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# Books of Abstracts

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## MULTIQUANTUM NUCLEAR SPIN-ECHO AND IMPURITY STATES IN MAGNETIC SEMICONDUCTORS

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The change of type and concentration of charge carriers in 3d-magnetic semiconductors is realized on the base of hetherovalent doping by diamagnetic impurities. The doping causes the change of electrical properties such well as the modification of magnetic properties of these materials. For example, the magnetic crystallographic anisotropy constant and the temperature magnetic ordering increase with $Ag^{1+}$-doping and decrease with $In^{3+}$-doping in model magnetic semiconductor $CdCr_2Se_4$. To study the nature of the hetherovalent doping on the microscopic level we have used the $^{53}Cr$ NMR in $CdCr_2Se_4$. Taken into account the quadrupole splitting of $^{53}Cr$ spectra we have applied the multiquantum spin-echo spectroscopy method, which is a high resolution NMR method in magnets with quadrupole nuclei [1 - 3].

The spectra of multiquantum echo $V_{4\tau}$ in undoped and $Ag^{1+}$ and $In^{3+}$ doped crystals are different significantly. The spectra are broadened and shifted into high frequency range in $CdCr_2Se_4$:Ag crystals. The inhomogeneous broadening and low frequency shift take place in $CdCr_2Se_4$:In crystals. The temperature measurements of the main frequency maximum $V_{4\tau}$ show that the 3/2-Bloch law is true for wide temperature interval. These measurements have been used to define the exchange stiffness constant A, which was found $A = 3.35\ 10^{-10}$ Oe/sm$^2$ in undoped crystals, and $A = 4\ 10^{-10}$ Oe/sm$^2$ in $Cd_{1-x}Ag_xCr_2Se_4$ (x=0.03) crystals. The growth of exchange stiffness constant correlates with the Curie temperature and show the increase of exchange interaction at Ag-doping. The $CdCr_2Se_4$:In crystals have opposite tendency.

At hetherovalent doping the Cr-ions change valence and impurity states $Cr^{4+} - Ag^{1+} - Cr^{3+}$ or $Cr^{2+}–In^{3+}–Cr^{3+}$ are formed near impurity. The exchange and spin-orbital interactions inside such clusters are different from similar interactions on the outside. We have found that the speed of multiquantum echo $V_{4\tau}$ decay at 77 K is greater in $CdCr_2Se_4$:Ag than in $CdCr_2Se_4$:In. The oscillations of spin-echo amplitude $V_{4\tau}$ have been detected as a result of detailed measurements of the dependences of echo-amplitude V on the delay time $\tau$ between two excited pulses. On the base of oscillations period the quadrupole constants have been valued in doped crystals. The lower NMR Q-factor of Ag-clusters causes appropriate properties of electron systems of such clusters. Really, the measurements of the electron paramagnetic resonance line width shown that the line width in $CdCr_2Se_4$:Ag into 6 times greater than in $CdCr_2Se_4$:In at the close impurity concentration. This mean that the spin-orbital coupling in $CdCr_2Se_4$:Ag - clusters is greater than in CdCr2Se4:In - clusters.



The impurity states (clusters) appear as a result of hetherovalent doping by diamagnetic impurities in the 3d magnetic semiconductors of $CdCr_2Se_4$. The $Cr^{4+}–Ag^{1+}– Cr^{3+}$ states (clusters) take place in Ag-doped crystals and $Cr^{2+}–In^{3+}–Cr^{3+}$ states (clusters) take place in In-doped crystals. The high exchange and spin-orbit interaction is observed for Ag-states with respect to the In-states.

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## INVESTIGATION OF MAGNETIC PROPERTIES OF MANGANITES $La_{1-x}K_xMnO_3$ AT HIGH TEMPERATURES

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The work is devoted to experimental investigation of temperature dependence of the magnetic susceptibility [$\chi$(T)] of K-doped manganites $La_{1-x}K_xMnO_3$ (x=0.1, 0.15) in a wide temperature interval 140-830 $^0$C, as well as to determination of their magnetic characteristics from this dependence.

The dependence $\chi$(T) was measured by the Faraday's method with the help of high-temperature magnetic pendulum balance in the atmosphere of refined argon. Maximal relative error of the measurements did not exceed 3%.

Analysis of the obtained dependence $\chi$(T) showed that the rise of K-doping rate increases the magnetic susceptibility of manganite. With rising temperature of manganite $\chi$ decreases monotonically. It should be specifically noted that in the temperature interval 600-680 $^0$C we observed anomalous change of $\chi$ with changing temperature. With rising temperature $\chi$ increases and at 680 $^0$C it reaches its maximal magnitude with further monotonic decrease.

Analysis of dependences $\chi^{-1}$(T) of the samples showed that in the investigated temperature region (except that from 600 to 680 $^0$C) they yield to Curie-Weiss law $\chi=C/(T-\theta_p)$. We observed three breaks on each dependence $\chi^{-1}$(T) of the samples. It should be noted that the slope of the dependence for manganites is negative in the temperature interval 600-680 $^0$C.

Reason of breaks of $\chi^{-1}$(T) dependence can be explained, obviously, by polymorphous transitions only (analogous to those in $La_{1-x}Ca_xMnO_3$ [1]), which occur in crystalline lattice depending on composition and temperature. In manganite $La_{0.9}K_{0.1}MnO_3$ at temperatures 430 $^0$C and 590 $^0$C there occur, respectively, phase transitions Q'→Q* and Q*→R. In $La_{0.85}K_{0.15}MnO_3$ such transitions occur at 470 $^0$C and 650 $^0$C, respectively. Anomalous character of dependence