Phase transitions (i.e., qualitative changes of properties of a system, appearing at certain values of external parameters) discovered by the authors at temperatures $T \sim 0.5$ K in $RAl_3(BO_3)_4$ borates (R is a rare earth ion), related the appearance of an order of the R^{3+} magnetic moments, are the main subject of the research, Fig 1.

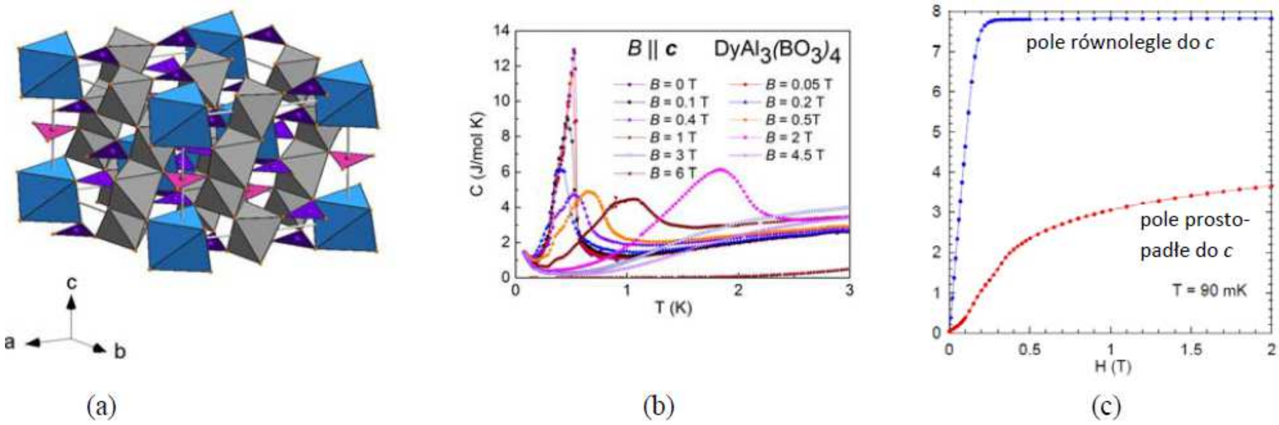

Fig.1. (a) Crystalline structure of the $RAl_3(BO_3)_4$ borates. Magnetic R^{3+} ions are located inside the trigonal (blue) prisms distributed along the 3-fold *c* axis. (b) Specific heat anomaly accompanying the phase transition in $DyAl_3(BO_3)_4$ and its evolution in magnetic field. (c) Magnetization curves for $DyAl_3(BO_3)_4$ (they are typical of ferromagnetic materials).

Determining and studying low temperature phase diagrams of the aluminoborates, i.e. of the lines that represent evolution of the phase transitions in the temperature – differently oriented magnetic field coordinates, is the **main objective** of the project. Observed lately, large interest in magnetic systems in which frustration of interactions appears, as well as dynamical development of a new branch of the condensed matter physics, i.e., the physics of quantum phase transitions (it deals with the transitions, which, on the contrary to the classical transitions induced by thermal fluctuations, appear at zero temperature and are induced by quantum fluctuations, activated by a change of Hamiltonian parameters, e.g. of magnetic field or pressure), are **the main motivation** for undertaking the studies. There exist numerous theoretical papers considering these issues, however, real systems, which would allow to verify the theoretical predictions experimentally, are scarce. Thus, the borates, which are such real systems, are very attractive objects. The preliminary specific heat and magnetization studies performed showed the borates to have complex magnetic structures, which can be influenced by frustration of interactions (e.g., in $DyAl_3(BO_3)_4$, the magnetic order has a ferromagnetic character along the trigonal c axis and an antiferromagnetic one perpendicular to the *c* axis) and to have rich phase diagrams (apart from the transitions mentioned above, some anomalies, which can accompany spin reorientation transitions, were observed). Since the absolute zero temperature can not be achieved in any experimental set up, the presence of a quantum transition can be recognized by investigating atypical behaviors of phase transitions appearing at low but nonzero temperatures. The preliminary studies showed that the phase transitions discovered in the borates show such atypical behaviors, thus they can have a quantum character, i.e., they can be modified by quantum fluctuations. Since for the borates, the appearance of phase transitions of various physical nature is expected, studies of specific heat (which is the quantity sensitive to all phase transitions) over the temperature range from 50 mK to 300 K, in the magnetic field up to 9 T, applied along different crystallographic directions, were chosen as **the main experimental method**. These studies will be supplemented by neutron magnetic structure studies and magnetization and magnetic susceptibility studies. There are expected the following **important results**: (1) Constructing the phase diagrams. (2) Separating and describing theoretically various contributions to the specific heat of the borates. (3) Determining the critical indices α, β, and γ, which will make possible determining a universality class to which the phase transitions appearing in the borates belong. (4) Studying the impact of the R sublattice on properties of the borates, which will be helpful in explaining a physical nature of multiferroic properties of isostructural ferroborates.