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Department of Physics and Astronomy

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Domains and Switching in Ferroelectrics

After discovery of the ferroelectric properties of barium titanate in 1945, Vitaly Ginzburg developed the phenomenological mean field theory of ferroelectricity (more commonly known as the Ginzburg-Landau-Devonshire – LGD – theory). The mean field theory explained all of the key ferroelectric properties, including the Curie-Weiss temperature dependence of the dielectric constant, the temperature dependence of the polarization, phase transitions of the second and first order, etc. The LGD theory did not, however explain the experimental value of the coercive field, which was 2-3 orders of magnitude lower than predicted. This was the first paradox of ferroelectricity.

In 1953, Indenbom and Chernysheva discovered domains in Rochelle Salt. In 1954 Merz discovered domains in barium titanate and explained their appearance and the mechanism of polarization switching by nucleation and domain movement in an external electric field. Discovery of domains resolved the parados of the low coercive field. From this time, we distinguished the large intrinsic coercive field from LGD theory, and the much lower extrinsic field associated with domain nucleation and growth. The intrinsic coercive field and intrinsic switching processes, however, were never observed in practice, neither in bulk crystals nor in thin films.

The second paradox is connected with the discovery by our group fifteen years ago of two-dimensional ferroelectricity in ultrathin films of a ferroelectric polymer made by Langmuir-Blodgett deposition. It was shown that the ferroelectric state persisted in such films as thin as two monolayers, about 1 nanometer in thickness, accompanied by the increase of the coercive field to the intrinsic value. This means that the thickness of such films is much lower than the minimum size of a domain nucleus, and therefore the domain mechanism of switching must be suppressed. This problem was solved by the development of the theory of intrinsic polarization switching, which predicts that the switching time exhibit critical behavior, diverging at the coercive field and at the critical temperature, in excellent agreement with the experiments on the ultrathin ferroelectric polymer films.

Host:
Dr. Stephen Ducharme
Department of
Physics and Astronomy

Wednesday, May 23
4:00 pm
Room 136, Jorgensen Hall

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