Development of strong magnetic field gradient coils for q-space Nuclear Magnetic Resonance (NMR) imaging

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Abstract

A magnetic field gradient coil is used in Nuclear Magnetic Resonance (NMR) to tag the spatial position of nuclear spins in a sample in both k-space and q-space imaging schemes. In this poster presentation we report on our analysis for generating a gradient field of 500,000 G/cm over a sample volume of 1 mm³. Previously reported gradient fields with these methods range from 1000 G/cm to 50,000 G/cm. The gradient fields will be used to investigate the structure of a broad range of materials in addition to quantum dynamics in homogenous solids in our laboratory at York College.

Applications of magnetic field gradients

- q-space imaging: Measures the average probability of molecular displacement of molecules in a porous structure. Limits of resolution are dictated by how well one can reproduce the gradient pulse areas and gradient strength.
- k-space imaging: Measures spin density versus spatial position. Limits of resolution are dictated by the strength of the gradient and molecular diffusion.

Gradient generated by single Maxwell pair

\[ G \approx \frac{3\mu l}{2} \left( 1 + \left( \frac{z}{R} \right)^{3/2} \right) \frac{R}{l} \]

Schematic cross sectional view of a gradient set

Cross sectional view of the wire making up the gradient set

Parameters used in this design

Gradient field for first set of turns:

\[ G_1(G/cm) = \sum_{n=1}^{4} \frac{3\mu l}{2} \left( 1 + \left( \frac{z}{R} \right)^{3/2} \right) \frac{R}{l} \]

Method used here involved pair wise summation of gradients generated by each turn of wire

Temperature increase of the gradient set

\[ \Delta T = 0.055 \frac{V^2\mu l}{m^2} \] (See Ref. 2)

Citations:


Conclusions

In this poster we presented an analysis performed to generate a strong magnetic gradient field over a sample volume of approximately 1 mm³. The techniques used relied on already developed methods by W. Zhang and D.G. Cory[2]. A pulsed gradient field of approximately 500,000 G/cm can readily be generated with these coils, with a suitable power supply that can deliver approximately 200 Amperes of current. In the past a set of car batteries were used for this application [2,5] resulting in a pulsed field gradient of approximately 50,000 G/cm.

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