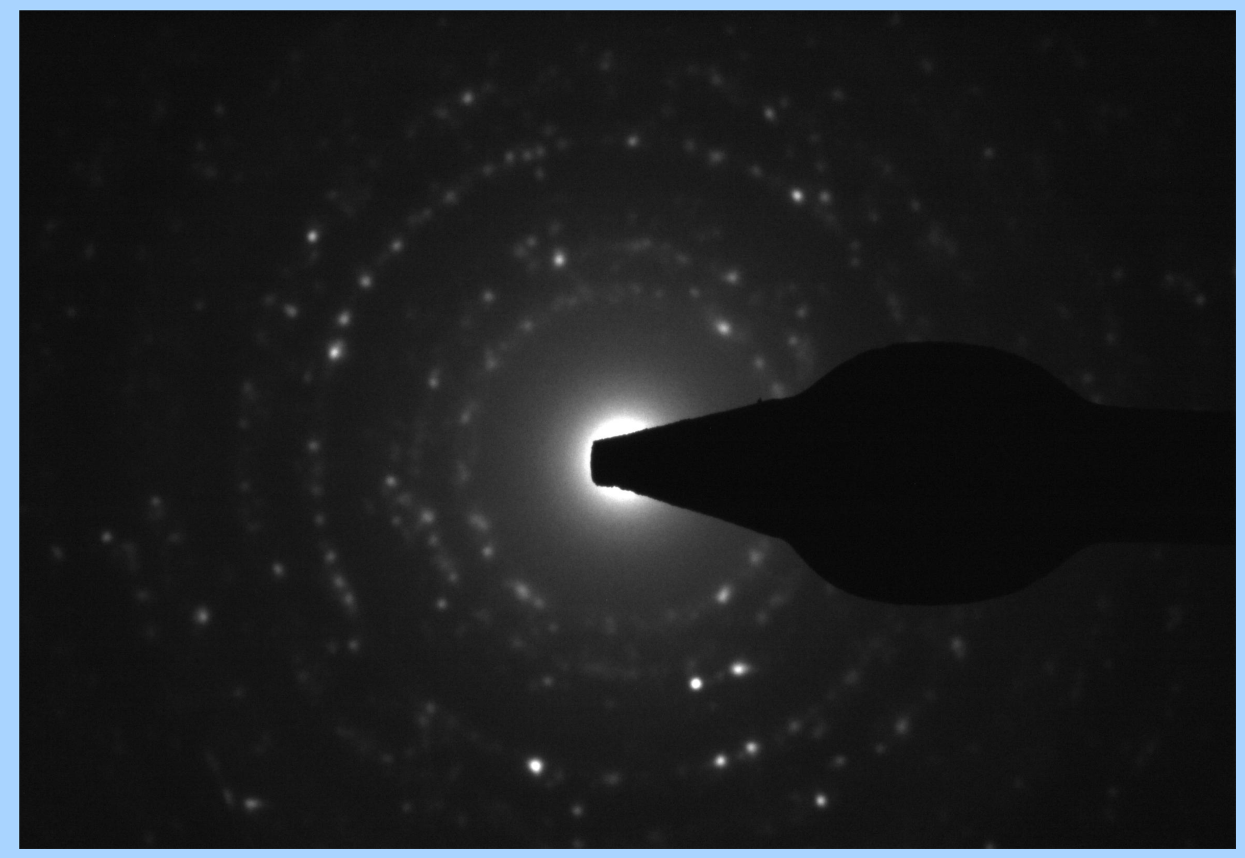
[1]The Vinca Institute, Condensed Matter Physics Laboratory, POB 522, 11001 Belgrade, Serbia; *e-mail: vojas@vin.bg.ac.yu

