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REU Report

My REU research this semester was spent further investigating composite materials and their effective properties. I considered both critical paths and the imaging of composite materials. Primarily, however, I considered variation principles to define certain characteristics of composite materials. As its name indicates, this technique involves varying parameters to result in bounds for some property. In particular, I looked at the bounds for conductivity of a composite structure derived by integrating over minimal divergence and curl free fields. Namely, the minimal fields that satisfy the following:

$$\nabla \times E = 0 \,, \; \nabla \cdot J = 0$$

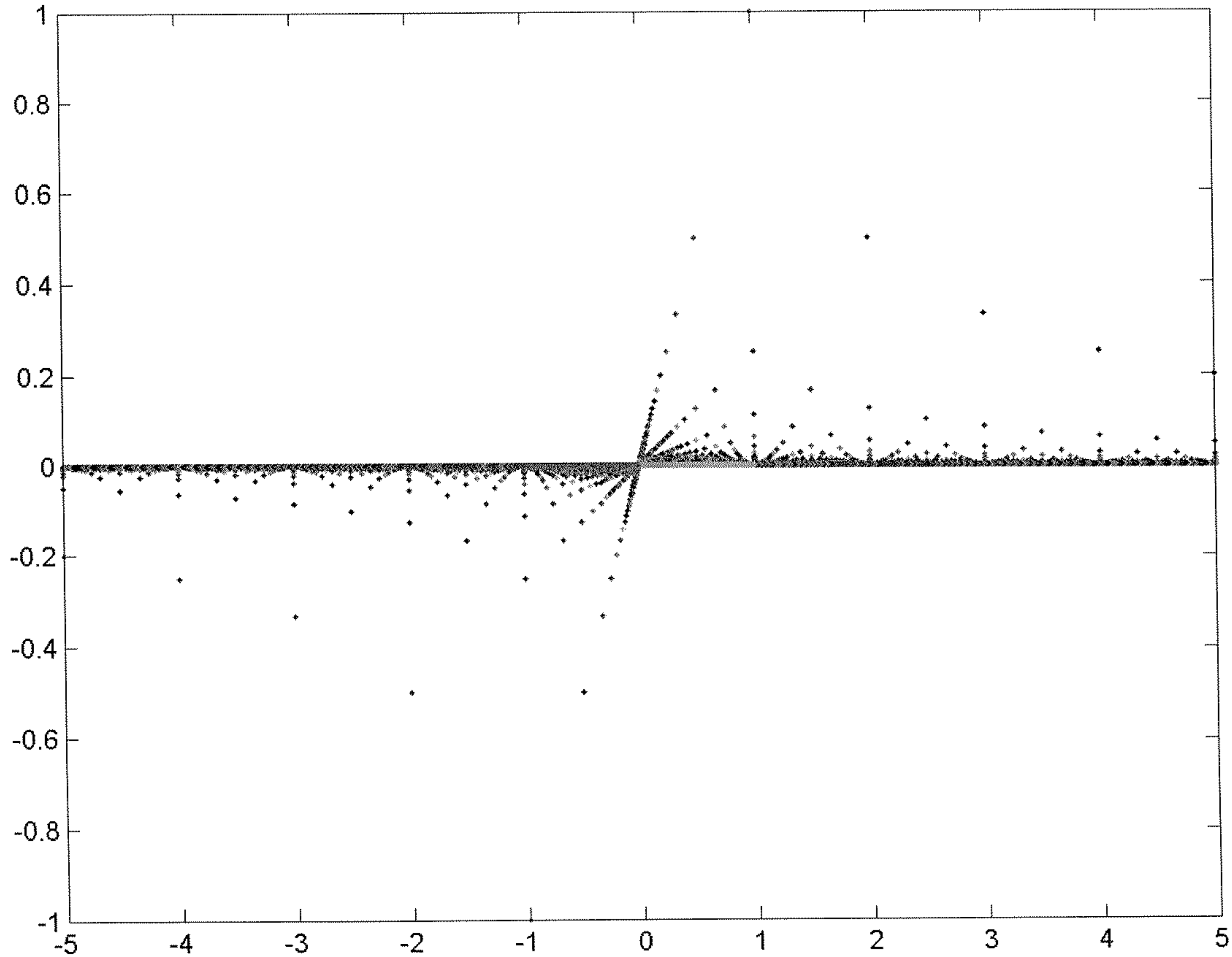
Subsequently, the effective conductivity, σ^* of a material composed of two different materials of conductivities σ_1, σ_2 in corresponding volume fractions p_1, p_2 is bounded as follows:

$$\frac{1}{\frac{p_1}{\sigma_1} + \frac{p_2}{\sigma_2}} \le \sigma^* \le p_1\sigma_1 + p_2\sigma_2$$

In addition to studying composite materials, I was able to create a graph using Matlab of the following function (shown on next page) which was used in a grant proposal of Ken Golden's this fall:

$$f(x) = \begin{cases} \frac{1}{p \cdot q}, x \in Q, x = \frac{p}{q} \\ 0, x \in Q^c \end{cases}$$

Variations of this intriguing function are found in quasiperiodic systems. Its interesting behavior may be a basis for investigation of photonicquasicrystals.



1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-5
-4
-3
-2
-1
0
1
2
3
4
5