Size effect on magnetic properties of (La,Ca)MnO_3 nanoparticles

A. Wisniewski[a], V. Markovich[b], I. Fita[a, c], R. Puzniak[a], and P. Iwanowski[a]

[a]Institute of Physics, Polish Academy of Sciences, Aleja Lotnikow 32/46, PL-02-668 Warsaw, Poland
[b]Department of Physics, Ben-Gurion University of the Negev, 84105 Beer-Sheva, Israel
[c]Donetsk Institute for Physics and Technology, National Academy of Sciences, 83114 Donetsk, Ukraine

Magnetic properties of $La_{1-x}Ca_xMnO_3$ nanoparticles (NPs), with particle size ranging from 12 to 42 nm for $x = 2/3$ and from 15 to 37 nm for $x = 0.8$, were studied. Reduction in the particle size suppresses antiferromagnetism and decreases the Neel temperature. Comparison of the results obtained for both compounds reveals some common features as well as significant differences. In particular, NPs of both $x = 2/3$ and 0.8 composition, exhibit an enhancement of weak ferromagnetism at $T > 200$ K that is linked to the reduction in the particle size. Moreover, magnetic hysteresis loops indicate size dependent exchange-bias effect. The temperature dependencies of magnetization of $x = 0.8$ composition show size dependent peak at orbital ordering (OO) temperature $T_{OO} = 153$ K for smaller 15 nm particles and $T_{OO} = 201$ K for larger 37 nm particles and two peak structure of ac-susceptibility, where high temperature peak is associated with establishment of orbital ordered AFM state. Such features are absent for $x = 2/3$ composition and for all particles one wide peak, associated with transition to AFM state, shows up. We suggest that the C-type AFM structure observed in bulk $x = 0.8$ composition is much more stable than the 2/3-type one in $x = 2/3$, resulting in surviving of OO even in 15 nm of $x = 0.8$ composition NPs and leading to an disappearance of any charge ordered state for $x = 2/3$ at particle size ≤ 42 nm.