The magnetic properties of the systems of the ultra-fine particles

Perov N.S., Sudarikova N.Yu.
Faculty of physics, M.V.Lomonosov Moscow State University, Leninskie Gory, Moscow, 119992 RUSSIA

The magnetic effects connected to finite-size of the particles become dominant at transition of particles in region several nanometers and less [1].

At reduction of atom numbers in magnetic cluster (tens or hundreds atoms), along the classical features, essential appear the quantum phenomena resulting in spin transformation of magnetic structure, both with reduction of the size and at applying of an external magnetic field. The relatively weak interaction between clusters and homogeneity of cluster size in the system allows to investigate the quantum tunneling magnetization of individual clusters. These types of clusters sometimes attributed to the mesoscopic systems.

Thus except for the well-known phenomenon of superparamagnetism as a result of the broken coordination and symmetry on a surface layer there are the fluctuations of exchange interactions resulting, for example, to surface non-collinear magnetic structure and transformation internal magnetic structure at whole cluster.

At the same time the dependence of the basic magnetic parameters, such as saturation magnetization, Curie temperature and magneto-crystalline anisotropy turn out a function of the size. In principle there is also a problem of inheritance or change of magnetic properties and structure of particles as the particles (or cluster) size increase.

In the present report the analysis of magnetic properties of nanoparticles and nanoclusters system, synthesized by the different methods, will be given and besides the basic achievements and the new results in the given area will be demonstrated. Abnormal magnetic features (parameters of hysteresis loop, a susceptibility, conductivity etc.) will be considered as well.

The particle size distribution have been evaluated from the analysis of hysteresis loops of cobalt (Co) nanoparticles system, measured by vibrating sample anisometer. Samples consisted of ferromagnetic single-domain Co particles and superparamagnetic Co particles. It was assumed that measured hysteresis loops could be represented as a superposition of the magnetization curve of superparamagnetic nanoparticles, which can be described by the Langevin function, and hysteresis loop of ferromagnetic single-domain particles, which can be calculated for a system of single-domain particles with uniform distribution of anisotropy axis. There is a good agreement between measured hysteresis loops and theoretically modeled hysteresis loops.

1. R.H.Kodama, A.E.Berkowitz, Phys.Rev.B. 59 (1999) 6321.