Barkhausen Noise in Relaxor Ferroelectrics

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Prof. Xu Group Meeting

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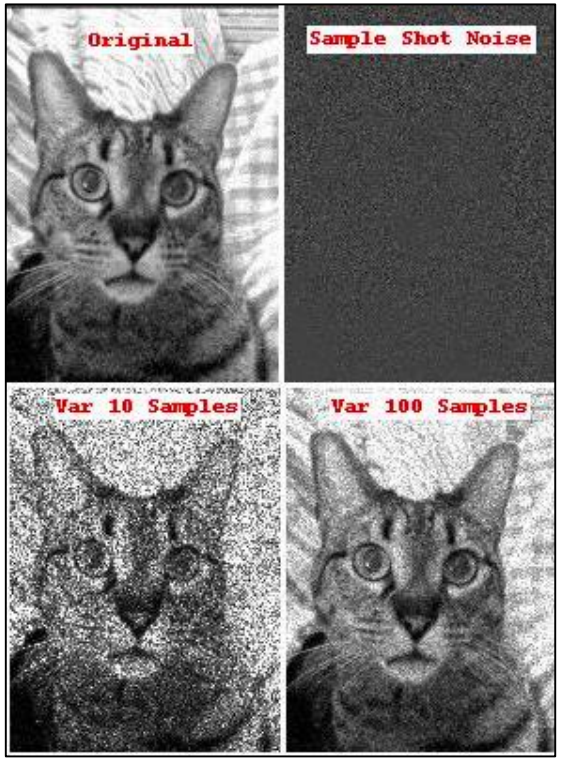
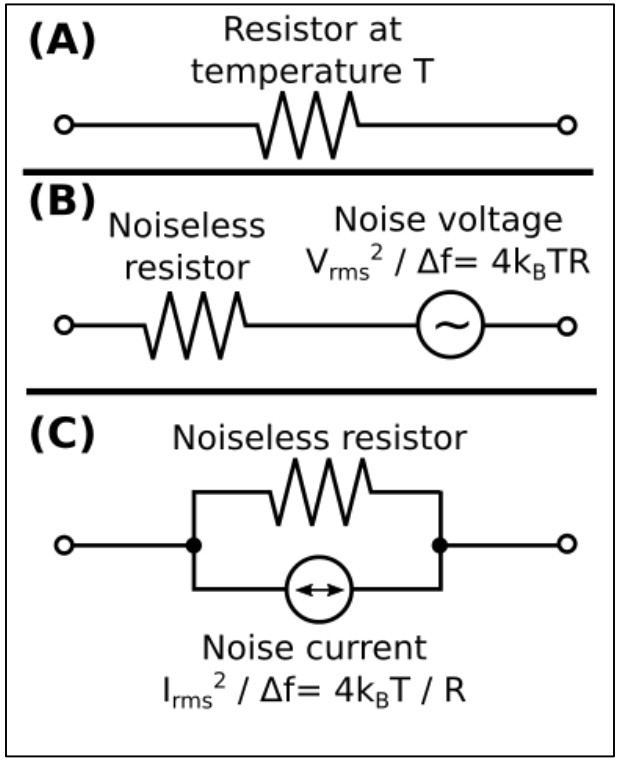
Fundamental Noise

- Shot noise: result of quantized charge carriers



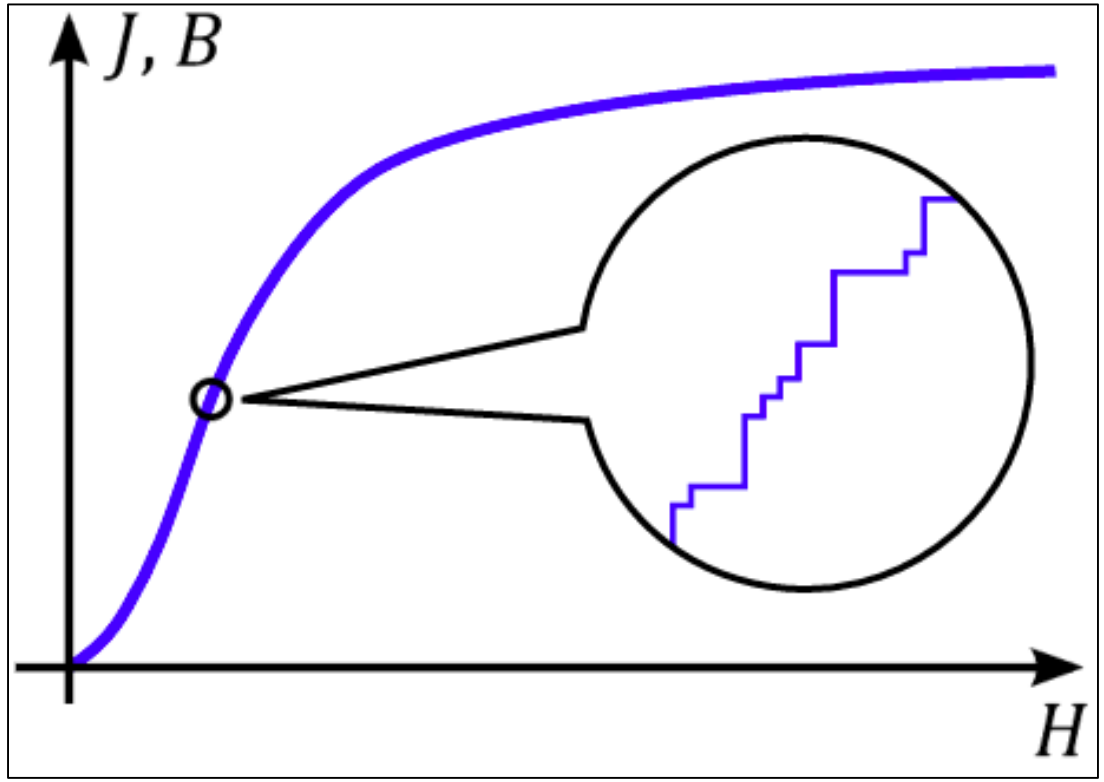
- Johnson-Nyquist noise: thermal motion of charge carriers