γ-Fe_2O_3/SiO_2 nanocomposite containing 15 weight percent of maghemite has been synthesized by the sol-gel method. The so-obtained nanocomposite of iron(III) nanoparticles dissolved in glassy silica matrix was investigated by transmission electron microscopy (TEM), and superconducting quantum interference device (SQUID) magnetometry. Transmission electron microscopy studies show that the estimated average particle size of spherical nanoparticles is around 3 nm with narrow size distribution, whereas selected area electron diffraction confirms the formation of the maghemite phase. The magnetic properties investigations by DC magnetization and AC susceptibility measurements indicate typical behavior of superparamagnetic system such as existence and frequency dependence of blocking temperature, irreversibility of ZFC and FC curves, and emergence of magnetic hysteresis below blocking temperature. The ZFC curve exhibits a narrow peak at around 8 K (blocking temperature T_B) and the ZFC-FC curves stay separated up to 25 K (irreversibility temperature Tirr). Below T_B the curves split significantly: the ZFC magnetization sharply decreases while the FC magnetization steadily rises. The shift of the hysteresis loop after field cooling are also observed, revealing exchange anisotropy effects due to the exchange coupling between the different core and surface magnetic structure. The quantitative analysis of the DC magnetic data indicates that system consists of an ultrafine single-domain nanoparticles with narrow size distribution, whereas AC data points to the non-interacting system.

