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Recent experimental and theoretical work concerning the relativistic increase in ionization of a charged particle moving through matter is discussed elsewhere.[1] The purpose of the present study was to compare the grain density at saturation ionization (plateau) with that at minimum ionization for negative electrons in G5 emulsion.

A single 1 in. x 3 in., 200 micron Ilford G5 emulsion was exposed to 300 Mev and 3 Mev electrons. The former were obtained by magnetic analysis of pairs produced from a tantalum converter in the bremsstrahlung beam of the Berkeley synchrotron. The latter were obtained by magnetic analysis of an electron linear accelerator beam. Primary electrons entering the emulsion at~5 degrees to the emulsion-air surface penetrated the emulsion in opposite directions and formed two adjacent bands of electron tracks. Grain counts were recorded in terms of a standard reticule unit, which, under the magnification used (~2500x) was 32 microns in length. For the purposes of comparing grain counts at the two energies, the following criteria were adopted:

(1) A grain was counted as one unit regardless of size.

(2) All grain counts were taken in a layer of developed emulsion between 40 and 10 microns from the emulsion-air surface.

(3) Track sections were accepted for grain counting only if their dip angle was in the same sense as would be expected from the exposure set-up.

(4) Consistent with (3), only portions of track were grain counted where the angle of dip in the developed emulsion was between 0 and arc tan 0.059.

The grain density determined on the basis of criterion (1) is essentially proportional to that obtained when clumps are resolved into individual grains for the thin tracks used here. The fourth criterion allows one to neglect the error in track length due to the uncertainty in the shrinkage factor. By grain counting tracks of ~300 Mev electrons as they penetrated the emulsion, the gradient of development in the acceptable layer (criterion (2)) was found to be less than one percent. Because of the large multiple scattering of ~3 Mev electrons, and in light of criterion (4), it was not feasible to grain count successive intervals of these tracks. Instead, the following "field of view" method was adopted: Grain counts per standard unit were taken for all portions of ~3 Mev tracks in a field of view lying within ± 22.5 degrees of the mean entrance angle. Tracks of ~ 300 Mev electrons were first grain counted by taking successive intervals of given tracks (7207 grains). Then the ~3 Mev tracks were grain counted by the "field of view" method. Finally, ~300 Mev tracks were grain counted by the latter method (7197 grains). The means and standard deviations of the two sets of ~ 300 Mev data agreed within the statistical errors. The error in track length due to multiple scattering over a standard unit is negligible. All counts were taken by one observer whose reproducibility was found to be better than one percent.

Our results are given in Table I. The two sets of ~ 300 Mev data are combined. The mean energies have been calculated taking into account the energy loss in the acceptable layer due to radiation[2] and ionization.[3] The ionization of 2.8 Mev electrons differs from minimum ionization by less than one percent.[3]

TABLE I

Mean Energy (Mev)	No. of Grains Counted	Mean Gr. Density With Std. Error (grains/32μ)	Std. Deviation (grains/32μ)	Ratio of Mean Gr. Densities With Std. Error
293	14404	8.61 ± 0.05	2.13	1.087 ± 0.010
2.8	7002	7.92 ± 0.06	1.95	

Assuming proportionality between grain density and ionization, the ratio in Table I is also that of saturation to minimum ionization.

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