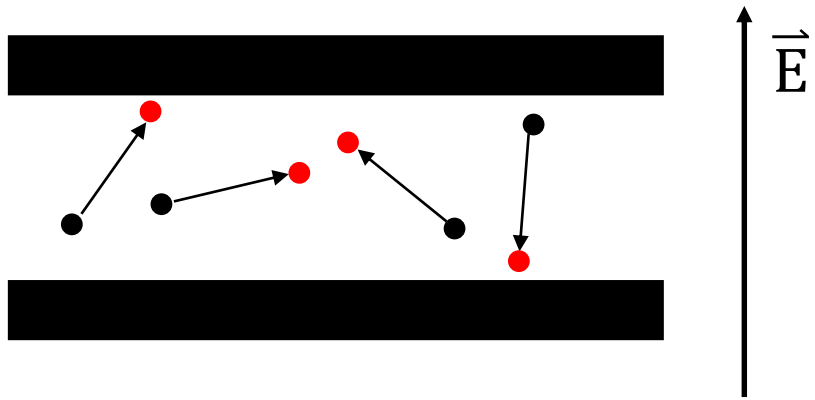
Barkhausen Effect

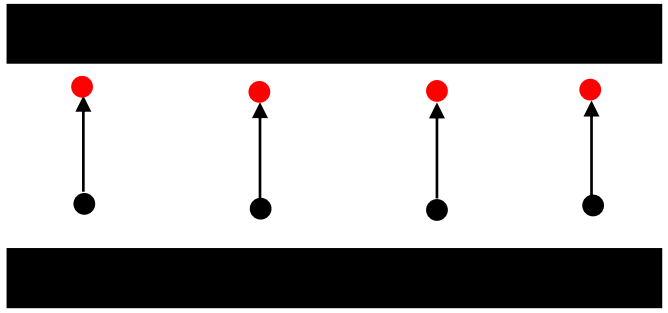
- Finite domains lead to discrete jumps in polarization

