RANDOM DOMAINS IN IRREGULAR FERROELECTRICS

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We consider here a possibility to obtain a frustrated ferroelectric state without short-range competing interactions characteristic for glass models like the Edwards-Anderson one. We have to understand discussing phase transitions in regular (RFE) and various irregular (IRFE) ferroelectrics that they have one common feature: the averaged order parameter vanishes in a macroscopic sample at the absence of an external electric field. It is important that in all of these cases the reason is the same: domains. Long-range interactions will suffice for domains to appear in RFE; a disorder (randomly distributed built-in fields, charges or solid-solution content spatial fluctuations) does not change drastically the macroscopic picture, it modifies only spatial and temporal correlations in the system. That is why a theory, pretending to explain something in ferroelectrics now, must describe domain correlations first of all. It is better to think about these microscopic ordered regions as domains not clusters since one usually imagines clusters as small spheres scattered randomly all over the sample. We have in mind spontaneously appearing cluster structure stimulated (but not formed!) by the crystal content inhomogeneities distributed with small enough correlation length excluding from the consideration the large R_c case. However, the well-known Derrick's theorem states that no cluster-like solutions with thin enough (in comparison with the cluster size) walls can exist in a dimension upper than two. At the same time, decomposition of the three-dimensional sample on domains separated by a random multiply-connected surface makes the problem locally one-dimensional that permits us to get round the restriction stemming from the Derrick theorem, while globally the system acquires rather sophisticated topology. Then we come to the domain structure problem at the random field influence. This structure looks one-dimensional at the length scale large in comparison with the mean domain size, but small in comparison with the correlation length for processes of the order parameter rotation between degenerate or almost degenerate directions. Then we shall have a quasi-one-dimensional domain structure at small distances with changing of the polarization orientation at larger scales. If free energies for distinct crystallographic orientations are getting very nearly as it is the case in the $BaTiO_3/SrTiO_3$ compound, a frustrated domain structure appears. We developed a stochastic approach to this problem. The saddle point equations of the model describe the small-scale random domains, while at larger scale they describe domain walls connecting mesoscopic domains of different polarization orientations. The macroscopic state of the sample can be considered as an array of mesoscopic domains charactered by different orientations of directors. Kinks joining these domains must minimize possible macroscopic electric fields and mechanical stresses. This macroscopic state is frustrated because very many different mesoscopic configurations have very near free energies. It is very important that small changes of say external mechanical stress can induce large changes of the mesoscopic structure and, therefore, large electrostiction coefficient can be observed.