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Study of the transformation of functional properties of materials under the influence of pulsed radiation irradiation by electrons and ions with dose

The project is aimed at a comprehensive experimental and theoretical study of exchange interactions, magnetotransport phenomena, spin and phase transitions in magnetic semiconductors, including complex cobalt oxides. These compounds demonstrate a wide range of physical phenomena, such as spin crossover, giant magnetoresistance, dielectric-metal transition, orbital ordering, ferroelectric and magnetoelectric effects, as well as structural phase transitions [1-3]. The study of these phenomena is one of the leading areas of modern condensed matter
physics, both fundamental and applied, although the microscopic mechanisms of formation of the properties of complex cobalt compounds remain insufficiently studied. The unique functional properties of these compounds are associated with the ability to change the spin states of cobalt ions (Co4+, Co3+ and Co2+) due to small changes in
thermodynamic parameters (temperature, pressure, magnetic field, pulsed electron irradiation). An additional degree of spin freedom creates differences in the mechanisms for the implementation of these phenomena compared to other transition metal oxides. Modification of the structure and magneto-transport properties of ferro-and antiferromagnetic materials will be carried out using pulsed ions Xe26+ irradiation on the NICA accelerator complex at the irradiation station of the SOCHI with an energy 3.2 MeV/nucleon with intensities at 10^7 particles/sec, pulse duration of 4 µs.
Note that pulse duration correspondsto the time scale of switching of domain walls, which play a decisive role in changing magneto-transport properties.
Pulsed electron irradiation includes a whole range of effects: ionizing radiation, electron concentration affectingspin states, temperature, dynamic pressure and electromagnetic pulse. These effects will be studied separately under pulsed action of a strong magnetic field from 20 to 150 Tl, which will allow more correctly identifying the
contribution of each of them to the transformation of magnetotransport properties and conducting a comparative analysis with changes in temperature and external pressure.
Preliminary results show that irradiation leads to structural and magnetotransport transformation in the studied compounds, including isotropization of the crystal structure and transition to the ferromagnetic phase. However, theeffect of irradiation parameters on metastability remains unclear.
Research methods include X-ray and neutron diffraction for analyzing the long-range order of the crystal and magnetic structure, EXAFS spectroscopy, X-ray magnetic circular dichroism (XMCD) for studying the short-rangeorder of the crystal and magnetic structure of the 3d-valence states of cobalt. All methods will be used in a wide
range of temperatures and pressures.
Theoretical data analysis is aimed at clarifying the microscopic mechanisms of the phenomena under study. Since the systems under consideration belong to the class of strongly correlated ones, the density functional theory will beused taking into account the Coulomb interaction and many-particle effects within the framework of the dynamic mean field theory (DFT+DMFT). The results of the research will reveal the relationship between lattice, electron and magnetic degrees of freedom, which will open up opportunities for controlling their physical and chemical properties and creating new functional materials for use in terahertz and subterahertz generators based on the excitation of spin oscillations by spin current [1-3].

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