MAGNETIC FIELD OF A SPHERE IN A UNIFORM FIELD

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If we place a linear magnetic sphere in a uniform magnetic field \( B_0 = B_0 \hat{z} \), we can find the magnetic field inside the sphere using the method of successive approximations we used for a dielectric sphere in an electric field.

We start by assuming that the only field present is the uniform field, which then induces a magnetization within the sphere:

\[
M_0 = \frac{\chi_m}{\mu} B_0
\]  

We then find the field produced by this magnetization (which is done by Griffiths in example 6.1):

\[
B_1 = \frac{2}{3} \mu_0 M_0 = \frac{2\mu_0 \chi_m}{3\mu} B_0
\]  

This field produces another bit of magnetization:

\[
M_1 = \frac{\chi_m}{\mu} B_1 = \frac{2\mu_0 \chi_m^2}{3\mu^2} B_0
\]  

which in turn produces a bit more field:

\[
B_2 = \frac{2}{3} \mu_0 M_1 = \left( \frac{2\mu_0 \chi_m}{3\mu} \right)^2 B_0
\]  

The process repeats so that for the \( n \)th iteration we get

\[
B_n = \left( \frac{2\mu_0 \chi_m}{3\mu} \right)^n B_0
\]  

The total field is then the sum of all the individual contributions:
\[ B = B_0 \sum_{n=0}^{\infty} \left( \frac{2\mu_0 \chi_m}{3\mu} \right)^n \quad (6) \]

\[ = B_0 \frac{1}{1 - \frac{2\mu_0 \chi_m}{3\mu}} \quad (7) \]

\[ = B_0 \frac{1}{1 - \frac{2\chi_m}{3(1+\chi_m)}} \quad (8) \]

\[ = B_0 \frac{3 + 3\chi_m}{3 + \chi_m} \quad (9) \]

Unfortunately, the same method doesn’t work for finding the field outside the sphere, since that field is not constant in space.

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