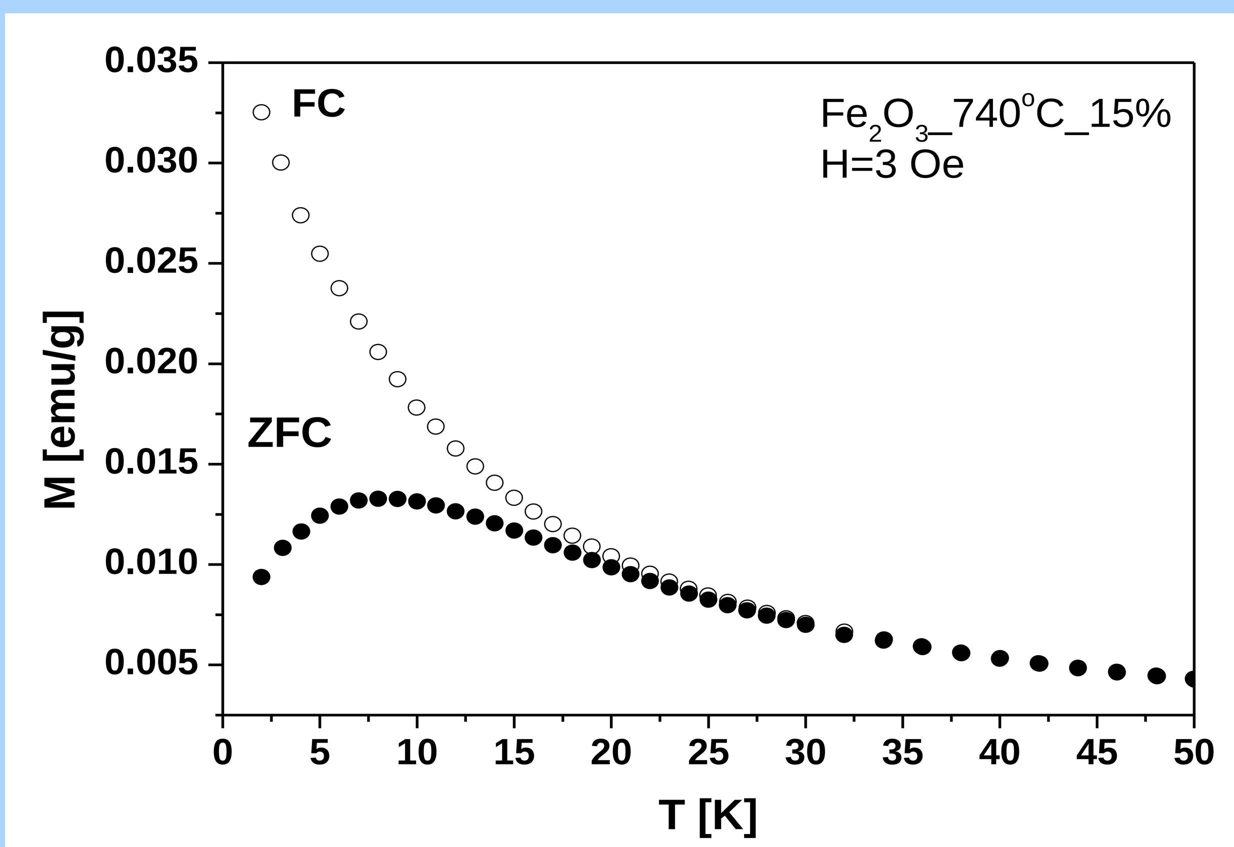


TEM measurement

d~3 nm



Electron diffraction

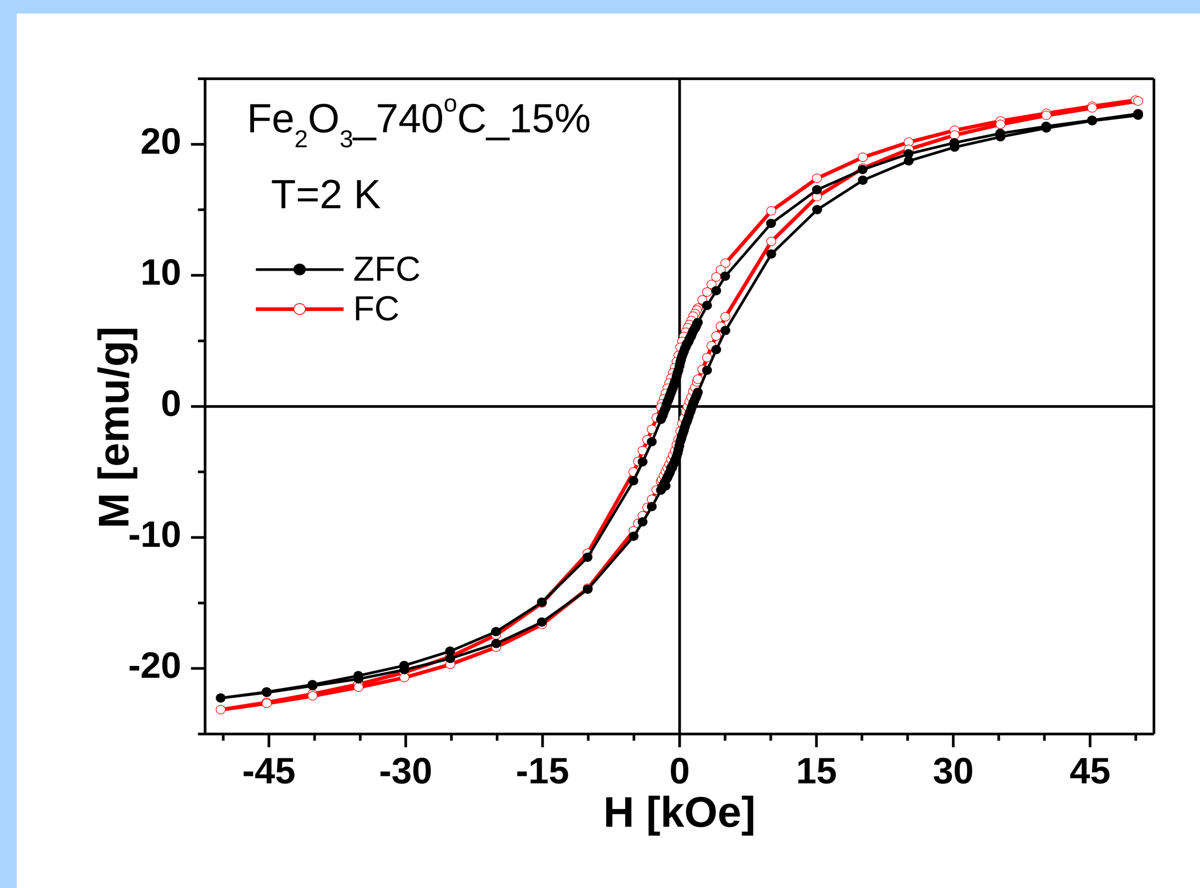


ZFC and FC magnetizations

