DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

1. State the objective of the project.

While the existence on instabilities in crystal lattice, and long range interactions in ferro-electric and anti-ferroelectric material just before the main phase transition to the ferro-electric and anti-ferroelectric has been well documented both experimentally and theoretically in principle, still the cause of their occurrence has not been fully verified. The hypothesis of this project is included in the statement that co-existence of long range interactions generated due to co-interactions of optic and acoustic phonons with similar frequency of oscillations, is a phenomenon that is independent of external factors - such as thermal and mechanical stresses – and leads to local breaking of symmetry above the so-called Curie-Weiss critical temperature, not accounted for in the widely used Landau theory of phase transitions.

In most general terms it can be stated that the aim of the project, being a part of fundamental research, is to investigate the subtle interactions between oscillating atoms that form arranged structures, in order to understand the natural mechanisms which lead to the generation of phase transitions in them, that is various geometric structures of the crystal lattice, in various temperature ranges, and to the occurrence – among other things – of such original physical properties as the piezoelectric phenomenon, widely used in macro- micro- and nano-scale science. The knowledge gained from the project will not only allow to extend the knowledge concerning basic (natural) properties of solids referred to as ferroics, but shall also simplify the controlled use of the investigated materials in electronics, information technology, medicine, automotive industry, as well as in sports.

2. Research to be carried out

The project hypothesis will be verified by studies concerning $Pb(Zr_{1-x}Ti_x)O_3$ crystals with Ti content, from the vicinity of morphotropic phase boundary (x=0.5), crystals $Pb(Zr_{1-x}Sn_x)O_3$, and $Pb(Zr_{1-x}Nb_x)O_3$ and thin layers of $PbZrO_3$. We have chosen these materials because the properties of the pure $Pb^{+2}Zr^{+4}O^{-2}_3$ has been already well recognized. The proposal to investigate thin layers of europe titanate, $EuTiO_3$, contemplated in literature as a compound with multiferroic properties, has been also chosen because we believe that the co-existence of long-range-interactions take place both in pure as well doped - with ions of iso- (Sn^{+4}) and hetero-valent (Nb^{+5}) - ABO_3 perovskites and in multiferroics.

Those studies include:

a) investigations of optic birefringence of crystals and thin layers,
b) investigations of dielectric and electromechanical properties in weak electric fields,
c) investigations of Brillouin light scattering using acoustic phonons,
d) investigations concerning Mössbauer phenomenon in $Pb(Zr_{1-x}Sn_x)O_3$ crystals,
e) investigations of an influence of defects of crystal surface on the bulk properties through the measurement of local conductivity by means of scanning microscope.

3. Present reasons for choosing the research topic

The research topic has been selected bearing in mind the understanding of influence exerted by external factors, such as electric field, magnetic field, temperature gradients, and gradients of mechanical stresses generated e.g. in the presence of crystalline network defects, upon the co-existence of long range interactions in selected ferroelectric and anti-ferroelectric crystals.

The existence of thermal fluctuations or temperature gradients in samples having macroscopic size (in the range of several milimeters) as well as mechanical stresses in nano-structures (thin layers), originating mainly from misfit between the crystal lattice layer and base, may lead to instabilities of the interactions mentioned, or the occurrence of structurally non-arranged phases (the so-called dipole glass phase), that is new physical properties of the extremely functional of ferroelectric materials, anti-ferroelectrics, or the multi-ferroics, which still generate big expectations.