1. Summary

In the last few years, an increasing interest in the scientific community was devoted to produce functional materials, due to their numerous technical applications in microelectronics, electronic computation, dielectric (RAM) and magnetic (MRAM) memories, spintronics, electronic sensors, magnetic refrigeration, etc. To reach this goal, the control of the physical properties of materials by various methods (such as doping, substituting of some atoms with some others, by applying a hydrostatic pressure, electric or magnetic fields, electromagnetic radiation, etc.), made possible the occurrence of some very interesting phenomena like superconductibility and colossal magnetoresistance, nearly total spin polarization of electrons mostly in the case of *perovskite and related structures* compounds. The complex physical properties of these transition metal compounds result from the correlation of d electrons, leading to the coupling of charge, spin and lattice degrees of freedom, and this make the understanding and the theoretical description of these systems extremly difficult.

This habilitation thesis presents the results obtained by the author after the scientific research done on the above mentioned compounds, most of them being complex transition metal oxides. Beside these oxides we also included the perovskite intermetallic compound $MgCNi_3$ which was found to have an unconventional superconducting behavior (in that it shows significant deviations of some important superconducting parameters from the values predicted by the BCS theory).

After a brief description of the general properties of the investigated classes of materials (structural, electrical and magnetic properties) in the Section 2, the results are presented in terms of the evidence of certain specific properties in the studied materials. To provide a concise picture of these proprieties, my results are presented in the context of the research done by some other workers for comparison and for supplementing.

An important feature of Mn an Co complex oxides, such as „manganites” and respectively „cobaltites” is the so-called *phase separation*. This scenario, described in Section 3, is related to the possibility that in the ground state, the system to contain macroscopically coexisting phases, separated from each other (e.g. *hole-rich* and *hole-poo*r regions, having different magnetic behavior). I showed, here, some ways to control the fraction of these regions by changing certain parameters. Beside conventional magnetic measurements we also used the muon spin relaxation spectroscopy measurements, µSR which allowed us, most often, to confirm this scenario. By using this scenario, we tried to explain the magnetic properties of the analyzed compounds. The spin glass-type (or cluster glass) behaviors which we have found in these compounds were interpreted as the effect of the phase separation state present in the systems. In the Section 4, I presented the electrical transport properties in the investigated complex transition metal oxides: manganites, cobaltites, double-perovskites. In the cases of Ba and La – ruthenates, presented here, their electrical and magnetic properties suggest the evidence of a 1 D quantum phase transition and respectively, the presence of quantum ferromagnetic fluctuations. In the end of this section, the electroresistance effect and its dependence on magnetic field in a composite system (doped-manganite $BaTiO_3$/) are analyzed. In the section 5, the phase transitions and the critical phenomena near the Curie temperature are analyzed in great detail for (Pr, Ba) and (La, Ca)-based

manganites and for (Pr, Sr)-base cobaltites. The critical exponents were estimated by using fitting with “scaling laws” (MAP method –modified Arrot plot) and their values indicated a short-range magnetic order 3 D Heisenberg model behavior for manganites and a long-range order, mean field model behavior. The type (i.e. first or second order) of the magnetic phase transition (ferromagnet-paramagnet) is very important for magnetocaloric effect in materials that are intended to be used for magnetic refrigeration. This effect was intensively studied in various materials in the context of problems concerning the ozone depletion layer induced by the using of chlorofluorocarbons (CFCs) in conventional refrigerators. In the next Section (6), the magnetocaloric effect of some manganite and cobaltites (the same which were analyzed in the previous section) as well as in some manganite-cobaltite solid solutions was presented. The obtained results indicated large values for the magnetic entropy changes and for the relative cooling powers. These values are situated in the range of those obtained for materials which are considered to be attractive candidate materials for magnetic refrigeration. The superconductibility phenomenon, continues to arouse interest in the scientific community, both in terms of possible practical application as well due to the aspects related with understanding of its mechanism in various materials, and why this can be different from the BCS theory predictions in some materials. In Section 7 it is shown how the Ni magnetic ions and the holes excess can depreciate the superconductibility in Y123 cuprates. Then, we analyzed how the impurities and some other defects affect the pinning forces and the Josephson coupling between the superconducting regions and how the critical current density depends on temperature, for the Bi-2223 superconductors. The Section ends analyzing the electrical and magnetic properties of the perovskite intermetallic superconductor $MgCNi_3$. The data obtained from measurements allowed us to obtain the main superconducting parameters. These parameters show substantial deviations from the values predicted by the BCS theory. This behavior is attributed to the existence of some bound Andreev states which can occur in the case of an unconventional pairing superconductor, non s-wave type, or they can be the results of multiple bands superconductivity.

The prospective research directions are briefly mentioned in Section 8 of the thesis and they are headed to the study of novel perovskite and perovskite-related bulk materials with interesting physical properties and applications, and to start the research of these type of compounds as thin films, heterostructures for multiferroic and spintronics systems. These prospective research directions will complete the experimental studies performed , mainly by the masterate and doctorate students, in the frame of the disciplines related with the transport phenomena in solids or advanced solid state physics, generally.