Exercises N9 14.04.2025 Ferroelectricity

9.1. $(Ba_{0.5}, Sr_{0.5})TiO_3$ is a ferroelectric. Its polarization response to electric field is described with the Landau theory with $\beta = 4 \times 10^9\ \mathrm{Jm^5/C^4}$. The Curie-Weiss constant of the material $T_{CW} = 1.1 \times 10^5\ K$.

(a) An electric field $E_0 = 5\ \mathrm{kV/cm}$ is applied to the material. Find the polarization P_0 induced by this field if the material is exactly at its ferroelectric-paraelectric transition temperature (at $T = T_c$). Find the average permittivity for this case defined as $K_{\mathrm{av}} = 1 + \frac{1}{\varepsilon_0}\frac{P_0}{E_0}$.

(b) Electric field in the material $E_0 = 0$. Evaluate the differential permittivity measured in this case at temperature $T > T_c$ close to T_c. Analyse its behaviour when $T \to T_c$.

(c) Compare the results for permittivity obtained in cases (a) and (b) at $T = T_c$. Why are these results different?

9.2. In the same material as in previous exercise, the differential permittivity K is measured in the presence of an additional electric field E_0.

Show that, in the paraelectric phase, K decreases with increasing E_0.

What electric field E_0 should be applied to this material at $T = T_c + 10$ K in order to reduce K two times compared to K measured at zero electric field?