Calculations of Fringing Fields of a Quadrupole Lens

著者	UEDA Masahiro, NODA Matu-tarow
journal or publication title	Journal of Applied Physics
volume	12
number	2
page range	323-324
year	1973-02
URL	http://hdl.handle.net/10098/1451

doi: 10.1143/JJAP.12.323

Calculations of Fringing Fields of a Quadrupole Lens

Masahiro UEDA and Matu-Tarow NODA
Faculty of Engineering, Ehime University,
Matsuyama, Ehime

To design quadrupole lens systems, it is important to know potential distributions in axial direction. In magnetic lenses, the distributions have been measured by few persons.^{1,2)} Here they are calculated for a electrostatic quadrupole lens by solving three-dimensional Laplace's equation numerically. The lens consists of circular-concave electrodes as shown in Fig. 1.

Boundary conditions imposed on the calculations are given on the following planes and surface.

1. a plane at $Z=0$.
2. a plane at $Z=Z_f$, where $Z_f=l_1+2a$.
3. a surface at $R=a$.

The potential distributions of the first condition, $\varphi(R, \theta, 0)$, are obtained by solving two-dimensional Laplace's equation. The distributions of the second one are assumed to be given by

$$\varphi(R, \theta, Z_f) = f(Z_f) \cdot \varphi(R, \theta, 0), \quad (1)$$

because the distributions are almost independent of θ -coordinate as seen from experimental results.¹⁾ The distributions of the last one are given by

$$\varphi(a, \theta, l_1 < Z < Z_f) = \varphi(a, \theta, 0 \leq Z \leq l_1) / \exp \{(Z-l_1)/b\}, \quad (2)$$

Fig. 1. Arrangement of an electrostatic quadrupole lens. (a) Construction of the lens. A plane normal to Z -axis at $Z=0$ is a central plane of the lens. (b) Cross-section of the lens.

from a comparison of the results obtained here with the one obtained experimentally as seen in Fig. 2. In these equations $f(Z_f)$ and b are determined from the results by electrolytic tank method.³⁾ Liebmann's accelerating method is used in this computer analysis.

Results are shown in Fig. 2. In this figure dots show the measured axial field distribution by H. Kawakatsu *et al.*²⁾ The numbers of mesh points for R -, θ -, and Z -coordinates are 10, 48, and 15, respectively. It is found from these results that R component has negligible influence on the fringing potential distributions and then an effective lens length hardly changes within an available lens region ($R/a \leq 0.4$). The results above mentioned throw a light to the calculations of the field distributions for quadrupole multiplet.

One of the authors (M.U) would like to

Fig. 2. Calculated potential distributions in axial direction for $f(Z_f)=0.04$, $b/a=0.5$ and $l_1/a=1.0$. Solid and dotted curves correspond to $R/a=0.1$ and 0.4 , respectively. Dots show the experimental results by H. Kawakatsu *et al.*²⁾

express his sincere thanks to Prof. H. Kuroda and Dr. K. Nagami of University of Osaka Prefecture and Dr. H. Kawakatsu of electrotechnical Laboratory for their continuing interests and valuable discussions. Numerical calculations were done on FACOM 230-60 at the Data Processing Center of Kyoto University and FACOM 230-60 at the Computer Center of Kyushu University.

References

- 1) A. Septier: *Advances in Electronics and Electron Physics* ed. L. Marton (Academic Press, 1961) Vol. 14, p. 85.
- 2) H. Kawakatsu, G. Vosburgh and B. M. Siegel: *J. appl. Phys.* **39** (1968) 245.
- 3) M. Ueda, K. Nagami and H. Kuroda: Preprint of the 31st Annual Meeting of the Japan Society of Applied Physics held in Tokyo, April, 1970, No. 2aG10.