Calculations of Fringing Fields of a Quadrupole Lens

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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

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

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

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

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 ($R/a\lesssim 0.4$). 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

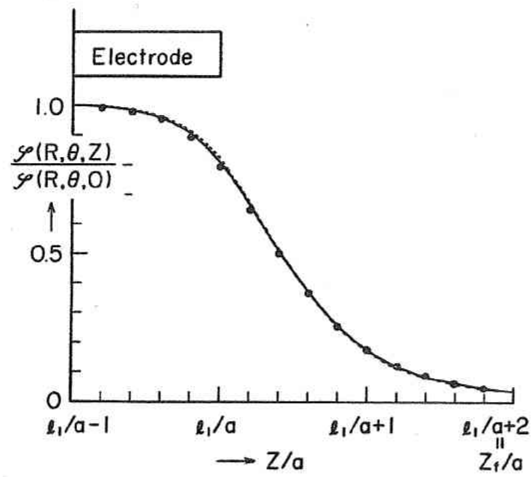

Fig. 2. Calculated potential distributions in axial direction for $f(Z_f)=0.04$, $b/a=0.5$ and $l_1/a=1.0$. Solid and dotted curves correspond to $R/a=0.1$ and 0.4, respectively. Dots show the experimental results by H. Kawakatsu *et al.*[2]

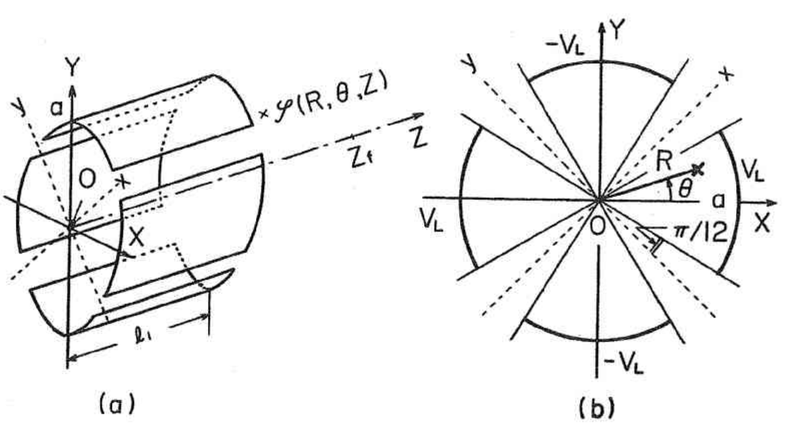

Fig. 1. Arrangement of a electrostatic quadrupole lens. (a) Construction of the lens. A plane normal to Z-axis at $Z=0$ is a central plane of the lens. (b) Cross-section of the lens.

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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.