Lets apply $\frac{L3}{\text{this}}$ theory to explain the effect of FERROELECTRICITY.

In many insulators an Applied electric field, E causes internal stress which is $\sim E^2$

This phenomenon is known as electrostriction

We don't want to discuss this, instead there are some interesting crystals where strain $\sim$ E: pyroelectrics, ferroelectrics and piezoelectrics.

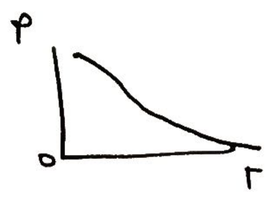
ferroelectrics are very interesting since they undergo the 2d order phase transition.

NB. Symmetry consideration: To have internally uncompensated dipole electric fields: $\sum \bar{p}_i(\bar{r}) = \bar{P}$

$\bar{p}_i = q \cdot \bar{r}_i$

Below the transition T_c, crystal must transform into a new crystal symmetry which has no inversion symmetry, i.e. non-centrosymmetric.

Side note: The difference between FERRO- and PYRO-



(inside pyroelectrics there are small microcrystalines of Ferroelctrics)

Lets apply the Landau Ideas from L1 and L2 to

$BaTiO_3$ = a "classic" FE

$$\boxed{\text{WHAT ARE FERROELECTRICS?}}$$

Free energy as usual can be written as:

not pressure!!

$$F(\eta, T) \equiv F(P, T) =$$

here P is polarization which is our order parameter since below T_c $\langle P \rangle \neq 0$

$$= F_0(T) + a(T - T_c)P^2 + \underset{>0}{B(T)}P^4 + D(T)P^6 + \dots$$

$$\frac{dF}{d\eta} = 0 \;\Big|\; \Rightarrow \cancel{2}a(T - T_c)\cancel{P} + \cancel{4}BP^{\cancel{3}\,2} = 0$$

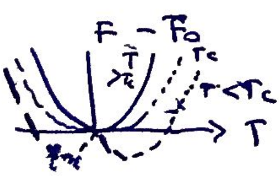
$$P_M = \begin{cases} 0 & T > T_c \\ \left[-\dfrac{a(T-T_c)}{2B}\right]^{1/2} ; & T < T \end{cases}$$

Note: cubic term not permitted by symmetry, since $\vec{r} \to -\vec{r}$ $\vec{P} \to -\vec{P}$

insert $P_M \to$ into $F(P, T)$ we can get:

$$F = \begin{cases} F_0(T) & T > T_c \\ F_0(T) - a(T - T_c) \cdot \left(-\dfrac{a(T-T_c)}{2B}\right) + \\ + B \cdot \dfrac{a^2(T-T_c)^2}{4B^2} + \dots \end{cases}$$

lets ignore ... P^6 term



$$= \begin{cases} F_0(T) & \text{for } T > T_c \\ F_0(T) - \dfrac{a^2(T-T_c)^2}{4B} ; & T < T_c \end{cases}$$

Lets think how heat capacity changes at T_c:

$$C = T\frac{dS}{dT} = -T\frac{\partial^2 F}{\partial T^2} \qquad \frac{\partial^2 F}{\partial T^2} = -\frac{a^2}{2B}$$

$$C = \begin{cases} C_0(T) + T\dfrac{a^2}{2B} & T < T_c \\ C_0(T) & T > T_c \end{cases}$$