Chapter 1

Magnetostatics

Garfield currently offers the following ways to describe the magnetic field:

- a constant field;
- a parametrised or a tabulated field;
- a field map computed by a finite element program.

This section deals with the distortions caused by the difference in magnetic permeability of the wire material and the gas. Such distortions are computed only when the field is constant.

When a homogeneous cylinder of radius a and magnetic permeability $\mu_{\rm w}$, surrounded by a gas with magnetic permeability $\mu_{\rm g}$, is placed with its axis parallel with z in an originally homogeneous magnetic field $(B^0_{\rm x}, B^0_{\rm y})$, the field will be perturbed by the addition of a term [1]:

$$B^{\rm out}_{\rm x}(x,y) = B^0_{\rm x} + \frac{\mu_{\rm w}-\mu_{\rm g}}{\mu_{\rm w}+\mu_{\rm g}} \frac{a^2}{(x^2+y^2)^2} \left((x^2-y^2)B^0_{\rm x} + 2xyB^0_{\rm y}\right)$$

$$B^{\rm out}_{\rm y}(x,y) = B^0_{\rm y} + \frac{\mu_{\rm w}-\mu_{\rm g}}{\mu_{\rm w}+\mu_{\rm g}} \frac{a^2}{(x^2+y^2)^2} \left(2xyB^0_{\rm x} - (x^2-y^2)B^0_{\rm y}\right)$$

Inside the cylinder, the field will be parallel with unperturbed field, but its magnitude has changed:

$$B^{\rm in}_{\rm x}(x,y) = \left(1 + \frac{\mu_{\rm w}-\mu_{\rm g}}{\mu_{\rm w}+\mu_{\rm g}}\right) B^0_{\rm x}$$

$$B^{\rm in}_{\rm y}(x,y) = \left(1 + \frac{\mu_{\rm w}-\mu_{\rm g}}{\mu_{\rm w}+\mu_{\rm g}}\right) B^0_{\rm y}$$

The field perturbations in the gas have therefore a quadrupolar shape. The magnitude of these perturbations decay with $(a/r)^2$ where r is the distance to the wire and are proportional with the difference in permeability between gas and wire material. Since most materials used for chamber construction has a permeability very close to μ_0, the perturbations are usually negligible.

Bibliography

[1] E. Durand. *Magnétostatique*, pages 373–374. Masson, Paris, 1968.

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