Comment on "Collective Ion Acceleration by Relativistic Electron Rings in the Magnetosphere"

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A proposal by Schumacher and Boswell for the generation of an electron ring in the magnetosphere, and subsequent collective ion acceleration, by a rocket- or satellite-borne electron gun is unfeasible, because it ignores the electric field by the charged-up gun.

In a paper [1], by Schumacher and Boswell an experiment is proposed in which an electron ring shall be generated in the magnetosphere by a rocket- or satellite-borne electron gun. After its production, the electron ring shall then collectively accelerate ions to higher energies, as in the well known electron ring accelerator proposed by Russian scientists many years ago. The electron ring accelerator concept has been nowadays abandoned by most researchers, and is replaced by an interest in other collective acceleration schemes, for example the multistage magnetically insulated diode proposed by the author [2] and somewhat later also by Humphries [3].

It is the purpose of this note, to call to Schumacher's and Boswell's attention, that the oversight of an elementary physics fact makes the proposed experiment unfeasible.

A similar situation, as in the proposed experiment, although with an ion beam, is known to exist for ion propulsion. There, unless the ion beam is space charge neutralized by the injection of electrons into the accelerated beam, the space ship would soon acquire such a large electric charge, that no further ions could be emitted. In the experiment proposed by Schumacher and Boswell, an electron current I_e, is ejected by an electron gun, producing an electron cloud with an extension of the order R. The time τ the electron beam pulse lasts is of the order $\tau \sim R/c$. The total charge emitted by the gun is therefore of the order $Q \sim I_e \tau \sim I_e R/c$. The electric field within the cloud at a distance $r < R$, is of the order $E_c \sim Q r/R^3$, with $E_c^{\max} \sim Q/R^2$. The electron gun however, is also charged up by the same amount, albeit with a charge of opposite sign. The electron gun, therefore becomes a point-like source of an electric field E_g, which at the distance $r < R$ is of the order $E_g \sim Q/r^2$, with $E_g^{\max} \sim Q/R^2$. One thus has $E_g > E_c$, for $r < R$ and $E_g^{\max} \sim E_c^{\max}$, for $r \sim R$. In first approximation the total electric field is a superposition of both fields, because the penetration depth c/ω_p is large compared to the dimension of the electron cloud which shall be of the order of a few 100 meters. The electric field produced by the positively charged-up electron gun is therefore in general larger than the field of the cloud itself, except at the maximum position $r \sim R$ where both are about equal. The omission of the large electric field, having its source at the gun, invalidates all the following calculations made by the authors.

In laboratory produced electron rings there is a return current conductor, but which in space is absent. In laboratory produced electron rings, the kind of electric field produced by a charged-up electron gun does not occur, because the gun is connected to the return current conductor. It therefore appears, that this fact, known to almost every engineer working with high voltage pulse power technology, is unknown to Schumacher and Boswell.

[1] U. Schumacher and R. W. Boswell, Z. Naturforsch. **37a**, 946 (1982).
[2] F. Winterberg, Z. Physik **280A**, 359 (1977).
[3] S. Humphries, Jr., J. Appl. Phys. **49**, 501 (1978).

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