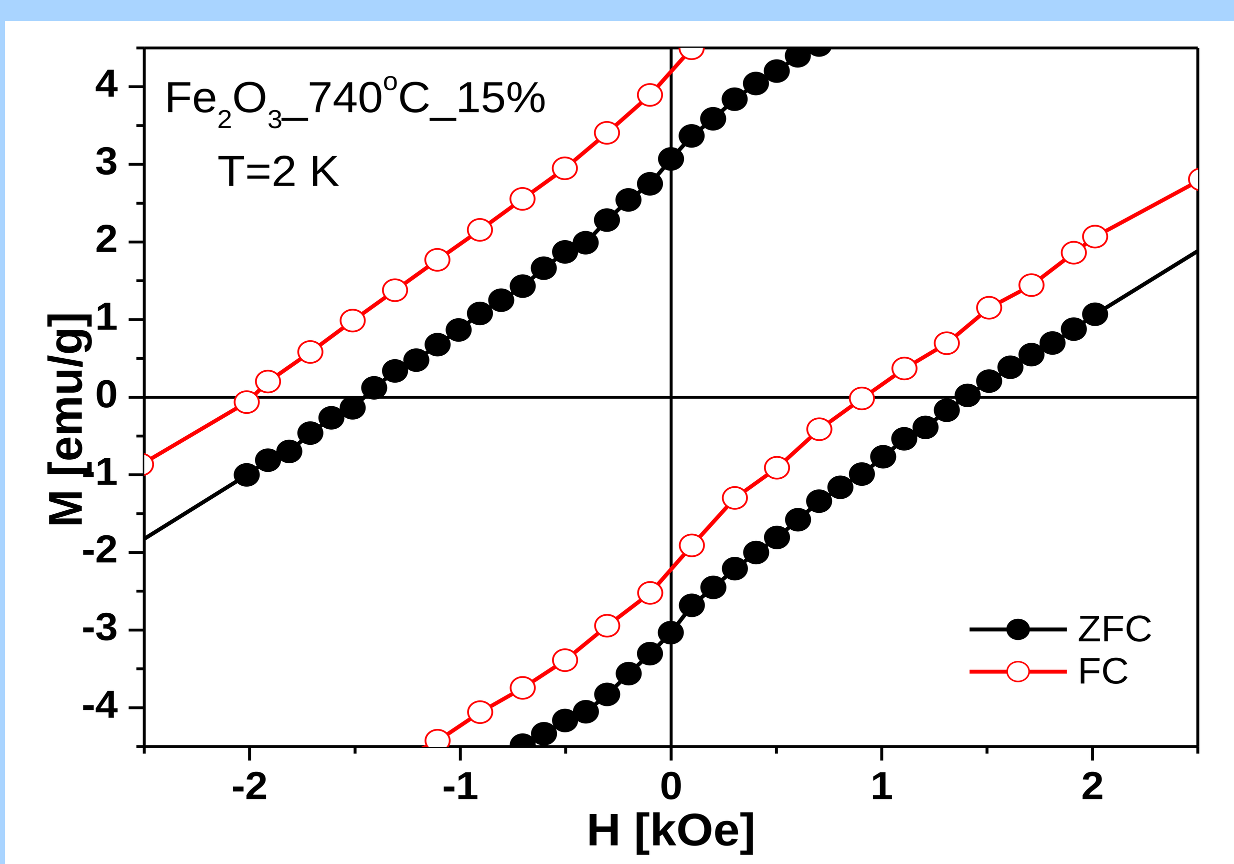
T_B=8 K

T_{irr}=25 K

M_S=27,5 emu/g



ZFC and FC hysteresis loops



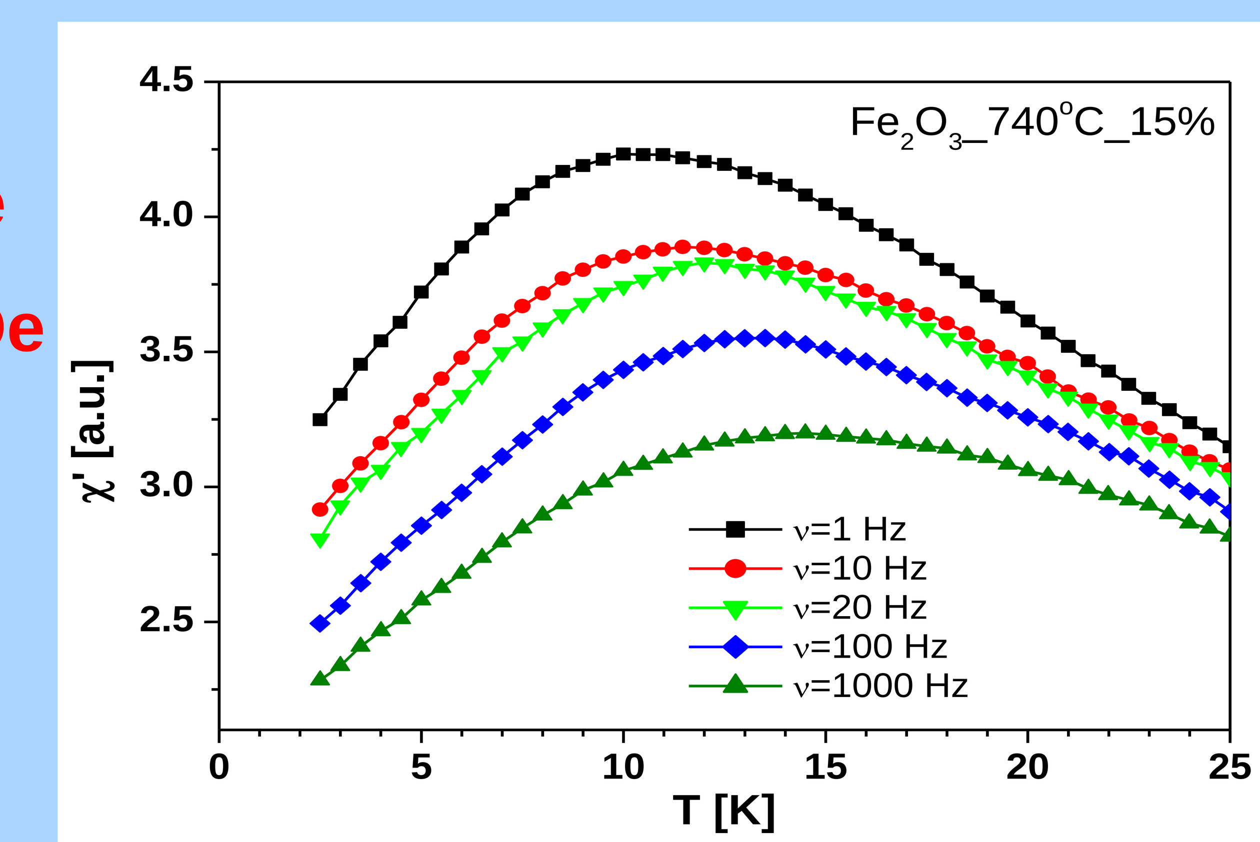
ZFC and FC hysteresis loops at low fields

$H_C=(H_{right}-H_{left})/2=1500$ Oe

$H_{ex}=-(H_{right}+H_{left})/2=650$ Oe

$C_1=\Delta T_B/(T_B \log \nu)=0,1$

$C_2=(T_B-T_0)/T_B=1$



Real part of the AC susceptibility