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FRINGING FIELDS FROM THE ELECTROSTATIC SEPTUM

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The electrostatic wire septum currently being tested in H20 consists of an array of .004 in. tungsten wires spaced uniformly 2 millimeters apart. This wire array forms the outer ground potential electrode. The high voltage solid electrode is spaced 1 cm for this wire array.

If this assembly is powered during injection, the injection orbit stability is adversely affected. The beam acts as if a quadrupole field was created by the electrostatic septum.

It may be possible that this quadrupole field is the result of the electrostatic fields fringing through the wire grids. The line integral $\int Eds$ along the injection beam line through this fringing electrostatic field is not zero since charge exists of the vacuum chamber walls

$$\int Eds = 4\pi q$$

where q is the total charge enclosed by the integral.

The vacuum chamber walls consists of conducting surfaces connected to ground potential. Some electrostatic lines of force will leave the high voltage electrode thread through the wire grids and terminate on the chamber walls.

A detail computation of the electrostatic field produced by this geometry involves a three-dimensional study. To avoid the difficulty of this study, a study of a simplified two-dimensional model was made.

In this mathematical model the high voltage electrode and the vacuum chamber wall was assumed to be two parallel planes of infinite extent separated by 20 cm. One centimeter from the high voltage electrode is located a parallel wire grid of 0.2 cm wire spacings. Each wire is infinitely long.

The electrostatic field produced by this model can be computed by relaxation methods. A relaxation grid of 0.02 cm spacing was choosen. To simplify the computer effort the electrostatic field more than 1 cm from the wire grid was assumed to be uniform. The relaxation region was therefore bounded by this assumption, the high voltage electrode and lines of symmetry. Thus a grid of 200 by 10 units was formed and a simple relaxation is possible.

The results in terms of E_o (defined as the potential between the high voltage electrode and the wire grid divided by the 1 cm separation) as given as follows:

$$E \text{ (in gap between electrodes)} = .937\ E_o \pm 0.3\%$$
$$E \text{ (fringing through the wires)} = .00329\ E_o \pm 3\%$$

Note the electric field in both regions were defined as the average field along a line through that region. A test of the accuracy of the numerical relaxation is Gauss' law. The integral of Eds along any line through a charge free region must be equal. Variations of this integral were about 0.3% in the high field region and about 3% in the fringe region. Thus the assigned accuracies above.

This mathematical model yields a computable dipole field. The real vacuum chamber is not infinite in extent vertically, but has a top and bottom wall. The septum is also limited in vertical height. Thus the dipole field of the model will fringe and produce a quadrupole component.

The threshold of observed effect on the injection occurs with 10 kV on the septum. With this potential on the high voltage electrode a field approximately 30 volt/cm could fringe through the wires. This is the correct order of magnitude to explain the observed effects and is offered as a possible explanation.

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