- Audible Barkhausen noise



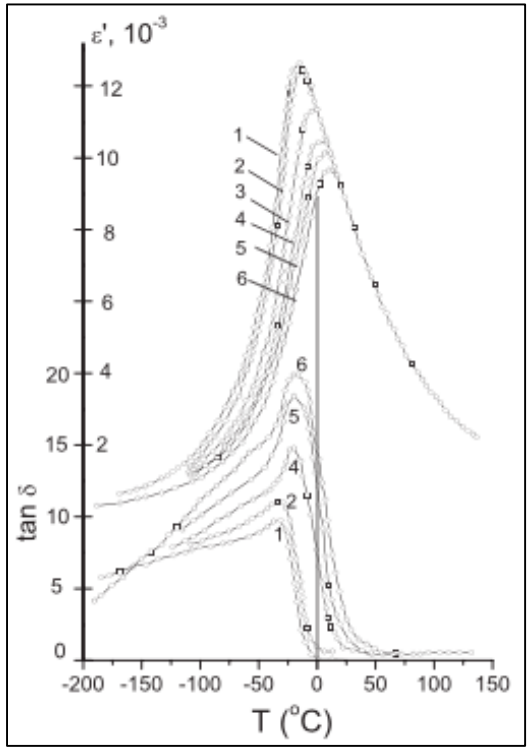
Polarization → Voltage Noise

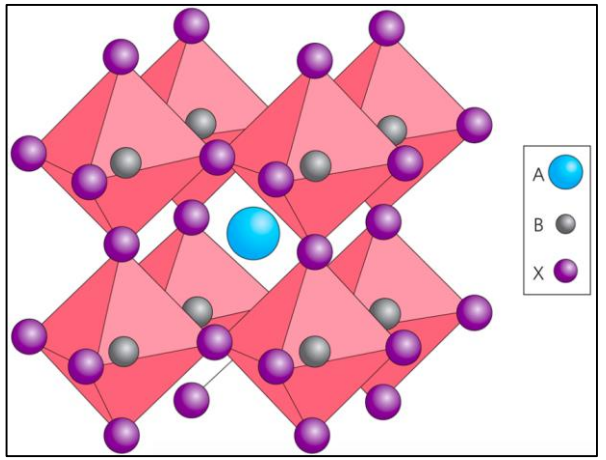




Relaxor Ferroelectrics

- Example: perovskite (ABO_3) structures
- Replacement of random A- or B-site atoms leads to frustration
- $\varepsilon \sim {}^{1}/_{(T-T_C)^2}$ near peak





"A Review in Relaxor Ferroelectrics", Advances in Physics, 60: 2 (229-327)

Experimental Details

- Apply oscillating field E_D to sample, remove background noise (60 Hz power lines, capacitive noise, etc)
- Integrate Fourier power spectral density to get voltage variance

- $\langle (\delta V)^2 \rangle \approx \frac{pE_D}{\varepsilon C_0}$: approximate size of dipole change *p* based on otherwise measured sample properties

Results: Noise spectrum & size of switching

- Calculate typical dipole switch p: actually range of sizes
- $p \approx 2 \times 10^{-22}\ (\mathrm{C} \cdot \mathrm{cm}) \approx 100$ domains

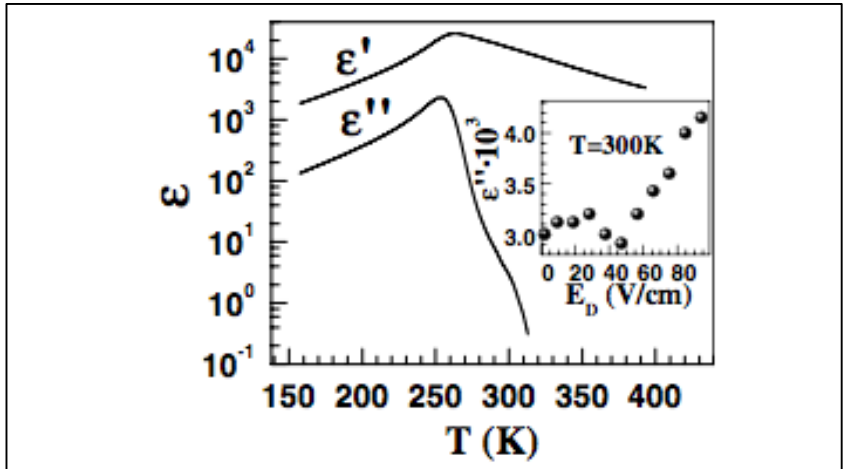


FIG. 1. $\varepsilon'(T)$ and $\varepsilon''(T)$ at 50 Hz, measured at 13 V/cm. The inset shows the nonlinear out-of-phase response, most apparent at high-T where the linear out-of-phase response is tiny.

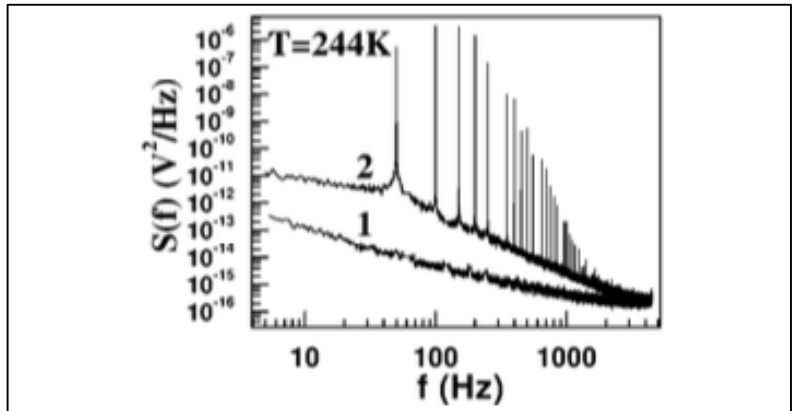


FIG. 3. $S(f)$ with $E_D = 130$ V/cm at $f_D = 50$ Hz at 244 K (spectrum 2) is shown above a background (spectrum 1) consisting of equilibrium noise from the dissipative sample plus amplifier noise, mainly from current noise from the Stanford 550 preamp. The harmonics of 60 Hz have been edited out.