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RBE, LET, and z/β^α

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LETTERS TO THE EDITOR

RBE, LET, and z/β^{α}

A call has been issued by Turner and Hollister in this journal[1] for nomination of a suitable combination of charge and velocity to replace LET. It is the purpose of this communication to point out that no single combination of these variables can fully characterize track effects, as these are affected by the ratio of the range r_m of the delta ray of maximum energy to the radius a_0 of the sensitive volume.

Recent developments in the theory of particle tracks make it clear that track effects are dominated by the spatial distribution of ionization energy deposited by delta rays.

The spatial extent is limited by the range of the delta ray of maximum energy, while the total energy deposited varies as $z^2\beta^{-2}$, so that we must expect that the average energy density within the allowed region to be a function of $z\beta^{-\alpha}$, where α depends on range energy relationships, and so would be different for molecular and cell sizes. A suitable guess would be that $1 < \alpha < 3$, for $a_0/r_m \gg 1$.

When the radius of the sensitive volume is much less than the range of the delta rays of maximum energy the case seems quite clear. Here $\alpha = 1$, and the suitable parameter is z/β, where the effective charge z_e of an ion of atomic number Z moving at speed β_c is given by the expression $z_e = Z_c[1 - \exp(-125\beta Z^{-2/3})]$. This conclusion seems to be compelled by work done on the interaction of charged particles with dry enzymes and viruses,[2] NaI(Tl),[3] dielectric track detectors,[4] and emulsion.[5] Over a large range of dimensions, from 10^{-7} to 10^{-1} cm, and for all media, the energy density E deposited by delta rays varies with the distance t from the path of a charged particle according to the expression $E \propto z^2\beta^{-2}t^{-2}$, to sufficient accuracy for present purposes, out to distances of order r_m, where the energy density drops rapidly to zero. Thus, where r_m is not the determining factor in the response of a system, most generally where $a_0 \ll 1$, the response depends upon $(z/\beta)^2$.

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References

1. J. E. Turner and Hal Hollister, *Health Phys.* **17**, 356 (1969).
2. J. J. Butts and R. Katz, *Radiat. Res.* **30**, 855 (1967).
3. R. Katz and E. J. Kobetich, *Phys. Rev.* **170**, 397 (1968).
4. R. Katz and E. J. Kobetich, *Phys. Rev.* **170**, 401 (1968).
5. R. Katz and E. J. Kobetich, *Phys. Rev.*, in press.

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